MEXICAN SPOTTED OWL RECOVERY PLAN, FIRST REVISON
(*Strix occidentalis lucida*)

Original Approval Date: October 16, 1995

Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

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Approved: Acting Jay E Nicholopoulos Date: _____
Regional Director, Region 2
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RECOVERY PLAN FOR THE MEXICAN SPOTTED OWL, FIRST REVISON

(*Strix occidentalis lucida*)

Prepared by:
Mexican Spotted Owl Recovery Team

Prepared for:
Region 2, Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

Original Approval Date: October 16, 1995
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DISCLAIMER

The Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.), requires the development of recovery plans for listed species, unless such a plan would not promote the conservation of a particular species. In accordance with Section 4(f)(1) of the Act and to the maximum extent practicable, recovery plans delineate actions that the best available science indicates are required to recover and protect listed species. Recovery plans are published by the U.S. Fish and Wildlife Service (FWS), and are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Recovery plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than the FWS. They represent the official position of FWS only after they have been signed by the Regional Director. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions. Please check for updates or revisions at www.fws.gov/southwest/es/arizona before using.

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EXECUTIVE SUMMARY

Current Species' Status: In 1993 the U.S. Fish and Wildlife Service (FWS) listed the Mexican spotted owl (*Strix occidentalis lucida*; "owl") as threatened under the Endangered Species Act (ESA). Critical habitat for the Mexican spotted owl was designated in 2004, comprising approximately 3.5 million hectares (ha) (8.6 million acres [ac]) on Federal lands in Arizona, Colorado, New Mexico, and Utah (69 FR 53182). Within the critical habitat boundaries, critical habitat includes protected and restricted habitats as defined in the original Mexican Spotted Owl Recovery Plan, completed in 1995. The species' recovery priority number is 9C, pursuant to the Endangered and Threatened Species Listing and Recovery Priority Guidelines (48 FR 43098). The Mexican spotted owl meets the species recovery priority 9C category due to its moderate degree of threat, high recovery potential, taxonomic classification as a subspecies, and conflict with construction or other economic activities. Surveys since the 1995 Recovery Plan have increased our knowledge of owl distribution but not necessarily of owl abundance. An owl site is an area with a high probability of being used by a single or a pair of adult or subadult owls for nesting, roosting, or foraging. For the current revision, the Recovery Team compiled over 1,300 owl sites known today in the U.S. portion of the owl's range (Table II.1; Table B.1 in Appendix B). The increase in the number of owl sites is mainly a product of new surveys being completed within previously unsurveyed areas (e.g., several National Parks within southern Utah, Grand Canyon in Arizona, Guadalupe National Park in West Texas, Guadalupe Mountains in southeastern New Mexico and West Texas, Dinosaur National Monument in Colorado, and Cibola National Forest in New Mexico), with only a few additions to numbers of sites recorded for previously well-surveyed National Forests. Thus, an increase in abundance cannot be inferred from these data.

Habitat Requirements and Limiting Factors: Two primary reasons were cited for the original listing of the Mexican spotted owl in 1993: historical alteration of its habitat as the result of timber-management practices; and, the threat of these practices continuing as evidenced in existing national forest plans. The danger of stand-replacing wildland fire was also cited as a threat at that time. Since publication of the 1995 Recovery Plan, we have acquired new information on the biology, threats, and habitat needs of the spotted owl. The primary threats to its population in the U.S. (but likely not in Mexico) have transitioned from timber harvest to an increased risk of stand-replacing wildland fire. Recent forest management now emphasizes sustainable ecological function and a return toward pre-settlement fire regimes, both of which are more compatible with maintenance of spotted owl habitat conditions than the even-aged management regime practiced at the time of listing. Conversely, southwestern forests have experienced larger and more severe wildland fires from 1995 to the present than previous to 1995. Climate variability combined with current forest conditions may also synergistically result in increased loss of habitat from fire. The intensification of natural drought cycles and the ensuing stress placed upon forested habitats could result in even larger and more severe wildland fires in owl habitat.

Within the Forest Service's Region 3, Southwest Region (Arizona and New Mexico), National Forest Plans were amended in 1996 to incorporate management recommendations presented in the 1995 Recovery Plan for the Mexican spotted owl. Since the Recovery Plan was published, our knowledge has increased. Given these changes and new information, it became timely to

revisit and revise the 1995 Recovery Plan. The recommendations contained within this revised Recovery Plan supersede those provided in the 1995 Recovery Plan.

Recovery Strategy: This Recovery Plan presents realistic and attainable goals for recovering the owl and its ultimate delisting, involving forest habitat management and vigilant monitoring. The goals are flexible in that they allow local land managers to make site-specific decisions. To accomplish the recovery of the Mexican spotted owl, the recovery strategy has five key elements designed to conserve the subspecies throughout its range: 1) protecting existing populations; 2) managing for habitat into the future; 3) managing threats; 4) monitoring population and habitat; and, 5) building partnerships to facilitate recovery.

Recovery Goal: The ultimate goal of the Recovery Plan is to recover owl populations to the point that the owl can be removed from the Federal list of endangered and threatened species. Success of the Recovery Plan hinges on the commitment and coordination among the Mexican government, U.S. Federal and state land-management organizations, sovereign Indian nations, and the private sector to ensure that the proposed population and habitat monitoring are implemented. Without careful and rigorous application of the proposed population monitoring, there would be no objective basis for delisting the owl. Under the proposed recovery criteria, the owl could be delisted within 10 years of implementing the revised Recovery Plan, though we acknowledge that this is an ambitious goal.

Recovery Objectives: To support the Mexican spotted owl throughout its range into the foreseeable future, and to maintain habitat conditions necessary to provide roosting and nesting habitat for the Mexican spotted owl.

Recovery Criteria: Two criteria (addressing Listing Factors A, C, and E) must be met before the Mexican spotted owl can be delisted:

1. *Owl occupancy rates must show a stable or increasing trend after 10 years of monitoring*. The study design to verify this criterion must have a power of 90% (Type II error rate $\beta = 0.10$) to detect a 25% decline in occupancy rate over the 10-year period with a Type I error rate (α) of 0.10. The monitoring approach recommended in Part V.B and in Appendix E describes a framework for accomplishing these study objectives.

2. *Indicators of habitat conditions (key habitat variables) are stable or improving for 10 years in roosting and nesting habitat* (for key habitat variables, see Table C.2 or C.3 in Appendix C). Habitat monitoring should be conducted concurrently with owl occupancy monitoring. Trends in all key habitat variables must be shown stable or increasing with a power of 90% (Type II error rate $\beta = 0.10$) to detect a 25% decline over the 10-year period with a Type I error rate (α) of 0.10.

To delist the owl, we recommend both criteria be met. Once the two criteria have been met, we would then review the regulations and known distribution of Mexican spotted owls to determine if the delisting process should proceed. At this time, we cannot describe the future desired distribution of owls across their range. For example, changes in the species' range may occur due to factors such as climate change which could result in shifts in the owl population to the

northern portion of its range. In addition, anthropogenic and non-anthropogenic threats to the Mexican spotted owl must be sufficiently moderated and/or regulated for the foreseeable future, as evidenced by the best scientific information available. The best scientific information is derived from research, management experiments, and monitoring conducted at the appropriate scales and intensity. An analysis of the five ESA listing factors must be conducted to verify that threat levels are acceptable for likely persistence of owl populations into the future.

Actions Needed: Actions required to ensure the recovery of the Mexican spotted owl include:

1. *Management.* Given that the owl is a widespread subspecies with a disjunct and somewhat fragmented distribution, management of the owl and its habitat must be conducted at the landscape scale. Landscape modeling and analysis are critical in evaluating the distribution of owls and habitats, identifying areas where threats are greatest, and then applying Recovery Plan recommendations in such a way as to sustain and improve owl habitat. Three levels of management are recommended in this Recovery Plan:

- Protected Activity Centers (PACs). PACs encompass a minimum of 600 acres surrounding known owl nest/roost sites. Management recommendations are most conservative within PACs, but by no means advocate a "hands-off" approach. The Recovery Team recognizes situations exist where management is needed to sustain or enhance desired conditions for the owl, including fire-risk reduction, as well as monitoring owl response. Mechanical treatments in some PACs may be needed to achieve these objectives; determining which PACs may benefit from mechanical treatments requires a landscape analysis to determine where the needs of fire risk reduction and habitat enhancement are greatest. PACs are the only form of protected habitat included in this revised Plan.

- Recovery habitat. This habitat is primarily ponderosa pine-Gambel oak, mixed-conifer, and riparian forest that either currently is, or has the potential for becoming, nest/roost habitat or does or could provide foraging, dispersal, or wintering habitats. Nesting/roosting habitat typically occurs either in well-structured forests with high canopy cover, large trees, and other late seral characteristics, or in steep and narrow rocky canyons formed by parallel cliffs with numerous caves and/or ledges within specific geologic formations. Ten to 25 percent of forested recovery habitat should be managed as recovery nest/roost habitat varying by forest type and Ecological Management Unit (EMU) (formerly called Recovery Units). This habitat should be managed to replace nest/roost habitat lost due to disturbance (e.g., fire) or senescence and to provide additional nest/roost habitat to facilitate recovery of the owl. The remainder of forested recovery habitat should be managed for other needs (such as foraging, dispersing, or wintering) provided that key habitat elements are retained across the landscape.

- Other forest and woodland types, such as ponderosa pine forest, spruce-fir forest, and pinyon-juniper woodland. No specific management is suggested for these habitat types, recognizing that current emphasis for sustainable and resilient forests should be compatible with needs of the owl.

2. *Monitoring.* As management proceeds, monitoring assesses the efficacy of management actions. Thus, it is critically important to monitor owl populations and habitat to determine whether both are stable or improving. Monitoring population trends provides a real-time assessment of the owl's status, whereas habitat monitoring allows us to predict if there will be adequate habitat to support a viable owl population in the future. As a surrogate for evaluating trends in actual owl numbers, owl occupancy will be monitored at a sample of fixed sites randomly selected throughout the U.S. range of the Mexican spotted owl. We also recommend that Mexico undertake a monitoring effort consistent with the one recommended for the U.S. No specific design is proposed for monitoring habitat, although Forest Inventory and Assessment data might have application to the owl. Combining owl occupancy and habitat monitoring provides an opportunity to examine relationships between habitat features and owl populations to assess whether a review of current management is warranted.

3. *Research.* The Recovery Team used available data, published papers, unpublished reports, and scientific expertise covering the U.S. and Mexico when developing the Recovery Plan. During the process, it became clear that critical knowledge gaps exist. Four general areas require additional research: 1) habitat relationships, 2) biological interactions, 3) population structure, and 4) ecosystem structure. Under each of these subjects, the Recovery Team has provided specific research recommendations. This research would increase our understanding of the effects of the Recovery Plan management recommendations on the owl and ecosystem composition, structure, and function.

4. *Implementation.* An implementation schedule is provided that details recovery tasks, the entities responsible for implementing them, and the estimated costs. The Recovery Team recommends that a working team be assembled for each EMU to oversee implementation and to provide feedback on successes and failures of the Recovery Plan.

Estimated Date and Cost to Recovery:

Estimated date: 2022

Total Cost of Recovery (minimum): $42,628,000

Costs, in thousands of dollars:

Year	**Minimum Cost ($1000s)**
2013	3,770
2014	3,707
2015	3,687
2016	3,687
2017	3,687
2018 - 2022	24,110

Date of Recovery: The date of recovery for the Mexican spotted owl is estimated at 2022 if actions delineated in this recovery plan are implemented.

RESUMEN EJECUTIVO

Estado actual de la especie: En 1993, el Servicio de Pesca y Vida Silvestre de los Estados Unidos (FWS, por sus siglas en inglés) incluyó al búho moteado mexicano en la categoría de amenazado en el Acta de Especies Amenazadas (ESA, por sus siglas en inglés). En 2004 se designaron aproximadamente 3.5 millones de hectáreas (8.6 millones de acres) de hábitat crítico para la especie en terrenos federales en Arizona, Colorado, Nuevo México y Utah (69 FR 53182). Dentro de sus límites, cada hábitat crítico sólo incluye hábitats protegidos y restringidos definidos en el Plan de Recuperación del Búho Moteado Mexicano, concluido en 1995. El número de prioridad de recuperación de la especie es 9C, de acuerdo a las Directrices para Enlistado y Priorización de la Recuperación de Especies En Peligro y Amenazadas (48 FR 43098). El búho moteado mexicano tiene la categoría de prioridad de recuperación 9C debido al grado moderado de sus amenazas, su alto potencial de recuperación, su clasificación taxonómica como subespecie, y su conflicto con la construcción y otras actividades productivas. Estudios elaborados a partir de la elaboración del Plan de Recuperación en 1995 han incrementado nuestro conocimiento sobre la distribución del búho, aunque no necesariamente sobre su abundancia. Un sitio con presencia de búhos es un área usada repetidamente para anidamiento, perchado o forrajeo por un individuo o una pareja de búhos (Recuadro 1). Para esta revisión, el Equipo de Recuperación compiló información sobre 1,301 sitios con presencia de búhos registrados a la fecha en la porción estadounidense del rango de distribución de esta especie (Tabla II.1; Tabla B.1 en el Apéndice B). Este incremento se debe principalmente a los resultados de información generada en áreas no estudiadas previamente (parques nacionales en el sur de Utah, el Gran Cañón en Arizona, Parque Nacional Guadalupe y Montañas de Guadalupe en el sureste de Nuevo México y el oeste de Texas, el Monumento Nacional del Dinosaurio en Colorado, y el Bosque Nacional de Cíbola en Nuevo México), que resultó en la adición de pocos sitios nuevos a los registrados previamente en los bosques nacionales. Por esta razón, no es posible inferir incrementos en la abundancia a partir de estos datos.

Requisitos de hábitat y factores limitantes: Las dos razones principales para incluir al búho moteado mexicano en la lista de especies amenazadas en 1993 fueron: alteración histórica de su hábitat como resultado de las prácticas de manejo para producción de madera y la amenaza continua de estas prácticas presentes en los planes de manejo existentes para los bosques nacionales. El riesgo de incendios catastróficos fue citado como una amenaza en aquel momento. A partir de la publicación de Plan de Recuperación de 1995, se ha obtenido nueva información sobre la biología, amenazas y requerimientos de hábitat del búho moteado. Las principales amenazas a las poblaciones en Estados Unidos (pero aparentemente no en México) han cambiado al aprovechamiento forestal al incremento del riesgo de incendios forestales catastróficos. El reciente manejo forestal ahora enfatiza la función ecológica sustentable, y un regreso a los regímenes de fuegos previos a los asentamientos, en ambos casos son más compatibles con el mantenimiento de las condiciones de hábitat de la especie que el régimen de manejo practicado en el momento en que se enlistó. Desde 1995 hasta la actualidad los bosques del suroeste de los Estados Unidos han experimentado incendios catastróficos más grandes y severos que aquéllos registrados en el pasado. La variación climática combinada con condiciones no saludables del bosque pueden sinérgicamente resultar en un aumento de efectos negativos en el hábitat debido a incendios. La intensificación de ciclos de sequia naturales y el estrés resultante en el hábitat de bosque densos podría resultar en incendios aún mas grandes y

severos en hábitat del búho.

Los Planes de los Bosques Nacionales de la Región 3 fueron editados en 1996 para incorporar recomendaciones de manejo presentadas en el Plan de Recuperación del Búho Moteado Mexicano de 1995. Desde que el Plan de Recuperación fue publicado, nuestro conocimiento se ha incrementado. Dados estos cambios y nueva información, se volvió tiempo para reconsiderar y revisar el Plan de 1995. Las recomendaciones contenidas en esta versión revisada del Plan de Recuperación, deberán sustituir a aquellas establecidas en la versión de 1995.

Estrategia de Recuperación: Este Plan de Recuperación presenta metas realistas y obtenibles para la recuperación del búho y su retiro de la lista de especies en peligro de extinción, a través del manejo del hábitat forestal y el monitoreo continuo. Las metas son flexibles, ya que permiten que los manejadores locales tomen decisiones específicas a nivel de sitio. Para realizar la recuperación del búho moteado mexicano, la estrategia de recuperación tiene cinco elementos claves diseñados para conservar la especie en todo su rango de distribución: 1) proteger poblaciones existentes, 2) manejo por el hábitat en el futuro, 3) manejo de amenazas, 4) de poblaciones y hábitat, y 5) construyendo alianzas para facilitar recuperación.

Meta de Recuperación: La meta final del Plan de Recuperación es que las poblaciones de búho sean sostenibles al punto de que la subespecie pueda ser removida de la lista de especies amenazadas y en peligro de extinción.

Sin embargo, el éxito del plan, depende del compromiso y la coordinación entre el gobierno de México, las agencias de manejo de tierras federales y estatales en los EEUU, las naciones indígenas soberanas, y el sector privado. De acuerdo con los criterios de recuperación propuestos en el Pan, el Búho podría ser removido del Acta de Especies Amenazadas, en un periodo de diez años a partir de la implementación de este Plan de Recuperación revisado, aunque se considera una meta ambiciosa.

Objetivos de Recuperación: Apoyar la conservación del búho moteado mexicano a través de su rango de distribución en un futuro predecible, y mantener las condiciones de hábitat necesarias para proporcionar hábitat de perchado y anidamiento a la especie.

Criterios de Recuperación: Para remover al búho moteado mexicano de la lista de especies en peligro de extinción deben de cumplirse dos criterios (relacionados con los Criterios de Enlistado A, C y E):

1. *Las tasas de ocupación de los búhos deben de mostrar una tendencia estable o incremento después de 10 años.* El diseño de los estudios para verificar este criterio debe de tener una confiabilidad de 90% (tasa de error Tipo II ó $\beta = 0.10$) para detectar una declinación de 25% en la ocupación con una tasa de error Tipo I (α) de 0.10. El enfoque del monitoreo recomendado en la Parte V.2 y el Apéndice F describe un marco de trabajo para alcanzar los objetivos de estos estudios.

2. *Los indicadores de las condiciones de hábitat (variables clave de hábitat) son estables y mejorando por10 años en el hábitat de perchado y anidamiento* (por las variables clave

de hábitat ver Tabla C.2 o C.3 el Apéndice C). El monitoreo de hábitat deberá llevarse a cabo de forma simultánea con el monitoreo de ocupación de hábitat del búho. Las tendencias de todas las variables clave de hábitat deberán de tener valores estables o incrementar con una confiabilidad del 90% (tasa de error Tipo II $\beta = 0.10$) para detectar una declinación de 25% con una tasa de error Tipo I (α) de 0.10. .

Para remover el búho de la lista de especies amenazadas y en peligro de extinción, recomendamos que se cumpla con ambos criterios. Al cumplirse los dos criterios, revisaríamos los reglamentos y la distribución conocida del búho moteado mexicano para determinar si la remoción debe proceder. En este momento no podemos describir la futura deseada distribución del búho a través de su rango. Por ejemplo, cambios en la distribución de la especie podrán ocurrir debido a factores como el cambio climático, el cual podría resultar en un desplazamiento en la población del búho hacia la parte norte de su rango. Además, las amenazas para la especie, antropogénicas y no antropogénicas, deberán de ser moderadas o reguladas lo suficiente en el futuro inmediato con base en mejor información científica disponible. Esta información científica deriva de experimentos de investigación, experimentos de manejo y monitoreo conducido a escalas e intensidades adecuadas. Se deberá llevar a cabo un análisis de los cinco factores de la inclusión en el listado de especies amenazadas, para verificar que los niveles de amenaza son aceptables para incrementar la probabilidad de persistencia en el futuro de las poblaciones de búhos moteados mexicanos.

Acciones necesarias: Las acciones requeridas para asegurar la recuperación del búho moteado mexicano incluyen:

1. *Manejo*. Dado que el búho es una especie generalista con una distribución dispersa y algo fragmentada, su manejo debe de tener un enfoque de paisaje. Los modelos y análisis de paisaje son críticos para la evaluación de la distribución del búho y su hábitat, identificando áreas en las que las amenazas son mayores, utilizando las recomendaciones del plan de forma que se mantenga y mejore el hábitat del búho. Tres niveles de manejo son recomendados en el Plan de Recuperación:

- Centros de Actividades de Protección (PACs, por sus siglas en inglés). Estos cubren aproximadamente 600 acres alrededor de sitios con presencia de búhos. Las medidas de manejo son en su mayoría conservadoras, lo cual no significa avocarse a una aproximación "manos fuera". El Equipo de Recuperación reconoce que existen situaciones en las que es necesario desarrollar actividades de manejo para mantener o mejorar las condiciones deseadas para el búho, incluyendo la reducción del riesgo de incendios, y el monitoreo de la respuesta del búho. Tratamientos mecánicos pueden ser requeridos en algunos PAC's para lograr estos objetivos; para determinar cuáles PAC's pueden beneficiarse de estos tratamientos, se requiere efectuar un análisis del paisaje que identifique las zonas donde más se requiere reducción de riesgo de incendios y mejoramiento de hábitat. PACs son el único tipo de hábitat protegido que se incluye en este Plan revisado.

- Hábitat de recuperación. Estos son principalmente bosques de pino Ponderosa-encino de Gambel, coníferas mixtas y bosques riparios que tienen potencial para convertirse en

hábitat de anidamiento y perchado o para proporcionar hábitat de forrajeo, dispersión o hibernación. Hábitat de anidamiento y perchado usualmente ocurre en bosques bien estructurados con una copa alta, árboles grandes, y otras características de sucesiones tardías, o en cañones rocosas muy inclinadas y angostas formados por acantilados paralelos con varias cuevas y/o salientes dentro de formaciones geológicas muy específicas. De un 10 a 25% del hábitat de bosque de recuperación deberá de ser manejado como reemplazo del hábitat de anidación y perchado, con variaciones de acuerdo al tipo de bosque y la Unidad Ecológica de Manejo (EMU, por sus siglas en inglés). Este hábitat debe de ser manejado como si fuese un remplazo del hábitat de anidación y percha perdido debido a la perturbación (e.g. por incendios) o a su antigüedad y con el fin de proveer hábitat de anidación y percha adicional, facilitando así la recuperación del búho moteado. El remanente de hábitat del bosque recuperado puede manejarse para otras necesidades, siempre y cuando se mantengan elementos clave del hábitat a lo largo del paisaje.

- Otros tipos de bosque y vegetación forestal, como bosque de pino ponderosa, picea-abeto y pino piñonero-junípero. No existen recomendaciones específicas para estos tipos de bosque, reconociendo que el énfasis actual para la restauración ecológica debe de ser compatible con las necesidades de los búhos.

2. *Monitoreo*. A medida que se avanza en el manejo, el monitoreo permite evaluar la eficacia de las acciones. El monitoreo del estado de las poblaciones de búhos y su hábitat es crítico para determinar si éstas son estables o mejoran. El monitoreo del estado de la población proporciona una evaluación en tiempo real de la situación del búho, mientras que el monitoreo del hábitat permite determinar a futuro, si habrá hábitat adecuado para mantener poblaciones viables de búhos. Para sustituir la evaluación de tendencias a través de cifras reales de las poblaciones de búhos, su ocupación será monitoreada a través de una muestra de sitios fijos seleccionados aleatoriamente a lo largo del rango de distribución del búho en los Estados Unidos. También recomendamos que México inicie un esfuerzo de monitoreo consistente con el recomendado en los Estados Unidos. No se proporciona un diseño específico para el monitoreo de hábitat, aunque los datos de la Evaluación e Inventario Forestal podrá tener aplicaciones para búho. La combinación de los modelos de ocupación del búho y el monitoreo de su hábitat proporciona una oportunidad para examinar relaciones entre las características del hábitat y las poblaciones de la especie para indicar si se justifica la revisión del manejo actual.

3. *Investigación*. El Equipo de Recuperación utilizó los datos disponibles, artículos científicos publicados, reportes no publicados e información de expertos científicos en los Estados Unidos y México para el desarrollo del Plan de Recuperación. Durante el proceso, se determinó que existen vacíos críticos de conocimiento. Cuatro áreas generales que requieren investigación adicional en los Estados Unidos son: 1) relaciones de hábitat, 2) interacciones biológicas, 3) estructura de las poblaciones, y 4) estructura de los ecosistemas. Dentro de estas áreas generales existen recomendaciones definidas por el equipo de recuperación, de investigación para entender mejor los efectos de la implementación de las recomendaciones de manejo sobre los búhos y la composición, estructura y función de los ecosistemas.

4. *Implementación*. Un calendario de implementación es proporcionado con detalles de las tareas de recuperación, las entidades responsables de su implementación y los costos estimados. El Equipo de Recuperación recomienda que un equipo de trabajo sea conformado para cada EMU, para para supervisar la y proporcionar retroalimentación en los éxitos y fracasos del Plan de Recuperación.

Fecha y Costos Estimados de la Recuperación:

Fecha aproximada: 2022

Costo total de la Recuperación (mínimo): $42,628,000

Costos, en miles de dólares

Año	**Costo mínimo (miles de USD)**
2013	3,770
2014	3,707
2015	3,687
2016	3,687
2017	3,687
2018 - 2022	24,110

Fecha de recuperación: La fecha de recuperación del búho moteado mexicano se estimada para el 2022 si las acciones indicadas en este plan de recuperación son implementadas.

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PART I. RECOVERY PLANS AND PLAN REVISIONS

A. Recovery Plans

The purposes of the ESA are to provide a means whereby the ecosystems upon which threatened and endangered species depend may be conserved and to provide a program for the conservation of such threatened and endangered species. Section 4(f)(1) of the ESA of 1973, as amended (ESA; 16 U.S.C. 1531), requires a recovery plan be prepared for each listed species, unless such plan will not promote its conservation.

Recovery plans describe the process by which the decline of a threatened or endangered species can be reversed and threats to its survival neutralized so that long-term survival can be assured. Section 4(f)(1)(B) of the ESA specifies the contents of a recovery plan. Sections of this Revised Recovery Plan meeting these requirements are:

1) A description of such site-specific management actions as may be necessary to achieve the Plan's goal for the conservation and survival of the species (Appendix C);
2) Objective, measurable criteria that, when met, would result in a determination that the species be removed from the list (Part III); and,
3) Estimates of the time required and the cost to carry out those measures needed to achieve the Plan's goal and intermediate steps toward that goal (Part V.1).

Recovery plans are neither self-implementing nor legally binding. Rather, approved recovery plans effectively constitute a FWS guidance document on that listed species or group of species, thereby serving as a logical path from what is known about the species' biology, life history, and threats to a recovery strategy and program. In some cases, recovery plans are followed by other Federal agencies in order to meet the provisions of 2(c)(1) and 7(a)(1) of the ESA, which require Federal agencies to utilize their authorities in carrying out programs for the conservation of endangered and threatened species. Agency regulations and policies (e.g., those implementing the National Forest Management Act) may also encourage management under recovery plan guidelines. In addition, foreign, state, and local governments often follow the recommendations of recovery plans in species-conservation efforts.

B. Recovery Teams

To develop scientifically credible recovery plans for listed species, the FWS may appoint recovery teams comprised of scientists and resource specialists with expertise either on the species being considered or with other relevant knowledge. In the case of the Mexican spotted owl, the FWS appointed the Mexican Spotted Owl Recovery Team (Recovery Team). A list of Recovery Team members and their areas of expertise can be found in Appendix A.

C. Recovery Plan Revisions

The recovery planning guidance states: "A revision is a substantial rewrite of at least a portion of a recovery plan and is usually required if major changes are required in the recovery strategy, objectives, criteria, or actions" (USDC NMFS and USDI FWS 2010). A revision may be required when new threats to the species are identified, when research uncovers new life history

traits or threats that have significant recovery ramifications, or when the current plan is not achieving its objectives. In some cases, a revision may be undertaken when a significant amount of time has passed and a number of updates have been completed. Section 4(f)(4) of the ESA requires that, prior to approval of a revised recovery plan, the public shall be notified and allowed the opportunity to review and comment on the revision.

D. Revised Mexican Spotted Owl Recovery Plan

The subject of this plan is the Mexican spotted owl. The U.S. Department of the Interior (USDI) FWS added the Mexican spotted owl (*Strix occidentalis lucida*; also "owl" and "spotted owl"; scientific names of all organisms are provided in Appendix I) to the List of Threatened and Endangered Wildlife (50 CFR 17.11) as a threatened species, effective 15 April 1993. The Recovery Plan for the Mexican Spotted Owl (Recovery Plan; USDI FWS 1995) was completed by FWS Region 2 (Southwest Region) in December 1995. Since that time, we have acquired new information on the biology, status, distribution, and other aspects of the Mexican spotted owl's life history. This Recovery Plan for the Mexican Spotted Owl, First Revision, revises the 1995 Recovery Plan, incorporating new information on the owl's biology, threats, and recovery needs, and outlines a comprehensive program for its recovery. We intend that this revised Recovery Plan be a stand-alone document. In other words, although the original Recovery Plan is referenced throughout this revised version, everything needed to inform recovery of the Mexcian spotted owl is included herein.

Implementing the recovery actions in the original Recovery Plan has resulted in various updates, clarifications, and changes to Recovery Plan recommendations that will lead the species to recovery (see E, below). There have been changes in land-management emphasis, relevant statutes and regulations, and specific threats to the species necessitating re-examination and, ultimately, further revision of the management recommendations (Appendix C). Population and range-wide habitat monitoring recommendations in the original Recovery Plan have been modified (Part V.B and Appendix E), and the implementation and cost schedule has been updated (Table V.1). A summary of changes and associated rationales are provided below.

E. Primary Differences From the 1995 Recovery Plan

With new knowledge and experience garnered from implementation of the 1995 Recovery Plan, a number of substantive changes were made in the revision. These include:

Part II:

- Includes an ESA five-factor threats analysis.
- Changes RUs to EMUs to conform to FWS policy.
- Provides a more explicit definition of an owl site.
- Merges Southern Rocky Mountain (SRM)-Colorado and SRM-New Mexico EMUs into one (SRM).
- Revises boundary between Colorado Plateau (CP) and SRM to reflect ecological differences between the two EMUs.
- Extends boundary of Basin and Range East (BRE) EMU into Texas to incorporate verified sightings and suspected habitat.

- Reduces the size of the Basin and Range West (BRW) EMU by removing much of the western part where there are no records of owls and little, if any, known owl habitat
- Adds descriptions of canyon cover types as they relate to the owl.
- Provides a clearer definition of riparian habitats as they relate to the owl.

Parts III-V:
- Revises delisting criteria to reflect changes in monitoring requirements (Part III).

Appendices A – G:
- Provides a more explicit definition of an owl site (Appendix C).
- Updates management recommendations given new information (Appendix C).
- Removes reserved lands from automatic inclusion as protected areas (Appendix C).
- Removes steep slopes from automatic inclusion as protected areas (Appendix C).
- Delineates activities that can be conducted inside of PACs and further specifies activities to occur within and outside of nest/roost core areas. Specifically, allows up to 20% of the total PAC area (external to the core) within an EMU to be treated to meet ecological restoration and fuels-reduction objectives if the appropriate monitoring is conducted.
- Provides guidance for removing PAC status from areas so designated.
- Renames "restricted habitat" to "recovery habitat" to more appropriately reflect the intent.
- Develops desired conditions for owls as targets to guide management.
- Provides threat-specific management recommendations for noise, recreation, energy development, land development, water development, grazing, insects and disease, fire suppression and related activities, prescribed fire and wildland fire, research, climate change, and West Nile virus (Appendix C).
- Describes a new approach to monitor owl populations based on owl occupancy (Appendix E).
- Describes a new approach to monitor range-wide owl habitat using Forest Inventory Assessment (FIA) data (Part V.2 and Appendix E).
- Includes a survey protocol (Appendix D).

F. Final Remarks on this Recovery Plan

The Mexican Spotted Owl Recovery Plan is based on the best available science. When published papers were not available, the Recovery Team conducted analyses and modeling to inform the development of management recommendations. The management recommendations should not be considered the end point. Rather, they represent a starting point and can be adjusted and improved as new information is acquired.

The Recovery Plan sets forth recommendations for management and monitoring of the Mexican spotted owl and its habitat. Both are key to the eventual recovery of the owl as management proceeds within an adaptive framework whereby monitoring is used to assess the efficacy of management actions. The Recovery Plan promotes a landscape scale approach to implementing owl recovery actions. Landscape modeling and analysis are critical in evaluating the distribution

of owls and habitats, identifying areas where threats are greatest, and then applying plan recommendations in such a way as to sustain and improve owl habitat.

Management recommendations represent a combination of protective and proactive measures. Areas currently occupied by owls require the greatest protection to ensure continued occupancy, reproduction, and survival. By no means, however, does this translate to a hands-off approach. In some cases, protection of these areas requires active intervention to sustain desired conditions and to reduce risk of habitat-reducing wildland fire. These interventions should be done after careful analysis and planning to ensure that actions taken are necessary and prudent.

Forests do not retain their characteristics in perpetuity. They become established, grow, and then enter senescence and lose characteristics favored by owls. As a result, landscapes are dynamic and management must look into the future. As nest/roost habitats are lost to natural and unnatural causes, recovery habitats should be in the queue ready for owls to occupy them. This is the intent of replacement nest/roost habitat within recovery habitats. Their development will require a balance between intervention and being allowed to develop naturally in absence of intervention. Management should strive to plan well into the future to ensure that an adequate proportion of the landscape remains in suitable nest/roost conditions to sustain owl populations.

PART II. BACKGROUND

The following summarizes the biology and ecological relationships of Mexican spotted owls. We intend for this to be an overview of biological characteristics of this subspecies, including those germane to recovering its populations. We emphasize information developed since the original Recovery Plan was published (USDI FWS 1995). Although information gaps still exist, our understanding of the Mexican spotted owl's natural history has increased since 1995. For example, the number of owls known to dwell in rocky canyon environments has increased greatly. We also have new information on how to predict habitat, effects of fire on owls and their habitat, and demographic parameters for a few owl populations. Because the following summary is a brief overview, we urge interested readers to explore Appendix B for a more comprehensive review of scientific literature addressing ecological relationships of Mexican spotted owls.

A. Taxonomy

The Mexican spotted owl is one of three subspecies of spotted owl recognized by the American Ornithologists' Union (AOU) in the last checklist to include subspecies designations (AOU 1957:285). The other two subspecies are the northern and the California spotted owls (Appendix B, Fig. B.1). The Mexican subspecies is geographically isolated from both the California and northern subspecies. Studies suggest that the Mexican spotted owl is genetically isolated from the other subspecies (Barrowclough and Gutiérrez 1990; but see also Funk et al. 2008).

Two other species within the genus *Strix* occur north of Mexico, the great gray and barred owls. The great gray owl is a northern species that does not occur within the range of the Mexican spotted owl. Historically, barred owls did not occur sympatrically with Mexican spotted owls within the United States. However, unconfirmed sightings of both species have been reported

from the vicinity of Big Bend National Park in southern Texas in recent times (Wauer 1996) and there are recent confirmed records of barred owls in northern (Williams 2005, cited in Cartron 2010) and eastern (H.Walker pers. comm.) New Mexico. Whether these confirmed records indicate a range expansion by barred owls or vagrancy is unknown.

Barred owls recently have expanded their range into the Pacific Northwest and California (Gutiérrez et al. 2004, Haig et al. 2004b); they appear to be both displacing territorial spotted owls and hybridizing with spotted owls, and are seen as a significant threat to the continued viability of northern spotted owls (Gutiérrez et al. 2004, Forsman et al. 2011). Given hybridization between northern spotted and barred owls in the Pacific Northwest, it seems likely that hybridization between Mexican spotted and barred owls would occur if barred owls expand their range into that of the Mexican spotted owl.

In Mexico, barred owls and another member of the *Strix* genus, fulvous owls, are found. The ranges of the Mexican spotted and barred owl may overlap in Mexico (Williams and Skaggs 1993, Howell and Webb 1995); little is known about local distributional patterns and habitats occupied in this zone of apparent overlap (Enriquez-Rocha et al. 1993). The fulvous owl does not appear to be sympatric with Mexican spotted owls in Mexico (but its distribution may overlap that of the barred owl to a small extent; Holt et al. 1999).

B. Description

1. Appearance

The Mexican spotted owl is a medium-sized owl without ear tufts. They are mottled with irregular white spots on its brown abdomen, back, and head (Appendix B, Fig. B.2). The Mexican spotted owl differs from the two other subspecies of spotted owls in plumage coloration; the white spots of the Mexican spotted owl are generally larger and more numerous than in the other two subspecies, giving it a lighter appearance. Wing and tail feathers are dark brown barred with lighter brown and white and, unlike most owls in North America, spotted owls have dark eyes (Gutiérrez et al. 1995).

Adult male and female Mexican spotted owls are similar in plumage; however, females are larger, on average, than males. Juveniles, subadults, and adults can be distinguished by plumage characteristics (Forsman 1981, Moen et al. 1991). Juvenile owls (hatchling to approximately five months) have a downy appearance (Appendix B, Fig. B.2). Subadult owls (5 to approximately 26 months) closely resemble adults, but they have pointed tail feathers with a pure white terminal band (Forsman 1981, Moen et al. 1991). The tail feathers of adults (>27 months) have rounded tips, and the terminal band is mottled brown and white (Appendix B, Fig. B.3).

2. Vocalizations

The Mexican spotted owl, being territorial and primarily nocturnal, is heard more often than seen. It has a wide repertoire of calls (Forsman et al. 1984, Ganey 1990). Most calls are relatively low in pitch and composed of pure tones (Fitton 1991), and thus are well-suited for accurate, long-distance communication through areas of relatively dense vegetation (Fitton 1991, see also Morton 1975, Forsman et al. 1984). Male and female owls can be distinguished by their calls. Males have a deeper voice than females (Forsman et al. 1984) and generally call more

frequently than females (Ganey 1990). The most common vocalization, used more often by males than females (Ganey 1990, Kuntz and Stacey 1997), is a series of four unevenly spaced hoots (Forsman et al. 1984, Fitton 1991). Females frequently use a clear whistle ending with an upward inflection as well as a series of sharp barks (Forsman et al. 1984, Ganey 1990).

Mexican spotted owls call mainly during March to November and are relatively silent from December to February (Ganey 1990), although spontaneous calling has been heard during all months (J. L. Ganey, Rocky Mountain Research Station, unpublished data). Calling activity increases from March through May (although nesting females are largely silent during April and early May) and then declines from June through November (Ganey 1990:Fig. 3). Ganey (1990:Fig. 4) reported that calling activity was greatest during a two-hour period following sunset, with smaller peaks in calling activity four to eight hours after sunset and again just before sunrise.

C. Distribution

The Mexican spotted owl occurs in forested mountains and canyonlands throughout the southwestern U.S. and Mexico (Gutiérrez et al. 1995, Ward et al. 1995; Appendix B). It ranges from Utah, Colorado, Arizona, New Mexico, and the western portions of Texas south into several States of Mexico (Appendix B, Fig. B.1). Whereas this owl occupies a broad geographic area, it does not occur uniformly throughout its range (USDI FWS 1995). Instead, the owl occurs in disjunct areas that correspond with isolated mountain ranges and canyon systems. In the U.S., the majority of owls are found on National Forest System (NFS) lands; however, in some areas of the Colorado Plateau EMU, owls are found only in rocky-canyon habitats, which primarily occur on NPS- and BLM-administered lands (Appendix B, Fig. B.4).

The current distribution of Mexican spotted owls generally follows its historical extent, with a few exceptions (Ward et al. 1995). For one, there are early records of spotted owls in lowland riparian areas along major rivers, such as the San Pedro in Arizona and the Rio Grande in New Mexico; but the species has not been documented in these areas recently (i.e., since the early 1900s) (Williams 1993, Ward et al. 1995). In addition, previously occupied riparian communities in the southwestern U.S. and southern Mexico have undergone significant habitat alteration since the historical sightings (USDI FWS 1993). For example, in southern Utah and northern Arizona, inundation of Glen Canyon by Lake Powell created a 299-kilometer (km) (186-mile [mi]) long and 40-km (25-mi) wide reservoir that may have flooded habitat for a potentially large population in the canyonlands region (McDonald et al. 1991, Willey and Spotskey 2000).

In Mexico, information on the status of Mexican spotted owls is limited (Tarango et al. 2001). As in the U.S., owl distribution in Mexico appears disjunct (Williams 1993, USDI FWS 1995). The majority of Mexican spotted owls has been located in the Sierra Madre Occidental Mountain range (Williams 1993), which includes the states of Chihuahua, Sonora, Sinaloa, Durango, San Luis Potosi, Aguascalientes, Zacatecas, Jalisco, Nayarit, Queretaro, and Guanajuato. It is not

known if the distribution of Mexican spotted owls in Mexico has changed nor how many additional sites have been recorded since 1995.

1. Ecological Management Units (EMUs)

The Mexican spotted owl occupies many habitat types scattered across a diversity of landscapes. In addition to this natural variability in owl habitat, human activities also vary across the owl's range. The combination of natural variability, human influences on owls, international boundaries, and logistics of implementating the Recovery Plan necessitates subdivision of the owl range into smaller management areas. The 1995 Recovery Plan subdivided the owl's range into 11 "Recovery Units" (RUs): six in the U.S. and five in Mexico. In this revision of the Recovery Plan, we renamed RUs as EMUs to be in agreement with current FWS guidelines (USDC NMFS and USDI FWS 2010). We divide the owl range within the U.S. into five EMUs: Colorado Plateau (CP), Southern Rocky Mountains (SRM), Upper Gila Mountains (UGM), Basin and Range-West (BRW), and Basin and Range-East (BRE) (Fig. II.1). The SRM EMU was created by merging the former SRM-New Mexico and SRM-Colorado RUs. We also continue to recognize the five EMUs identified in the original Recovery Plan (USDI FWS 1995) for Mexico: Sierra Madre Occidental-Norte, Sierra Madre Oriental-Norte, Sierra Madre Occidental-Sur, Sierra Madre Oriental-Sur, and Eje Neovolcanico (Fig. II.7).

As with RUs in the original Recovery Plan, we use EMUs as geographical subdivisions of the owl range to organize owl recovery efforts. The EMUs allow localized Working Teams of resource managers to coordinate their efforts and share information about owls and owl habitat across administrative boundaries. These Working Teams (see Part V.C) provide an opportunity for interested parties to participate in discussions affecting owl management at a more local level. In addition to activities described in this Recovery Plan, the Working Teams may choose to develop and recommend actions they deem necessary to locally gather information or further owl recovery.

The boundaries of the 1995 RUs and the estimate of the species' range extent were based on the best information available when the Recovery Plan was written. Since 1995, additional information has clarified the expected extent of the species' range and led to changes in U.S. EMU boundaries. These changes are discussed below.

a. United States

In the following sections, we describe dominant physical and biotic characteristics, patterns of owl distribution and habitat use, and the dominant patterns of land ownership and land use within each EMU. We primarily emphasize the U.S. portion of the owl range, with briefer discussion of the Mexico portion. To assist with the transition from the 1995 Recovery Plan to this new version, each narrative starts with a brief description of the changes to the EMU configuration since 1995.

We identified the five EMUs based on the following considerations (in order of importance):

1) physiographic provinces;
2) biotic regimes;
3) perceived threats to owls or their habitat;
4) administrative boundaries; and,
5) known patterns of owl distribution.

It is important to note that owl distributional patterns were a minor consideration in EMU delineation, and EMUs do not necessarily represent discrete populations of owls. In fact, movement of individuals between EMUs has been documented (Ganey and Dick 1995). We used four major physiographic provinces in delineating EMUs in the U.S.: the Colorado Plateau, Basin and Range, Southern Rocky Mountains, and Upper Gila Mountains (Wilson 1962, Bailey 1980). We considered both administrative boundaries of Federal agencies and locations of major highways to simplify implementation of the Recovery Plan for the Working Teams described above.

Figure II.1. Ecological Management Units for the Mexican spotted owl in the southwestern United States.

i. Colorado Plateau (CP)

In this revision of the 1995 Recovery Plan, we have significantly enlarged the CP EMU (Fig. II.2). We moved the eastern boundary farther east to approximate a physiographic province line in Colorado. We based this change on our premise that the EMUs should reflect areas of similar habitat, if possible. We moved the northern extent of the EMU to include known owls at Dinosaur National Monument and in similar canyon habitats nearby.

The CP EMU roughly coincides with the Colorado Plateau Physiographic Province (Bailey 1980), with the exception that the southern end of the plateau is included in the Upper Gila Mountains EMU (see below). This EMU includes most of eastern and southern Utah plus portions of northern Arizona, northwestern New Mexico, and western Colorado. Major landforms are interior basins and high plateaus dissected by deep canyons, including the canyons of the Colorado River and its tributaries (Williams 1986).

Grasslands and shrubsteppes dominate the CP EMU at lower elevations, with woodlands and forests predominant at higher elevations (Bailey 1980, West 1983). Pinyon pine and various juniper species are the primary tree types in the woodland zone (see Appendix I for scientific names of tree species). A montane zone extends over areas on the high plateaus and mountains (Bailey 1980). Forest types in this zone include ponderosa pine, mixed-conifer, and spruce-fir. Conifers may extend to lower elevations in canyons. Deciduous woody species dominate riparian communities found along streams.

Figure II.2 illustrates the currently known distribution of Mexican spotted owls in this EMU; the owl reaches the northern limit of its documented range here. Owl habitat appears to be naturally fragmented in this EMU, with most owls found in disjunct canyon systems or on isolated mountain ranges in wilderness and roadless areas. In Utah, breeding owls primarily inhabit deep, steep-walled canyons and hanging canyons. These canyons typically are surrounded by terrain that does not appear to provide nest/roost habitat but may provide foraging habitat for owls (Willey 1993). Owls also apparently prefer canyon terrain in southwestern Colorado, such as the known owl locations in and around Mesa Verde National Park. In northern Arizona and northwest New Mexico, owls have been reported in both canyon and montane forest situations (Ganey and Dick 1995).

Looking solely at land ownership, and not at presumed owl habitat, Federal lands account for 46% of the CP EMU (Table G.2, Fig. II.2). Tribal lands collectively total 27%, with the largest tribal entity being the Navajo Nation. Private ownership accounts for 19%, and state lands 4%. Approximately 15% of all known owl sites recorded since 1989 occur in the CP EMU. Of the 206 owl sites documented for this EMU (Table II.1), most have been located on NPS-administered lands (64%), followed by BLM-administered lands (22%), and then FS-administered lands (13.5%; Appendix B, Table B.1). One owl site has been documented on Utah Division of Wildlife Resources (UDWR) lands and an unknown number occur on tribal lands.

Recreation ranks as a primary land use within the CP EMU because of high recreation pressure on public lands. The potential for recreation to affect owl presence and recovery is compounded by the terrain, with owls established in narrow canyons having less opportunity to move away

from human activity. Activities such as hiking, camping, hunting, rock climbing, mountain biking, and off-road vehicle (OHV) use occur in owl habitat within the EMU. Forest and fire management are important land activities on FS-administered, NPS-administered, and Tribal lands. In addition, commercial enterprises take place in the EMU; particularly important are livestock grazing, timber cutting, coal and uranium mining, and oil and natural gas development. Clearing of vegetation and human disturbance are coincident with these activities and have the potential to impact owls here.

ii. Southern Rocky Mountains (SRM)

We made two principal changes to the SRM EMU in this revision. First, we merged the former SRM – Colorado and the SRM – New Mexico EMUs (Fig. II.3). This change was deemed appropriate because management of owls and their habitat did not differ significantly between the two states, and the habitat is similar enough to allow managers to find common solutions to owl-management issues. Second, we adjusted the new boundary on the western extent to better follow ecological breaks in habitat between the SRM and CP EMUs.

The SRM EMU falls partly within the Southern Rocky Mountains Physiographic Province and partly within the Colorado Plateau Ecoregion (Bailey 1980). Mountain ranges characterize the EMU. Vegetation varies from grasslands at low elevations through pinyon-juniper woodlands, interior shrublands, ponderosa pine, mixed-conifer and spruce-fir forests, to alpine tundra on the highest peaks (Daubenmire 1943).

This EMU boundary extends almost to the Wyoming state line based on historical owl records and similarity of habitat (Webb 1983); further owl surveys would help define a more ecologically appropriate range delineation here. Though found primarily in canyons in this EMU, the owls also occupy forest habitat types. The canyon habitat often has mature Douglas-fir, white fir, and ponderosa pine in canyon bottoms and on the north- and east-facing slopes. Ponderosa pine grows on the more xeric south and west-facing slopes, with pinyon-juniper growing on the mesa tops.

Federal lands encompass 50% of the SRM EMU, with the majority administered by the FS, followed by the BLM, and NPS (Table G.2 and Fig. II.3). Approximately 43% is private lands, 4% is state lands, and 3% is Tribal lands. Approximately 6% of all Mexican spotted owl sites occur in SRM EMU (Table II.1; Appendix B, Table B.1). Most of the 74 owl sites reported for this EMU were documented on FS-administered lands (79.7%), followed by BLM-administered lands (13.5%) and NPS-adminstered lands (4.1%). Two sites are known for privately owned lands (Appendix B, Table B.1). We do not know how many occur on Tribal lands.

Land-use practices throughout the SRM EMU include recreation, ecological restoration, firewood cutting, livestock production, mining, forest fuels management, and energy development, including the associated human presence and development that are coincident with these uses. Recreational activities such as off-road driving and rock climbing could result in disturbance as well. Transportation and urban development are also considered likely threats to owl habitat in the SRM EMU. In particular, urban development along the Front Range of Colorado may threaten owl wintering habitat.

iii. Upper Gila Mountains (UGM)

We did not deem any changes necessary to the configuration of the UGM EMU in this revision.

The UGM EMU (Fig. II.4) is based primarily on the Upper Gila Mountains Forest Province (Bailey 1980), but also includes the southern end of the Colorado Plateau Ecoregion. Williams (1986) refers to this area as the Datil-Mogollon Section, part of a physiographic subdivision transitional between the Basin and Range and Colorado Plateau Provinces. This complex area consists of steep mountains and deep, entrenched river drainages dissecting high plateaus. The Mogollon Rim, a prominent fault scarp, bisects the UGM EMU.

McLaughlin (1986) described a "Mogollon" floral element in this region. The vegetation ranges from grasslands at lower elevations through pinyon-juniper woodlands, ponderosa pine, mixed-conifer, and spruce-fir forests at higher elevations. Many canyons contain stringers of deciduous riparian forests, particularly at low and middle elevations. The UGM EMU contains the largest contiguous ponderosa pine forest in North America, an unbroken band of forest 40- to 64-km (25- to 40-mi) wide and approximately 483-km (300-mi) long extending from north-central Arizona to west-central New Mexico (Cooper 1960).

Mexican spotted owls are widely distributed and use a variety of habitats within the UGM EMU, but are most common in mixed-conifer forests dominated by Douglas-fir and/or white fir and canyons with varying degrees of forest cover (Ganey and Balda 1989a, Ganey and Dick 1995, Ward et al. 1995). Owls also occur in ponderosa pine-Gambel oak forest, where they are typically found in stands containing well-developed understories of Gambel oak (Ganey and Dick 1995, Ganey et al. 1999). Ganey et al. (2011) summarized our current knowledge of spotted owls in this EMU in greater detail.

Federal lands, mostly FS, encompass 67% of the UGM EMU (Table G.2 and Fig. II.4). Tribal lands account for 17%, privately owned lands 12%, and state lands 4%. The largest known population of Mexican spotted owls occurs in this EMU, accounting for approximately 52% of all known owl sites (Table II.1; Appendix B, Table B.1). Of the 688 known owl sites in this EMU, 684 are designated on FS-administered lands and 4 are designated on NPS-adminstered lands. Many Mexican spotted owls are found in wilderness areas in this EMU; the Gila Wilderness supports the largest known wilderness population (Ganey et al. 2008). An unknown number of owl sites occur on tribal lands.

Major land uses within the UGM EMU include fuels reduction, ecological restoration, livestock production, and recreation. Timber and fuelwood harvest, for both personal and commercial use, occurs across much of the UGM EMU. Livestock grazing is common on FS-administered lands and large portions of Fort Apache and San Carlos tribal lands. In addition, recreational activities such as OHV use, hiking, camping, and hunting attract many people to this EMU.

iv. Basin and Range-West (BRW)

We made one significant change to the BRW EMU in this revision. Because the southwestern extent of the previous BRW EMU included large areas that did not provide Mexican spotted owl

habitat, we modified the EMU boundary to omit this area (Fig. II.5). For convenience, we used highways to define the new southwestern boundary. This boundary does not necessarily denote the true ecological extent of owl occurrence, but the boundary does encompass all recorded owl locations.

The Basin and Range Area Province (Bailey 1980) provided the basis for delineating two EMUs. We subdivided the Basin and Range area into eastern and western EMUs using the Continental Divide as the partition. We based the division on differences in climatic and floristic characteristics between these areas. The BRW EMU flora is dominated by Madrean elements, while the BRE EMU shows more Rocky Mountain affinities (Brown et al. 1980, Dick-Peddie 1993).

Geologically, the BRW EMU exhibits numerous fault-block mountains separated by valleys (Wilson 1962). Complex faulting and canyon carving define the physical landscape within these mountains. Vegetation transitions from desert scrubland and semi-desert grassland in the valleys upward to montane forests. Montane vegetation includes interior chaparral, encinal (evergreen oak) woodlands, and Madrean pine-oak woodlands at low and middle elevations, with ponderosa pine, mixed-conifer, and spruce-fir forests at higher elevations (Brown et al. 1980). Isolated mountain ranges are surrounded by Sonoran and Chihuahuan desert basins.

Mexican spotted owls occupy a wide range of habitat types within the BRW EMU. The majority of owls occur in isolated mountain ranges where they inhabit encinal oak woodlands; mixed-conifer, pine-oak, riparian forests; and, rocky canyons (Ganey and Balda 1989a, Duncan and Taiz 1992, Ganey et al. 1992, Ganey and Dick 1995).

Federal lands encompass 40% of the BRW EMU, mostly administered by the FS followed by the BLM and a small portion by Department of Defense (DoD) and NPS (Table G.2 and Fig. II.5). Privately owned lands amount to 27%, State lands 25%, and Tribal lands (mainly the San Carlos Apache Reservation) 7%. Approximately 13% of all owl sites documented for the U.S. are found within this EMU (Table II.1). Of the 174 owl sites in this EMU, most occur on FS-administered lands (89%), and the majority of these sites occur in the Coronado National Forest within wilderness. There are 11 owl sites designated on DoD lands on Fort Huachuca and eight sites designated on NPS-administered lands (Appendix B, Table B.1). An unknown number of owl sites occur on tribal lands.

Recreation dominates land use within the BRW EMU. Activities such as hiking, bird-watching, camping, off-road driving, and hunting are particularly popular. Livestock grazing is widespread, but it is most intensive at low and middle elevations. Urban and rural development and mining activities occur in portions of the EMU. Timber harvest occurs mainly on the San Carlos Apache Indian Reservation. The Coronado, Prescott, and Tonto national forests have active fuels-reduction and forest-management programs in place to reduce fire hazard, implement ecological restoration, and provide community protection. Military training maneuvers take place in and around Mexican spotted owl habitat on the Fort Huachuca Army Base.

v. Basin and Range-East (BRE)

We extended the southeastern boundary of the BRE EMU to incorporate portions of West Texas. This change was based primarily on recent sightings of Mexican spotted owls in the Davis and Chisos mountains of Texas (Bryan and Karges 2001, J. P. Ward, unpubl. data). There also are unverified sightings of *Strix* owls in and near Big Bend National Park, and there may be potential owl habitat along the Rio Grande in that area that has not been effectively surveyed for owls (Peterson and Zimmer 1998).

We delineated the BRE EMU (Fig. II.6) based on the Basin and Range Area Province and the Desert and Steppic Ecoregions (Bailey 1980). This EMU is characterized by numerous parallel mountain ranges separated by alluvial valleys and broad, flat basins. The climate features mild winters, as indicated by the presence of broad-leaved evergreen plants at relatively high elevations (USDA FS 1991).

Regional vegetation transitions from Chihuahuan desert scrubland and Great Basin grasslands at lower elevations, through Great Basin woodland (pinyon-juniper) at middle elevations, to petran montane coniferous forests at high elevations (Brown et al. 1980, Dick-Peddie 1993). Montane habitat includes ponderosa pine, mixed-conifer, Madrean pine-oak, and spruce-fir forests and is patchily distributed throughout the higher mountain ranges. Cottonwood bosques as well as other riparian vegetation exist along the Rio Grande corridor. Montane and especially riparian plant communities have been altered considerably by human activities.

Mexican spotted owls occur in the isolated mountain ranges and in deep reticulated canyons scattered across this EMU. They are most common in mixed-conifer forest but are also found in ponderosa pine and Madrean pine-oak forests, riparian habitats, and pinyon-juniper woodland (Skaggs and Raitt 1988, Ward et al. 1995, Bryan and Karges 2001, Mullet 2008). The owl has been found within mixed-conifer and deep rocky canyon habitat in Guadalupe Mountains National Park (McDonald et al. 1991, Mullett 2008).

Of the BRE EMU land area, Federal lands comprise 35%, private lands 38%, State lands 13%, and Tribal lands 4% (Table G.2 and Fig. II.6). Approximately 14% of all owl sites reported for U.S. lands occur in the BRE EMU (Appendix B, Table B.1). Of the 182 known sites recorded for this EMU (Table II.1), most occur on FS-administered lands (82.9%) and are primarily concentrated in the Sacramento Mountains in the Lincoln National Forest in New Mexico. Another 14.2% of these sites are on NPS-administered lands (Appendix B, Table B.1). Five sites are on private lands, primarily The Nature Conservancy, and an unknown number occur on tribal lands.

Dominant land uses within the BRE EMU include forest management and livestock grazing. Recreational activities such as off-road driving, skiing, hiking, camping, and hunting also are locally common within this EMU.

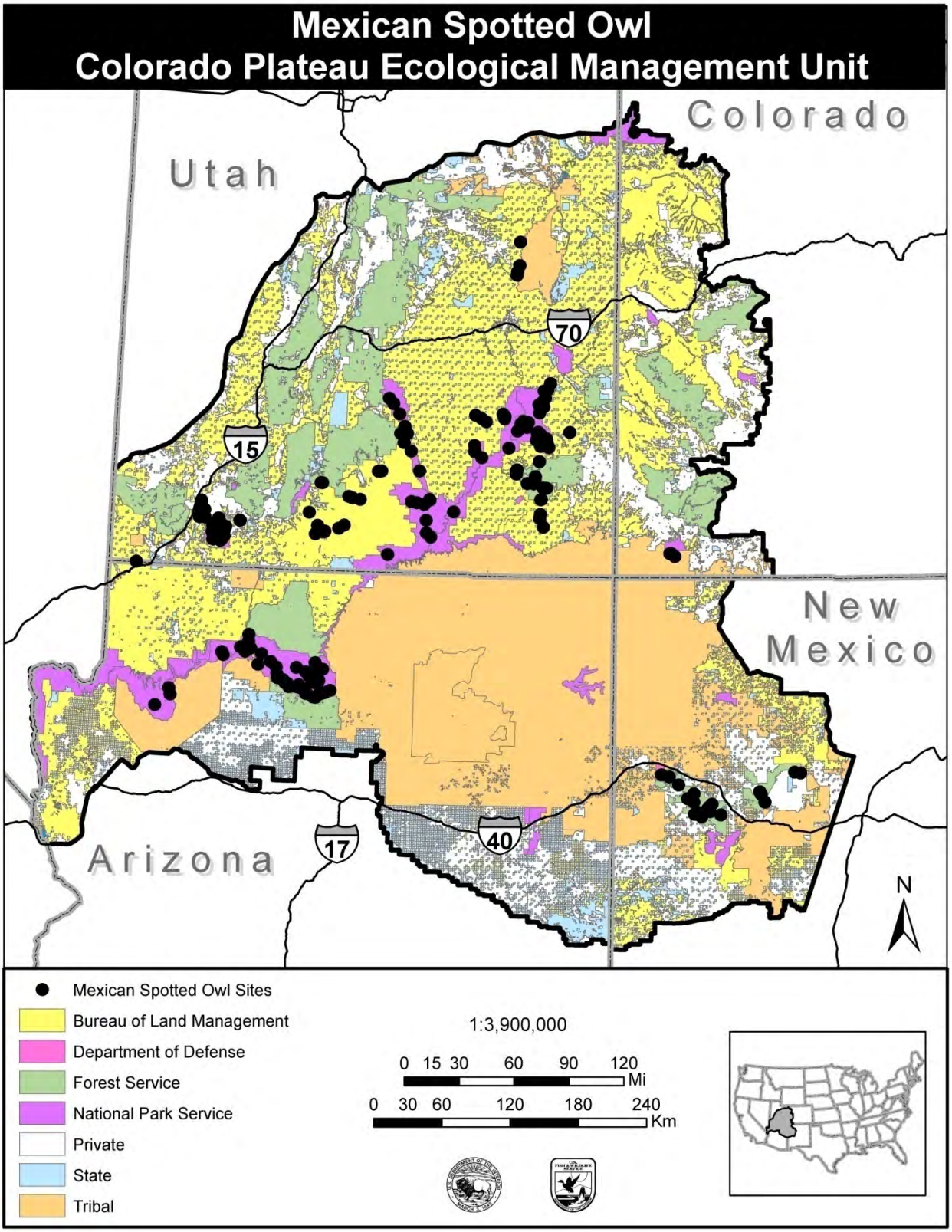

Figure II.2. Colorado Plateau Ecological Management Unit for the Mexican spotted owl in the southwestern United States. The lack of mapped sites within potential owl habitat is an artifact of a lack of data and does not necessarily indicate absence of owl sites.

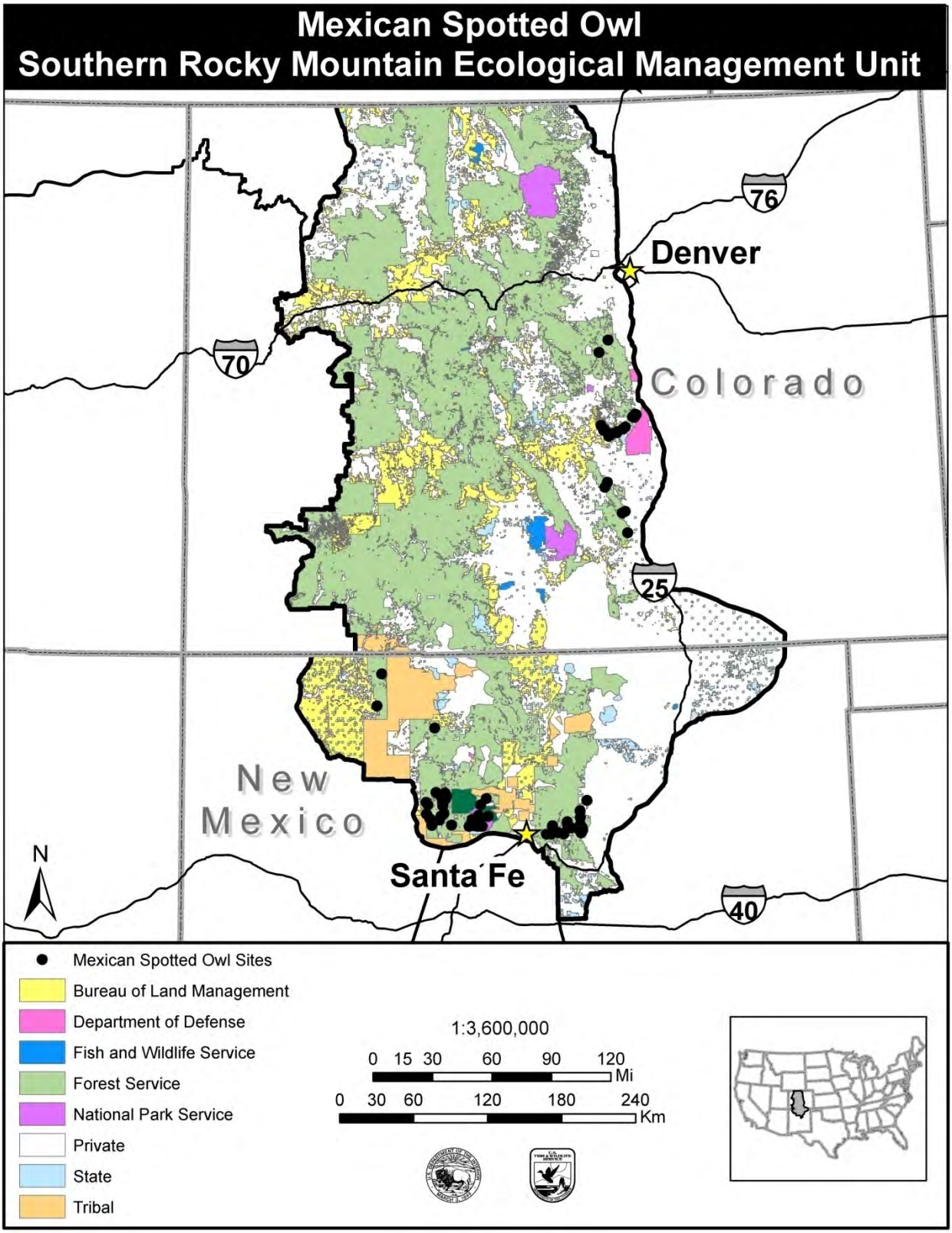

Figure II.3. Southern Rocky Mountains Ecological Management Unit for the Mexican spotted owl in the southwestern United States. The lack of mapped sites within potential owl habitat is an artifact of a lack of data and does not necessarily indicate absence of owls sites.

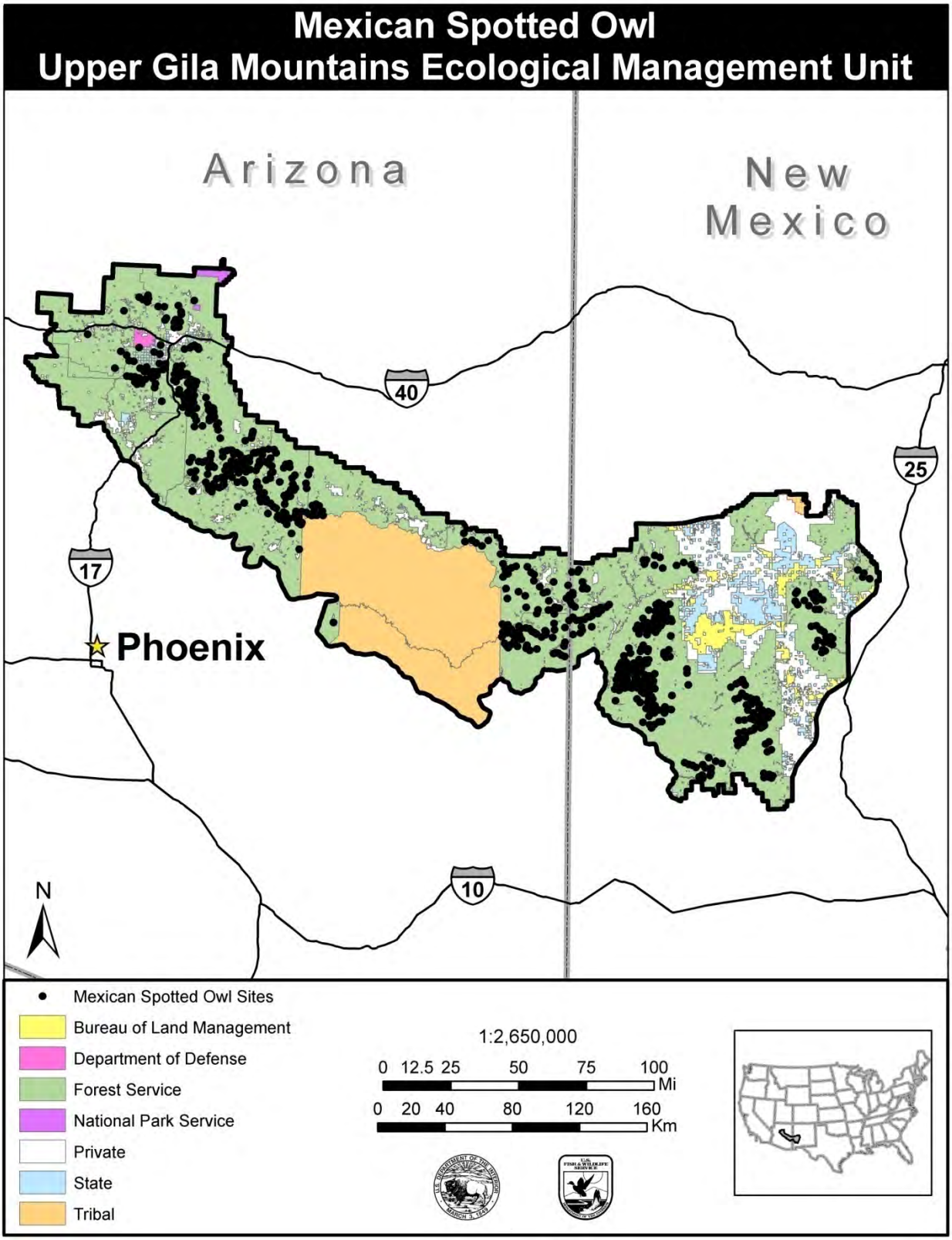

Figure II.4. Upper Gila Mountains Ecological Management Unit for the Mexican spotted owl in the southwestern United States. The lack of mapped sites within potential owl habitat is an artifact of a lack of data and does not necessarily indicate absence of owl sites.

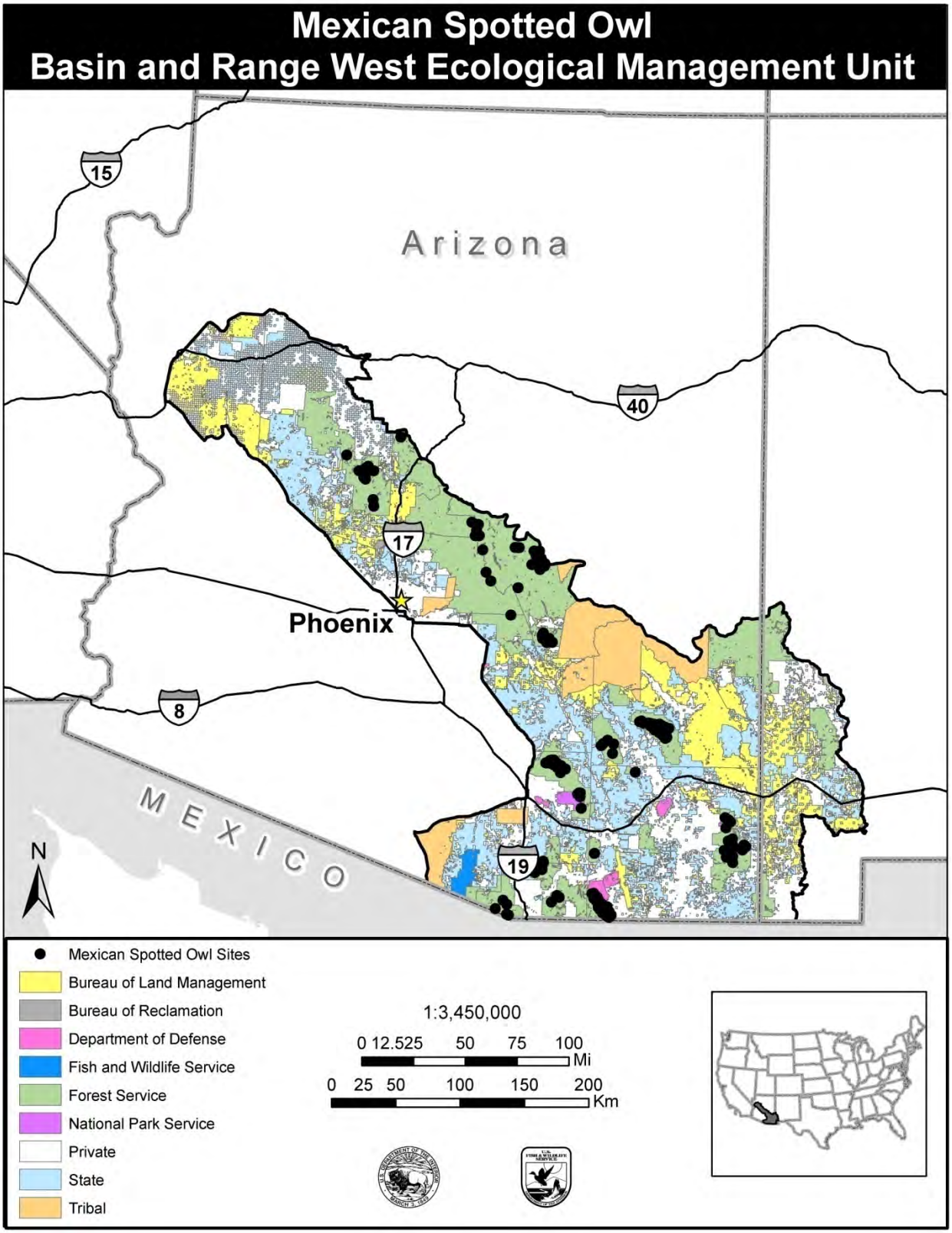

Figure II.5. Basin and Range-West Ecological Management Unit for the Mexican spotted owl in the southwestern United States. The lack of mapped sites within potential owl habitat is an artifact of a lack of data and does not necessarily indicate absence of owl sites.

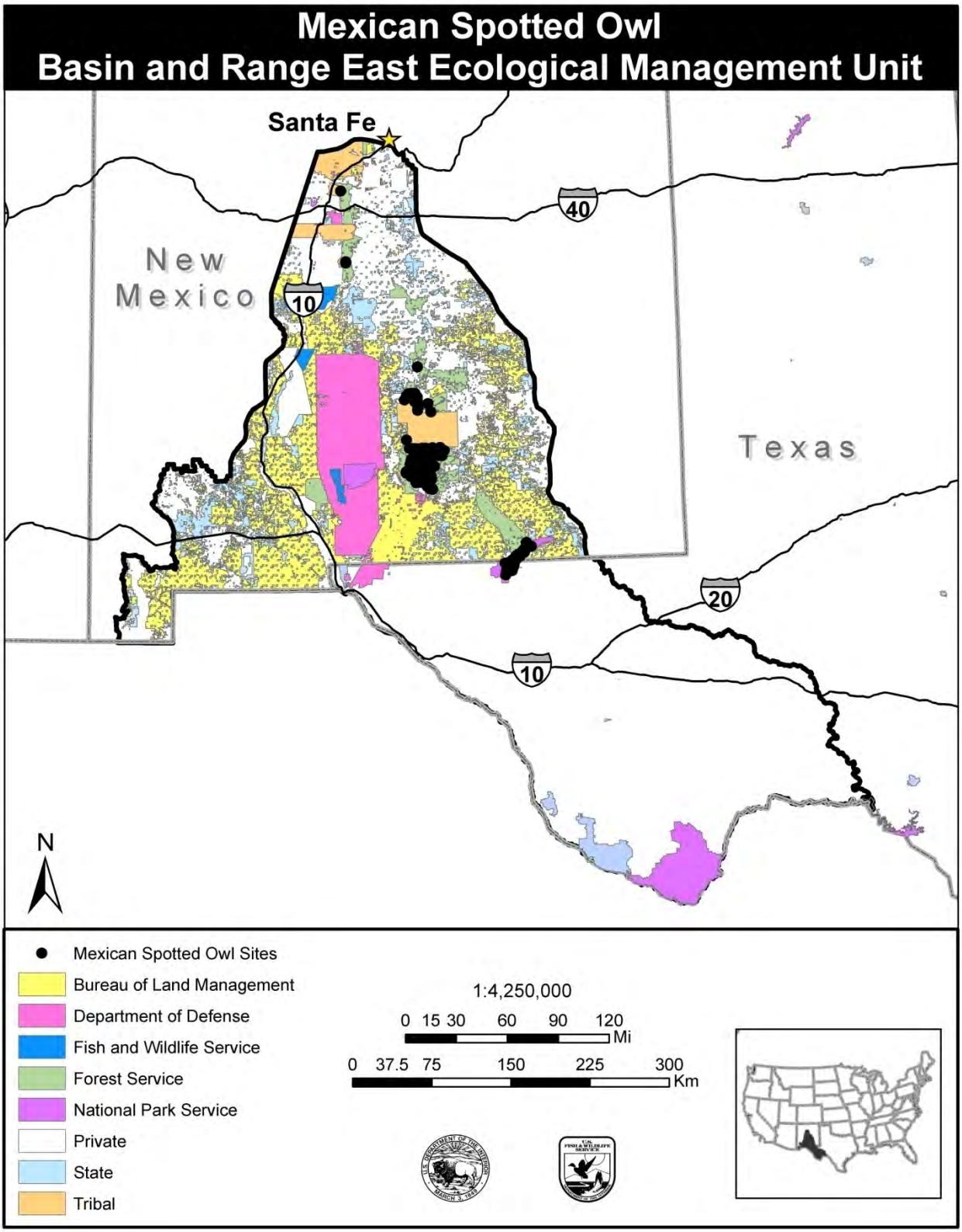

Figure II.6. Basin and Range-East Ecological Management Unit for the Mexican spotted owl in the southwestern United States. The lack of mapped sites within potential owl habitat is an artifact of a lack of data and does not necessarily indicate absence of owl sites.

b. Mexico

The five EMUs in Mexico include: Sierra Madre Occidental – Norte; Sierra Madre Oriental – Norte; Sierra Madre Occidental – Sur; Sierra Madre Oriental – Sur; and Eje Neovolcanico (Fig. II.7). We used three major physiographic provinces in the delineation: Sierra Madre Occidental, Sierra Madre Oriental, and Sistema Volcanico Transversal (Cuanalo et al. 1989). Criteria we used to delineate EMUs in Mexico were similar to those used in the U.S. These criteria, listed in order of importance, were:

1) distribution of the Mexican spotted owl;
2) local vegetation;
3) physiographic features;
4) administrative boundaries; and,
5) potential threats to the conservation of the owl and its habitat.

Mexican spotted owl distribution is disjunct across Mexico. Williams and Skaggs (1993) located Mexican spotted owls at 53 locations in 11 mainland Mexican States. These were partitioned by Ward et al. (1995) into 35 historical (pre-1989) and 18 current (since 1989) locations (see Young 1996 for additional sites discovered in the Mexican State of Chihuahua). Although vegetation types differ throughout each EMU, oak and pine-oak forest types appear to be commonly associated with owl habitat in most or all EMUs. These oak species include *Quercus resinosa* (no common name), Gentry's oak, Mexican red oak, gray oak, Chihuahua oak, Mexican white oak, and red oak. Aztec pine is the most common pine species occurring on upper mesas and occasionally on north-facing slopes in some areas where owls are found. Land uses within all EMUs include timber cutting, cattle and sheep grazing, fuelwood gathering, and clearing forested areas for agriculture. Although these land uses are practiced at different degrees throughout each EMU, the majority occur within ejidos (communally-operated land).

Several Natural Protected Areas (Áreas Naturales Protegidas) in Mexico have records of this species (Table G.3) and others have potential habitat but no records of Mexican spotted owls (Table G.4). The Zona Sujeta a Conservación Ecológica "Sierra Fría" in Aguascalientes is a state-protected area where pairs of owls have been documented in six different localities: Barranca El Tiznado, Cueva Prieta, El Carrizal, El Pinal, El Tejamanil, and La Angostura. Because nests have not been found, it is unclear if the Mexican spotted owl nests in the Zona Sujeta a Conservación Ecológica (Márquez-Olivas et al. 2002).

There are also records of Mexican spotted owls in the Reserva de la Biosfera de la Michilía, a federally protected area in southeastern Durango. According to Garza-Herrera (1999), the species distribution in this Reserve is above 2,330 m (7,700 ft) in conifer and pine-oak forest. He also mentions a crude density of 0.054 owls/km^2 (0.021 owls/mi^2), which is lower than previously reported elsewhere in its range (0.105 to 0.273 owls/km^2, or 0.041 to 0.105 owls/mi^2; Garza-Herrera 1999).

The following narratives describe dominant physical and biotic attributes, distribution of owls, and land administration and ownership of each unit. Where available, we provide a brief description of potential threats to the owl.

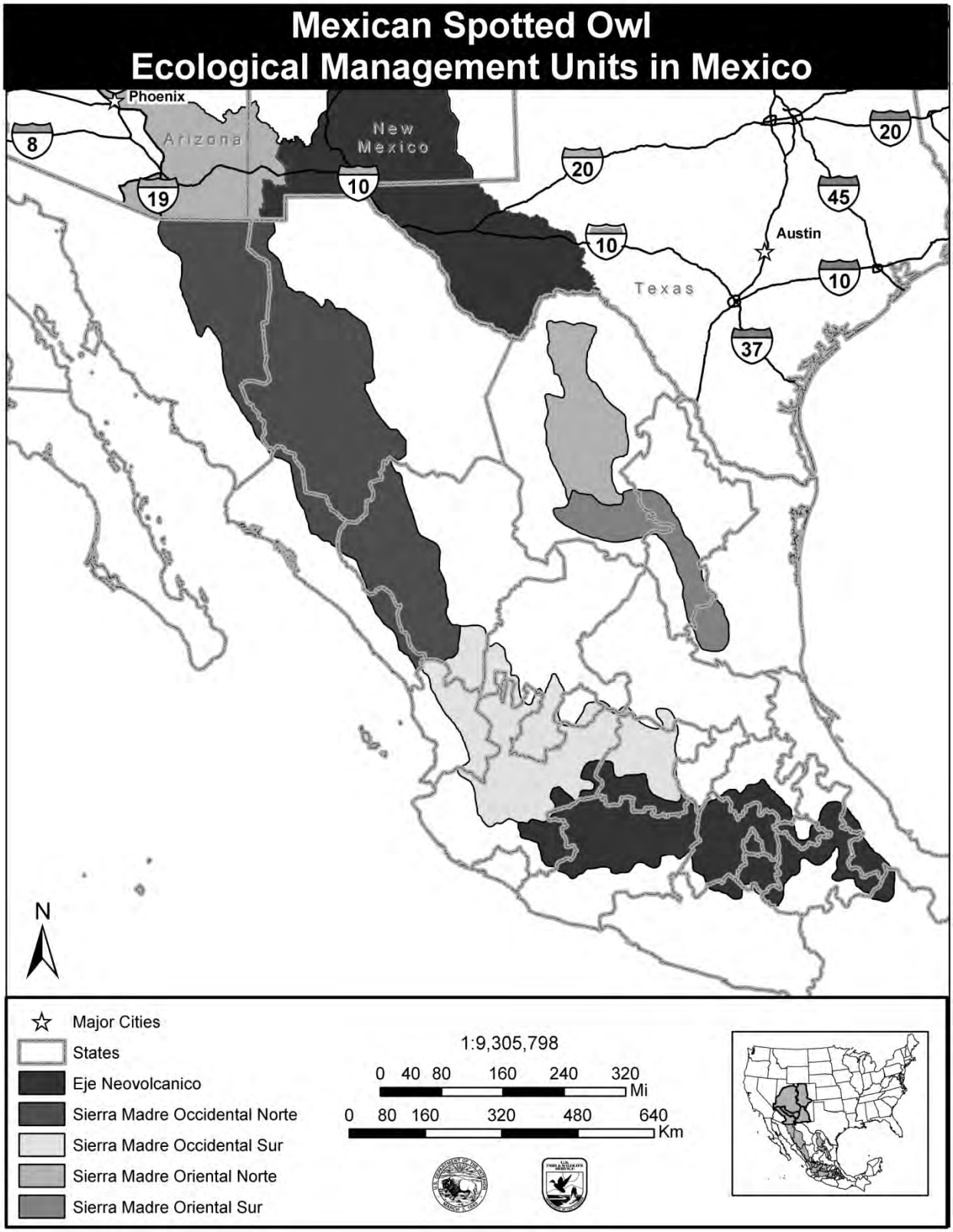

Figure II.7. Ecological Management Units for the Mexican spotted owl in Mexico (showing adjacent U.S. EMUs for reference).

i. Sierra Madre Occidental-Norte

Covering an enormous area, the Sierra Madre Occidental - Norte includes parts of the States of Chihuahua, Sinaloa, Durango, and Sonora. In general, this area is characterized by isolated mountain ranges surrounded by both narrow and wide valleys. Vegetation communities consist of pine-oak forest, tropical deciduous forest, oak forest, microphyll shrub, and grassland.

Mexican spotted owls have been reported in the northern and western portions of this EMU. A recent study in Sonora found 12 locations in isolated mountain ranges (Cirett-Galan and Diaz 1993). The owls occupied canyons and slopes with various exposures, and most were found in pine-oak forest. In portions of Chihuahua, 25 owls were located at 13 different localities in several mountain ranges (Tarango et al. 1997). Most owls were found in small, isolated patches of pine-oak forest in canyons. Records for the State of Sinaloa are limited. There are at least two records from the high-elevation Rancho Liebre Barranca, near the Sinaloa-Durango state boundaries (Williams and Skaggs 1993). These sites were described as deep canyons containing pine-oak and subtropical vegetation (Alden 1969).

A study by CONANP (National Commission on Natural Protected Areas) and Pronatura Sur in 2008 concluded that large-scale logging operations in the Sierra Madre Occidental have significantly reduced pine forest coverage to supply paper and to clear forests in order to reduce the risk of wildland fires and the spread of pests (CONANP-Pronatura Sur 2008). These studies from the Sierra Madre Occidental have not quantified the exact amount of forest lost to these operations. However, it is believed that from 1976-2000, temperate forest in Mexico was being lost at a rate of 0.25%, or about 86,718 ha (214,285 ac) per year (Bray et al. 2007). Several researchers also have suggested that the clearing of trees, especially cutting of mature forests, has resulted in the disappearance of the imperial woodpecker and declines in western thick-billed parrot (CONANP-Pronatura Sur 2008). Other recent analysis suggests that throughout Mexico, current pine forest cover consists of 75% of the potential original distribution, and that 48.4% of the remaining pine forests are "well-conserved" (CONABIO 2008).

ii. Sierra Madre Oriental-Norte

The Sierra Madre Oriental-Norte includes the central portion of the State of Coahuila. This area is characterized by broad mountain ranges surrounded by valleys. Vegetation consists of grasslands, mesquite woodland, dwarf oak groves, submontane shrubland, desert shrubland, crasicaule shrub, and pine-oak and oak forests.

Two owl records are reported for this EMU. At one of these locations an owl was observed roosting in a canyon bottom under a dense canopy of maples and oaks. Vegetation in the other canyon was described as "garden-like," containing pines, oaks, and madrones (Williams and Skaggs 1993).

iii. Sierra Madre Occidental-Sur

The Sierra Madre Occidental-Sur EMU includes parts of the States of Durango, Zacatecas, San Luis Potosi, Aguascalientes, Jalisco, Nayarit, Queretaro, and Guanajuato. In general, this area is characterized by isolated mountains, valleys, and severely dissected canyons and gorges. Vegetation includes mesquite woodland, submontane shrub, grasslands, pine-oak forest, crasicaule shrub, low tropical deciduous forest, and desert shrubland.

Records exist for Mexican spotted owls in La Michilia Biosphere Reserve. In addition, Mexican spotted owls have been found in Aguascalientes near the border of Zacatecas, in the Sierra Fria (Williams and Skaggs 1993, Márquez-Olivas et al. 2002), and in Zacatecas State near Valparaiso (Bravo-Vinaja et al. 2005). Owl records also exist within Guanajuato State. Logging is prohibited in Sierra Fría and security guards inspect every vehicle driving through the area to stop illegal timber harvest as part of the protected area management (Tarango et al. 2001).

iv. Sierra Madre Oriental-Sur

The Sierra Madre Oriental - Sur includes parts of the States of Coahuila, Nuevo Leon, and Tamaulipas. This EMU is characterized by long ridges with sharp pinnacles, narrow valleys, and a few plateaus. Vegetation consists of pine, pine-oak, and mixed conifer forests, submontane shrublands, dwarf oak, and desert rosetofilo shrublands.

Mexican spotted owls have been found in the southern portions of the northern states of Coahuila (Williams and Skaggs 1993) and Tamaulipas (Ward et al. 1995). The owls were found in oak, pine, juniper, and mixed-conifer forests. They were reported to use cliff sites for nesting and roosting. Five locations have been reported in Nuevo Leon. These locations were described as pine-oak and mixed-conifer forests with large cliffs having northeast exposures.

In the Sierra Madre Oriental, devastating wildland fires have resulted in the loss of old-growth forests. Within natural protected areas, management actions to prevent wildland fires have promoted the heavy accumulation of coarse woody debris. This situation has generated several problems in Mexico in recent years; during 2011 more than 424,000 ha (1,047,727 ac) were burned by fires just in Coahuila, and in Chihuahua, 1,680 fires burned 87,888 ha (217,176 ac), just to mention the most affected states in Mexico (CONAFOR 2011). The spread of bark beetles during the dry season has also increased the wildland fire risk. In 2006, 200 ha (494 ac) of mature forest were lost in El Taray, and in 2008, 400 ha (988 ac) were lost in the Municipio de Santiago Nuevo León (CONANP-Pronatura Noreste 2008). These mature forests areas must be maintained if biodiversity in the Eastern Sierra Madre, including the Mexican spotted owl, is to be protected.

v. Eje Neovolvanico

The Eje Neovolcanico EMU covers portions of the States of Jalisco, Michoacan, Guanajuato, Queretaro, Hidalgo, Guerrero, Puebla, Morelaos, Tlaxcala Veracruz, Oaxaca, and Mexico City. This EMU is characterized by volcanic cones severely dissected by ravines. The EMU also includes rounded hills, slopes, and plateaus. Vegetation communities include pine-oak forest,

grassland, low tropical deciduous forest, crasicaule shrub, oak forest, juniper forest, pine forest, mesquite woodlands, and desert shrublands.

Mexican spotted owls have been reported in Jalisco on the volcano of Cerro Nevado de Colima (Voacan de Nieve). Vegetation in this area consists of pine-oak forest. One Mexican spotted owl was collected near the city of Uruapan in the State of Michoacan at Cerro de Tancitaro. However, this area is now developed and no longer contains owl habitat. Although other states in this EMU appear to contain suitable owl habitat, Jalisco is the only state known to have recent records of Mexican spotted owls.

In this EMU, increased habitat modifications in proximity to urban areas pose threats to the owl (Navarro-Sigüenza et al. 2007). Human overpopulation and associated activities such as agriculture, cattle production, and other land-uses threaten native species (Navarro-Sigüenza et al. 2007). This area also faces deforestation, illegal mining, illegal hunting and poaching, burning of natural vegetation to increase cattle forage, and wildland fires by arson, all of which increase threats to the Mexican spotted owl (Navarro-Sigüenza et al. 2007).

Table II.1. Known Mexican spotted owl sites in the United States and in Mexico by EMU as of 2011.

Ecological Management Area	Number of Owl Sites	Percent of Total Sites
	United States	
UGM EMU	688 sites	52%
CP EMU	206 sites	15.6%
BRE EMU	182 sites	13.7%
BRW EMU	174 sites	13.1%
SRM EMU	74 sites	5.6%
	Mexico	
Sierra Madre Occidental - Norte	27 sites	Unknown
Sierra Madre Oriental - Sur	5 sites	Unknown
Sierra Madre Oriental - Norte	2 sites	Unknown
Sierra Madre Occidental - Sur	extant	Unknown
Eje Neovolvanico	extant	Unknown
Total	**1,324 known sites in the U.S. 34+ known sites in Mexico**	

Figure II.8. Photograph illustrating Mexican spotted owl sites within the rocky-canyon habitat.

D. Habitat Use

Although Mexican spotted owls have been observed to nest, roost, forage, and disperse among a diverse array of biotic communities, the owl is typically considered a "habitat specialist" in that roost and nest habitats classically occur in late seral forests or rocky canyon habitats. Some Mexican spotted owls undergo altitudinal migrations during winter to areas where habitat structure and composition differ from that used during breeding (refer to Appendix B for a more comprehensive discussion).

1. Nesting and Roosting Habitat

Owls occur in both forested and rocky-canyon habitats. Forests used for roosting and nesting often contain mature or old-growth stands with complex structure (USDI FWS 1995:26). Forests used by spotted owls are typically uneven-aged, are multistoried, and have high canopy cover (USDI FWS 1995:27). In these areas, nest trees are typically large (average diameter of nest trees is 61cm [24 in]), although owls roost in both large and small trees (Ganey 1988, Seamans and Gutiérrez 1995, Willey 1998b, Ganey et al. 2000, May and Gutiérrez 2002, May et al. 2004). Tree species used for nesting vary somewhat among areas and cover types, but Douglas-fir is the most common nest tree in many areas (SWCA, Inc. 1992, Willey 1998b).

In parts of its range, the Mexican spotted owl occupies a variety of steep, rocky-canyon habitats (Ganey and Balda 1989b, Rinkevich and Gutiérrez 1996, Willey 1998a, Willey and Van Riper 2007). For example, the rocky-canyon habitats of Utah typically include landscapes with

complex tributary canyons, a variety of desert scrub and riparian vegetation communities (Brown et al. 1980), and prominent vertical cliffs (Rinkevich and Gutiérrez 1996, Willey 1998a, Willey et al. 2007, Mullet 2008). Within these canyons, owls nest in protected caves and roost in caves and on rocky ledges as well as in trees (Willey 1998a).

In northern New Mexico, the volcanic-tuff canyons of Bandelier National Monument also provide many pot-holes, ledges, and small caves for owls to use as daytime roosts and nests (Johnson and Johnson 1985). Mexican spotted owls also occur within the complex canyon networks of the Guadalupe Mountains in southern New Mexico and west Texas. Mullet and Ward (2010) quantified 21 microhabitat features surrounding known nest and roost sites to characterize conditions within canyon habitats in the Guadalupe Mountains. Mexican spotted owl nest and roost sites were associated with steep-walled and relatively narrow canyons, high canopy cover, saplings in the understory, and rocky outcrops.

2. Foraging Habitat

Mexican spotted owls appear to use a wider variety of cover types for foraging than for roosting or nesting (Ganey and Balda 1994, Ganey et al. 2003). Radio-marked owls in Arizona foraged more than expected (in relation to its proportion on the landscape) in unlogged forest (Ganey and Balda 1994), and Ward (2001) found that woodrats (an important prey item for Mexican spotted owls) were more abundant in late-seral mixed-conifer forests. However, owls forage in a variety of habitats: managed and unmanaged forests, pinyon-juniper woodlands, mixed-conifer and ponderosa pine forests, cliff faces and terraces between cliffs, and riparian zones (Ganey and Balda 1994, Willey 1998a,b; Ganey et al. 2003, Willey and Van Riper 2007).

3. Home Range and Territoriality

Mexican spotted owls are territorial in the sense that mated pairs defend a breeding territory within a larger home range (or use area). Fidelity to these territories is relatively high in Mexican spotted owls, with most owls remaining on the same territory year after year (Ganey 1988, Gutiérrez et al. 1995). Mexican spotted owls use relatively large home ranges, and home-range size appears to vary among geographic areas and habitats (Ganey and Balda 1989a, Zwank et al. 1994, Willey 1998b, Ganey et al. 2005, Willey and Van Riper 2007, Bowden 2008). Some of this variation may be due to differences in methods, but some of the observed variation is likely real. However, at this time, the relative influences of biogeographic regions versus local differences in habitat quality on home-range size of Mexican spotted owls remain unclear, although limited information suggests that local differences can be important (Ganey et al. 2005, see also Carey et al. 1992, Zabel et al. 1995).

4. Juvenile Dispersal

Mexican spotted owls appear to be obligate dispersers, with all juveniles dispersing from natal areas. Most radio-marked juvenile Mexican spotted owls were observed to disperse in September and October, with the majority dispersing in September (Arsenault et al. 1997, Ganey et al. 1998, Willey and Van Riper 2000). Like the other spotted owl subspecies, juvenile Mexican spotted owls are capable of moving long distances (Ganey et al. 1998, Willey and Van Riper 2000). Distance from the natal site to the last observed location for radio-marked juveniles observed by Ganey et al. (1998) ranged from 1 to 92 km (0.6. to 57 mi). However, based primarily on work on northern spotted owls (Forsman et al. 2002), we believe that most

successfully dispersing juveniles occupy territories near their natal territories. Juvenile Mexican spotted owls move through a wide variety of habitats during the dispersal period (Ganey and Block 2005b), and many of these habitats differ greatly from typical breeding habitat and have no formal protective measures under the 1995 Recovery Plan or this revision (i.e., they fall under the category of other forest and woodland types).

5. Migration and Wintering Areas

Although most radio-marked adult Mexican spotted owls have been found to remain on or near their breeding territory throughout the year, some territorial owls migrated during winter. This migration generally entailed a change in elevation as Mexican spotted owls moved down slope in winter (Willey 1998a, Ganey and Block 2005b). Migrating radio-marked owls typically left study areas in November or December and returned from January to April. Distances moved typically ranged from 5 to 50 km (3 to 31 mi), although Gutiérrez et al. (1996) recorded a color-banded adult moving >160 km (>99 mi) south of its breeding territory. At present, there is little information on specific habitat features that migratory Mexican spotted owls use in wintering areas. Further, wintering owls are unlikely to vocalize (Ganey 1990), thus reducing detection. Low winter detection rates make it difficult to locate migratory or wintering areas, and thus, we are left with no rigorous methods to identify such areas for protection (Ganey and Block 2005a). The types of lowland areas in which wintering owls have been observed cover vast areas, and we presently have no evidence that suitable wintering areas are limiting. Nevertheless, this is a topic on which further research would be valuable.

6. Key Habitat Variables

Throughout its lifetime, a Mexican spotted owl will use a variety of habitats to meet different life-history needs. To maintain a diversity of habitat types for the various activities of the owl, key habitat variables are required. These include nesting, roosting, and foraging habitat patches with structural, compositional, and successional diversity, as well as connectivity among suitable patches. Specifics regarding key habitat variables are found in Appendix C describing desired conditions.

E. Life History

1. Prey

Mexican spotted owls consume a variety of prey throughout their range. They commonly eat small- and medium-sized rodents such as woodrats, deer mice, pocket gophers, and voles, but they also consume bats, birds, reptiles, and arthropods (Ward and Block 1995). Their diet varies by geographic location (Ward and Block 1995). For example, Mexican spotted owls dwelling in canyons of the CP EMU take more woodrats and fewer birds than do spotted owls from other areas (Ward and Block 1995). In contrast, spotted owls occupying montane forests with forest-meadow interfaces, as found within the BRE EMU, consume more voles (Ward and Block 1995). Regional differences in the owl's diet likely reflect geographic variation in presence and population densities of prey and across owl habitats. Forsman et al. (2001) also documented spatial variation in a regional analysis of diets of northern spotted owls. For additional information on food habits and prey selection see Appendix B.

2. Reproductive History

Mexican spotted owls nest in caves, in stick nests built by other birds, on debris platforms in trees, and in tree cavities (Johnson and Johnson 1985, Ganey 1988, Gutiérrez et al. 1995, Seamans and Gutiérrez 1995, Johnson 1997, Willey 1998a). They do not build nests; instead they rely on existing structures. Spotted owls exhibit one of the lowest clutch sizes among North American owls (Johnsgard 1988, Gutiérrez et al. 1995). Females normally lay one to three eggs, two being most common, and four observed rarely (LaHaye 1997, Gutiérrez et al. 2003). Re-nesting following nest failure is uncommon, but has been observed (Kroel and Zwank 1992, Gutiérrez et al. 1995).

Knowledge of the annual reproductive cycle of the Mexican spotted owl is important both in an ecological context and for placing seasonal restrictions on management or on other activities that could disturb nesting owls. Mexican spotted owls have distinct annual breeding periods, with timing that may vary slightly throughout their range but is generally consistent overall. In Arizona, courtship begins in March with pairs roosting together during the day and calling to each other at dusk (Ganey 1988). Eggs are laid in late March or, more typically, early April. Incubation begins shortly after the first egg is laid, is performed entirely by the female, and lasts approximately 30 days. During incubation and the first half of the brooding period, the female leaves the nest only to defecate, regurgitate pellets, or to receive prey delivered by the male, who does most or all of the foraging (Forsman et al. 1984, Ganey 1988). Eggs usually hatch in early May (Ganey 1988). Females brood their young almost constantly for the first few weeks after the eggs hatch, but then begin to spend time hunting at night, leaving chicks unattended for up to several hours (Forsman et al. 1984, Delaney et al. 1999a). Nestling owls (owlets) generally fledge in early- to mid-June, four to five weeks after hatching (Ganey 1988). Owlets usually leave the nest before they can fly, jumping from the nest to surrounding tree branches or the ground (Forsman et al. 1984, Ganey 1988). Fledglings depend on their parents for food early in the fledgling period. Hungry fledglings give a persistent, raspy "begging call," especially when adults appear with food or call nearby (Forsman et al. 1984, Ganey 1988). Begging behavior declines in late August, but it may continue at low levels until dispersal occurs, usually from mid-September to early October (Arsenault et al. 1997, Ganey et al. 1998, Willey and Van Riper 2000).

Mexican spotted owls are sporadic breeders. Most of the population nests successfully in good years, whereas only a small proportion of pairs will nest successfully in poor years (Fletcher and Hollis 1994; Gutiérrez et al. 1995, 2003). This life history strategy allows owls to reproduce when conditions are favorable and to survive by reducing reproduction during unfavorable periods.

3. Fatality Factors

Several fatality factors have been identified as potentially important to the Mexican spotted owl, including predation, starvation, accidents, disease, and parasites. Although some owl carcasses have been found and examined by field biologists and laboratory personnel, most owls that die are not collected for sampling purposes. Even when dead owls are recovered, the cause of death is often difficult or impossible to determine because carcasses are often too decomposed. Consequently, we know little about the extent or relative importance of these fatality factors.

Predation. Mexican spotted owls are preyed upon by great horned owls, northern goshawks, red-tailed hawks, and golden eagles. Some of these predators occupy the same general habitats as the Mexican spotted owl, but there is little direct evidence that they prey on owls (Gutiérrez et al. 1995). Ganey (1988) reported one instance of apparent great horned owl predation on an adult spotted owl, but Ganey et al. (1997) did not document predation on Mexican spotted owls in a study involving radio-marked, sympatric spotted and great horned owls. We know of one report of a golden eagle preying on a Mexican spotted owl (R. Reynolds, RMRS, pers.comm.).

Starvation. When starvation occurs in resident adults, it is likely due to synchronous declines in prey populations which can result in impacts to a number of owls at one time. When low survival is combined with lack of reproduction, population decrease can be rapid. There is evidence that this occurs in some Mexican spotted owl populations (Seamans et al. 1999, Ward 2001, Gutiérrez et al. 2003). Starvation or hunger could predispose owls to accidents or predation if it drives them to hunt along roadsides or in other unfamiliar areas or in weakened condition.

Accidents. Instances of spotted owls being hit by cars have been documented (R. Skaggs, Glenwood, New Mexico, pers.comm.; R. Duncan, Southwestern Field Biologists, Tucson, Arizona, pers. comm.; S. Hedwall, FWS, pers. comm.; J. L Ganey, RMRS, unpubl.data). Roads involved in these accidents ranged from unpaved forest roads to paved highways. Owls flying at night also might collide with utility lines, tree branches, or other obstacles. This might be particularly true for birds migrating or dispersing through unfamiliar terrain (Martin 1986) or if new structures (such as fences) have been constructed since an owl occupied an area. Little information is available on how frequently collisions might occur or when they occur.

Research. Owl fatalities also can occur when capturing and handling owls for research purposes. Given the limited extent of research studies on Mexican spotted owls, such impacts are likely limited. Similarly, widespread inventory and monitoring surveys may impact Mexican spotted owl behavior to some unknown extent, but likely do not result in fatalities.

West Nile virus. Little is known about how disease and parasites contribute to fatality of spotted owls. One disease of particular concern is West Nile virus (WNV). This virus was first isolated in Africa, and it first appeared in the U.S. in 1999, in New York (see review in Blakesley et al. 2004). It spread rapidly across the country, and it has now reached the range of the Mexican spotted owl. Millions of birds have died from WNV since its arrival in the U.S., and all owl species appear to be susceptible (Fitzgerald et al. 2003, McLean 2006). The impact of WNV on Mexican spotted owls is difficult to ascertain. The WNV is an arbovirus that is transmitted primarily by mosquito vectors. In general, we know little about the abundance and behavior of

the relevant vectors in areas occupied by Mexican spotted owls. Thus, it is difficult to predict infection rates. We also do not know how many of the owls infected by WNV will die or suffer reduced viability, or whether or not owls develop some level of immunity to the disease following initial exposure. Recent surveillance in the Sierra Nevada of California failed to detect antibodies to WNV in California spotted owls (Hull et al. 2010). However, this could indicate lack of exposure, sampling error, or high mortality rates of infected individuals, leaving no survivors. Thus, all we can say with certainty at this time is that WNV occurs within the Mexican spotted owl's range, and it has the potential to impact population viability of the owls.

Competition. Several other species of owls occur within the range of the Mexican spotted owl. In general, we know little about potential competitive relationships among these owl species. Logically, the two species most likely to compete directly with Mexican spotted owls are the great horned owl and the barred owl, based on their relative size, natural history, and, in the case of the barred owl, genetic similarity. Throughout much of the range of the Mexican spotted owl, the most likely competitor is the great horned owl (Forsman et al. 1984, USDI FWS 1995). This owl is larger than the Mexican spotted owl, and is sympatric with Mexican spotted owls throughout their range, and both owls are active at night, suggesting that they could compete for nocturnally active prey (Gutiérrez et al. 1995, Houston et al. 1998, Ganey and Block 2005b).

F. Population Trends

Mexican spotted owl population trends remain unclear. However, Mexican spotted owl population size for a specific area and time can be modeled using the combined effects of births, deaths, immigration, and emigration, which influence the viability of the population and its long-term persistence. Because these owls are long-lived, population trend studies must be long-term (i.e., at least 10 years). Data on trends in populations or occupancy rates are few, and methods and sample sizes differ among studies, making comparisons difficult. However, results from these study areas have all noted that the study populations have declined in the recent past (Seamans et al. 1999, Stacey and Peery 2002, Gutiérrez et al. 2003). Further, range-wide conclusions cannot be reliably inferred from the limited data available.

Environmental conditions greatly affect reproduction and/or survival of Mexican spotted owls, and environmental variability across space and time is pronounced within the range of the Mexican spotted owl (Gutiérrez et al. 2003). Consequently, understanding how the owl responds to environmental variation is critical to its recovery. Despite concerted efforts to understand the influence of environmental variation on owl vital rates, considerable uncertainty remains. In general, temporal variation in owl vital rates appears to be influenced by climatic factors, especially precipitation. Because estimated vital rates appear responsive to precipitation several months prior to the estimation period, Gutiérrez et al. (2003) suggested that precipitation influences vital rates through an indirect mechanism. They further proposed that this mechanism might involve precipitation influencing primary productivity, prey population dynamics and, ultimately, owl vital rates. A greater understanding of these interactions will be required to project the effects of climate change on Mexican spotted owls. For detailed information regarding specific studies of population trends and factors affecting Mexican spotted owl populations, see Appendix B.

We have learned a great deal about the Mexican spotted owl in the last decade, but significant information gaps remain. Most studies of the owl have been descriptive rather than experimental. Although we have identified patterns with respect to some aspects of the owl's ecology (e.g., habitat use), cause and effect relationships have not been documented. Much more information is needed on how specific factors alone and in combination affect change in Mexican spotted owl abundance. These considerations suggest that additional research would contribute greatly to our understanding of the owl (see Part V.F), and that management recommendations in the near-term must deal with high levels of uncertainty.

G. Critical Habitat

On 31 August 2004, the FWS designated approximately 3.5 million ha (8.6 million ac) of critical habitat for the Mexican spotted owl on Federal lands in Arizona, Colorado, New Mexico, and Utah (69 FR 53181). Within the critical habitat boundaries, critical habitat includes only protected and restricted habitats as defined in the original Recovery Plan (USDI FWS 1995). Similarly, the primary constituent elements of critical habitat were listed as those habitat features recognized in the 1995 Recovery Plan as associated with Mexican spotted owl occupancy, as follows:

1. Primary Constituent Elements Related to Forest Structure:
    - A range of tree species, including mixed-conifer, pine-oak, and riparian forest types, composed of different tree sizes reflecting different ages of trees, 30-45% of which are large trees with a trunk diameter of ≥0.3 m (12 in) when measured at 1.4 m (4.5 ft) from the ground;
    - A shaded canopy created by the tree branches and foliage covering ≥40% of the ground; and,
    - Large, dead trees (i.e., snags) with a trunk diameter of at least 0.3 m (12 in) when measured at 1.4 m (4.5 ft) from the ground.

2. Primary Constituent Elements Related to Maintenance of Adequate Prey Species:
    - High volumes of fallen trees and other woody debris;
    - A wide range of tree and plant species, including hardwoods; and,
    - Adequate levels of residual plant cover to maintain fruits, seeds, and allow plant regeneration.

3. Primary Constituent Elements Related to Canyon Habitat (one or more of the following):
    - Presence of water (often providing cooler air temperature and often higher humidity than the surrounding areas);
    - Clumps or stringers of mixed-conifer, pine-oak, pinyon-juniper, and/or riparian vegetation;
    - Canyon walls containing crevices, ledges, or caves; and,
    - High percentage of ground litter and woody debris.

H. Threats and Threats Assessment

1. Reasons for Listing

The Mexican spotted owl, listed as a threatened species under the ESA in 1993 (58 FR 14248), is one of three subspecies of spotted owl. Under Section 3 of the ESA, the term species includes "...any subspecies of fish or wildlife...." Although the Mexican spotted owl is a subspecies, it is sometimes referred to as a species in the Recovery Plan when discussed in the context of the ESA or other laws and regulations. An endangered species is defined under the ESA as "...any species which is in danger of becoming extinct throughout all or a significant portion of its range...." A threatened species is one "...which is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range." Section 4(A)(1) of the ESA lists five factors that can, either singly or collectively, result in listing a species as endangered or threatened provided their effects are significant enough that the species meets one of the above definitions. We summarize those five factors below, as they were discussed in the 1993 final listing rule (58 FR 14248). Our assessment of the current situation with regard to the subspecies' status and threats is reflected, below.

a. Present or Threatened Destruction, Modification, or Curtailment of the Mexican Spotted Owl's Habitat or Range (Factor A)

Timber-harvest practices in the Southwestern Region (Region 3 of the FS; within Region 2 of the FWS) were cited as the primary factors threatening the continued existence of the owl. The final rule stated that the FS managed timber primarily under a shelterwood harvest regime. This harvest method produces even-aged stands rather than the uneven-aged, multi-layered stands that are most often used by owls for nesting and roosting. In addition, the shelterwood silvicultural system calls for even-aged conditions in perpetuity. Thus, stands already changed from "suitable" (i.e., presently supporting Mexican spotted owls) to "capable" (i.e., not currently supporting Mexican spotted owls but with the potential to support them in the future) would not be allowed to return to a suitable condition. Acreage slated for future harvest would be similarly rendered perpetually unsuitable for owl nesting and roosting.

The final listing rule stated that "...significant portions of spotted owl habitat have been lost or modified," and it cited Fletcher (1990) in estimating that 420,000 ha (1,037,000 ac) of habitat on FS-administered lands were converted from suitable to capable. Of this, about 78.7%, or 330,000 ha (816,000 ac) was converted as a result of human activities, whereas the remainder was converted primarily by wildland fire. We were not aware of similar data for Mexico, so could not provide information about habitat change in Mexico. According to the final rule, forest plans in FS Region 3 allowed up to 95% of commercial forest (59% of suitable Mexican spotted owl habitat) to be managed under a shelterwood system. The final rule also cited the loss of lower- and middle-elevation riparian habitat plus habitat lost to recreation developments as factors in habitat loss.

b. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes (Factor B)

The final listing rule stated that scientific research had the greatest potential for overutilization of the Mexican spotted owl, whereas overutilization for birding and education were likely to increase as the owl became better known. The effects of these activities, either chronically or acutely, were unknown.

c. Disease or Predation (Factor C)

The final listing rule stated that great horned owls and other raptors are predators of Mexican spotted owls. The rule implied that forest management created transition habitats (i.e., ecotones) favored by great horned owls, thus creating an increased likelihood of contact between the two owl species.

d. Inadequacy of Existing Regulatory Mechanisms (Factor D)

The final listing rule discussed various Federal and state laws and agency management policies, concluding that existing regulatory mechanisms were inadequate to protect the owl. Specifically cited was the conflict between attaining assigned timber-volume targets and management of occupied and unoccupied Mexican spotted owl habitat.

e. Other Natural or Manmade Factors Affecting the Mexican Spotted Owl's Continued Existence (Factor E)

The final listing rule cited wildland fires as a threat to owl habitat. The potential for increasing malicious and accidental anthropogenic harm to the species was also cited as a possible threat. In addition, the final listing rule recognized the potential for the barred owl to expand its range into that of the Mexican spotted owl, resulting in possible competition and/or hybridization. It was speculated that habitat fragmentation may encourage and hasten this expansion.

2. Federal Actions Affecting the Mexican Spotted Owl

Since the Mexican spotted owl was listed as threatened, the FWS has completed numerous formal consultations on actions affecting this subspecies. These formal consultations have reviewed Federal agency actions affecting over 400 PACs (S. Hedwall, FWS, pers. comm.). Agencies initiating consultation have included the FS, Bureau of Indian Affairs (BIA), DOD (including Air Force, Army, and Navy), Department of Energy (DOE), NPS, BLM, and Federal Highway Administration (FHwA). Proposed projects have included timber sales, road construction, fuels treatments, fire/ecosystem management projects (including prescribed natural and management-ignited fires), livestock grazing, recreation activities, utility corridors, military and sightseeing overflights, oil and gas exploration and extraction, and other activities. Only two projects resulted in biological opinions that the proposed action would likely jeopardize the continued existence of the Mexican spotted owl: 1) implementation of the Region 3 Forest Plans without adopting the Recovery Plan (an action that was never implemented); and, 2) the release of site-specific owl location information (that information was ultimately released under the

Freedom of Information Act, but the release is not known to have resulted in adverse effects to the owl).

3. Factors Affecting the Mexican Spotted Owl in the United States

Section 4 of the ESA requires consideration of five factors when determining whether a species should be listed, delisted, or reclassified under the ESA. Thus, in this revised Recovery Plan, we included an up-to-date five-factor analysis (Part II.H) to ensure that recommended recovery actions (Appendix C) address the factors responsible for the species' threatened status.

In this section we analyze factors currently influencing the species. The activities we discuss may not necessarily be threats *per se*, depending on their level of intensity, duration, or geographic extent. The activities and situations we discuss are potential influencing factors on the owl and/or its habitat, and we evaluate their impacts herein.

a. Present or Threatened Destruction, Modification, or Curtailment of the Mexican Spotted Owl's Habitat or Range (Factor A)

Human-managed alteration of forests in the southwestern U.S. has resulted in extensive areas of Mexican spotted owl habitat that are now more vulnerable to the effects of stand-replacing wildland fires. A plethora of ecological and historical research has documented intensified land-use in southwestern U.S. forests beginning in the 1880s with European-American settlement (Weaver 1951; Cooper 1960; Bahre 1991, 1995; Swetnam et al. 1999). Livestock grazing and selective timber harvesting were identified as management practices that resulted in substantial changes to forests (e.g., Fulé et al. 1997, Kaufman et al. 1998, Swetnam and Baisan 2003). Furthermore, human land-use practices resulted in fire exclusion, altering pre-settlement forest ecology throughout the Southwest.

Frequent, low-intensity surface fire regimes played an important role in the evolution and ecology of pine-oak, ponderosa pine, and mixed-conifer forests prior to European-American settlement (Weaver 1951, Cooper 1960, Grissino-Mayer et al. 1995a, Swetnam and Baisan 2003). The primary fuels for these low-intensity surface fires included conifer needles, leaf litter, grasses, and forbs. During pre-settlement, low-intensity surface fires burned regularly across southwestern forests (Swetnam 1990, Swetnam and Baisan 1996a).

Pine-oak and ponderosa pine forest fire-scarred trees have recorded mean fire intervals of every 2–14 years, while dry mixed-conifer-site intervals ranged from 9–30 years (Dieterich 1983; Kaib et al. 1996; Swetnam and Baisan 1996b; Swetnam et al. 1999; Brown et al. 2001; Grissino-Mayer et al. 1995a, 1995b; Heinlein et al. 2005; Brown and Wu 2005; Fulé et al. 2009). The more frequent fire intervals occurred in the lower elevations and on southern slope-aspects in the pine-oak, ponderosa, and dry mixed-conifer forests. In the higher elevations and on northern aspects with wetter mixed-conifer forests, mean fire intervals were longer with greater variation, and fire effects included mixed severities with surface and stand-replacing fire characteristics often discernible within existing aspen stands (e.g., Brown et al. 2001, Fulé et al. 2004, 2009; Margolis et al. 2007, Margolis and Belmat 2009). Fires were less frequent in arid and rocky-

canyon habitats, where natural fire barriers and limited fuels existed (Swetnam and Baisan 1996a, 1996b; Brown et al. 2001; Swetnam et al. 2001; Fulé et al. 2003a, 2003b).

Historical descriptions of mixed-conifer forests 100 or more years before present included a variety of conditions depending on the time since and severity of the most recent fire incidents. Accounts of mixed-conifer forest described large old Douglas-fir trees and understories composed of vigorous ponderosa pines and regeneration cohorts of Douglas-fir. Fulé et al. (2004, 2009) found that mixed-conifer forest composition and structural changes between 1880 and 2004 included >50% increases in basal area (BA) from smaller diameter age classes, declines in ponderosa pine, increases in white fir, subalpine fir, and spruce, and a decline in early seral habitats at higher elevations. Others have noted similar changes to mixed-conifer forest in different mountain ranges of the Southwest (Heinlein et al. 2005, Margolis et al. 2007, Margolis and Belmat 2009).

i. Stand-replacing Fire

Current forest conditions have the potential to sustain landscape-scale stand-replacing fires that would positively or negatively alter owl habitat over extensive landscapes in a single fire incident, depending on certain conditions discussed below. Indeed, several large fires—Whitewater-Baldy, Wallow, Las Conchas, Cerro Grande, Rodeo-Chedeski, Hayman as examples—have burned in owl habitat since 1996. Thus, broad-scale, high-severity, stand-replacing fires have had, and will likely continue to have, long-term effects on both watershed and forest function (Fulé et al. 2004). Wildland fires can cause direct and indirect effects from combustion, charring, heating, smoke, and biophysical changes to the burned area. Dense forests with heavy fuel accumulations, like many forests in the southwestern U.S., are at greater risk to high-severity and stand-replacing fires (Fulé et al. 2004). The potential effects of fire and related activities on owls depend upon:

- whether or not the fire and/or suppression activities are within owl habitat;
- type of habitat involved (e.g., nest/roost, foraging, dispersal habitat);
- severity and intensity of the wildland fire;
- areal extent, location, and intensity of suppression activities;
- frequency and cumulative effects of the suppression activities; and,
- time of year.

Direct and indirect fire effects on habitat include the alteration of vegetation structure, soil, and watershed conditions. These effects can be detrimental, beneficial, or both depending on the six factors we list above. Evaluation of effects is also dependent on temporal scale; effects that are detrimental in the near-term may have long-term beneficial effects. Conversely, fires may provide short-term benefits, but result in stand degradation over time. The fire-severity class is directly related to the magnitude of these effects, and it also influences whether such effects are positive or negative on owl habitat. High-severity burns have the most negative long-term effects on spotted owl nest and roost habitats but could enhance foraging habitats used by owl prey species (e.g., woodrats or deer mice) (Franklin et al. 2000, Kyle and Block 2000). Bond et

al. (2002) monitored the fate of 21 color-marked owls representing all three (northern, California, and Mexican) spotted owl subspecies. They concluded that when relatively large wildland fires burned known nest and roost sites, the fires appeared to have a short-term effect on survival, site fidelity, mate fidelity, and reproductive success (see also Jenness et al. 2004).

Bond et al. (2009) evaluated wildland fire effects on seven radio-marked California spotted owls and found that owls roosting during the breeding season selected low-severity burned forest and avoided moderate- and high-severity burned areas. Bond et al. (2009) also found that most owls foraged in high-severity burned forest more than other burned-forest categories. Furthermore, within 1 km (0.6 mi) of the center of foraging areas, foraging owls selected all severities of burned forest and avoided unburned forest. Further, anecdotal evidence from Mexican spotted owl monitoring suggests that PACs burned with moderate-to-high fire severity continue to be occupied by reproductive owls (S. Hedwall, FWS, pers. obs.; J.P. Ward, Jr, FWS, pers. obs.). Conversely, owl surveys conducted two years post-wildland fire in some previously occupied, but severely burned areas (e.g., within some areas of the Rodeo-Chedeski Fire on the Mogollon Rim in Arizona), failed to locate Mexican spotted owls (S. Hedwall, FWS, pes. comm.).

The Recovery Team examined the rate of fire burning at different severities in the owl's habitat in the U.S. during a recent (1996-2005) period and then used the rate of high-severity fire to project the potential for habitat alteration and loss by high-severity wildland fire. This analysis indicated that the effects of future fire on the owl's habitat will very likely depend on the type of habitat that is occupied. Owl populations dwelling in canyon habitats may be at less risk than those dwelling in forested habitats. However, despite the variability of fire effects and existing gaps in knowledge regarding short- and long-term effects on habitat and owl responses to wildland fire, we believe that stand-replacing crown fires pose a threat to Mexican spotted owls. This is especially true when considering that 55 spotted owl PACs experienced some degree of high-severity stand-replacing fire in the 2002 Rodeo-Chediski Fire, including approximately 33,000 PAC acres that were reduced to an early successional stage. In 2011, the largest wildland fire in Arizona history, the Wallow Fire, impacted 76 PACs. As of this time, we do not have fire severity data for owl habitat within the Wallow Fire, nor do we have information yet for the 2012 Whitewater-Baldy fire impacts to owls in New Mexico. Furthermore, most climate-change models predict hotter and drier conditions in the southwestern U.S. in future decades, which will increase susceptibility of forests to large-scale, stand-replacing fires. Therefore, this Recovery Plan provides management recommendations to reduce fire risk to PACs and recovery habitat valuable to spotted owls while maintaining the integrity of nest/roost core areas (see Appendix C).

ii. Fire Suppression

Fire-suppression activities can result in habitat loss through building of fire lines, construction of support areas such as helipads and fire camps, and ignition of backfires and burnouts to reduce the amount of fuel available to the wildland fire. Whether the habitat effects of fire-suppression activities cause more or less impact to habitat than the benefits gained by controlling the fire can only be determined site-specifically, and then only to the extent that with-suppression and without-suppression scenarios can be accurately evaluated. Fire-management teams typically include resource advisors whose responsibility is to assess and attempt to minimize potential

effects to threatened, endangered, and sensitive species habitats. Although fire-suppression activities can have significant negative effects on owl habitat, at least locally, fire suppression tactics like backfires and burnouts can also be used to reduce fire severity and canopy losses. Management recommendations to minimize adverse effects of fire-suppression activities are provided in Appendix C.

iii. Burned Area Response

Emergency stabilization (ES) and burned area rehabilitation (BAR) treatments are applied to stabilize and rehabilitate a burned area so that it can recover more rapidly. ES is performed within one year of the wildland fire to stabilize and prevent unacceptable degradation to natural and cultural resources, to minimize threats to life or property resulting from the effects of a fire, or to repair/replace/construct physical improvements necessary to prevent degradation of land or resources (USDA and USDI 2006). BAR is undertaken within three years of wildland fire containment to repair or improve fire-damaged lands unlikely to recover naturally to management-approved conditions, or to repair or replace minor facilities damaged by fire (USDA and USDI 2006). Methods of ES and BAR include aerial mulching and seeding, tree planting, and construction of water/soil control structures (e.g., gabions, water bars, straw bales). From a habitat standpoint, ES and BAR activities are probably beneficial in that they provide protection of soils, thereby reducing the likelihood of permanent soil loss in preparation for longer-term rehabilitation efforts. Use of non-native species, however, for post-fire seeding is often ineffective at meeting management objectives and may have long-term implications on forest ecology (Peppin et al. 2010).

ES and BAR activities probably do not constitute a significant threat to spotted owls, but treatments instituted post-fire can have an effect on stand structure well into the future. We therefore provide management recommendations for this activity in Appendix C.

iv. Wildland Urban Interface (WUI) Treatments

Guidance for Implementation of Federal Wildland Fire Management Policy (Fire Executive Council 2009) defined the WUI as the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetation fuels. These areas may include critical communications sites, municipal watersheds, high-voltage transmission lines, observatories, camps, research facilities, and other structures that, if destroyed by fire, would result in hardship to people and communities. The WUI often is defined to encompass these sites and a buffer that includes continuous slopes and fuels that lead directly to the sites, regardless of distance. The amount of area included can be substantial. For example, the WUI within the Sacramento Ranger District of the Lincoln National Forest in New Mexico encompasses over 80% of the district as defined by Otero County under the auspices of the Healthy Forests Restoration Act (HFRA; see discussion in 8.B.d, below). Although a variety of threats may affect owls within the WUI, our focus is on the effects of intensive fuels reduction treatments on the owl and its habitat. Fuels reduction treatments in the WUI typically aim to reduce tree BA to 30 to 60 sq. ft/ac and change forest structure (e.g., reduce canopy cover by 35 to 75%) to significantly modify fire behavior (USDA, USDI 2001).

Analyses for the purpose of planning WUI treatments consider the "condition class" of the vegetation. Condition classes are a function of the degree of departure from historical fire regimes resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, and canopy closure. One or more of the following activities may have caused this departure: fire exclusion, timber harvesting, grazing, introduction and establishment of exotic plant species, insects and disease (introduced or native), or other past management activities. Condition class one means that fire regimes are within or near historical range. In condition class two, the fire regime and vegetation structure and composition have been moderately altered; that is, >1 fire cycle has been missed, allowing for denser stocking and an increase in understory woody species. Areas in condition class two primarily include pinyon/juniper woodlands and mixed-conifer stands. Fire condition class three indicates that the fire regime and vegetation structure and composition are substantially altered; that is, multiple fire cycles have been missed. Forests and woodlands are now densely stocked, and there is a greater risk from uncharacteristic high-severity wildland fire effects. This typically applies to pine and pine-oak stands. Of the forested areas identified for treatment in the WUI within the FS Southwestern Region, 85% (or 650,000 ha [1.6 million ac] of the 730,000 ha [1.86 million ac]) occur in fire condition class two and three.

On the Lincoln National Forest in New Mexico forest personnel conducted an assessment of fuels treatments needed to ensure community protection, firefighter safety, and ecological functionality in the WUI. The Lincoln National Forest Capability Assessment evaluated several options, including intensive treatments applied across essentially the entire forest landscape (because most all of the Lincoln National Forest is considered to be WUI), including owl nest stands. This approach could involve significant risk to the Mexican spotted owl population in the Sacramento Mountains. This owl population comprises the bulk of the population in the BRE EMU (Ward et al. 1995). The BRE EMU appears to receive little if any immigration from other populations (Barrowclough et al. 1999), but it may serve as a source population for smaller populations within the region. Thus, implementation of this approach to fuels reduction in the WUI could seriously endanger owls within this EMU.

In summary, large blocks of land are scheduled to be treated to reduce fire risk and protect human communities throughout the Mexcian spotted owl's range within the U.S. (USDA, USDI 2001). Prather et al. (2008) evaluated potential conflicts between fuels-reduction treatments and spotted owls in the western Mogollon Plateau and concluded that there were ample opportunities to treat forests without compromising owl habitat. In the Sacramento Mountains of New Mexico, however, intensive landscape-wide treatments aimed at ensuring community protection, public health and safety, and ecological functionality have the potential to impact a large percentage of the known PACs in the BRE EMU. As proposed, the intensity of many of these treatments may affect owls and owl habitat negatively. Also, note that many proposed treatments within the WUI were not consistent with guidelines in the 1995 Recovery Plan. As such, some WUI treatments may represent a threat to the owl, and we address these threats in Appendix C.

v. Silvicultural Treatments

A review of recent harvest data from the 11 National Forests in Arizona and New Mexico (i.e., FS Region 3) shows a shift in the type of harvest activities performed over the past few decades. Prior to the 1980s, but post World War II, harvesting throughout the Southwest tended to cover large, contiguous areas. The number of trees per acre removed was highly variable and generally consisted of removing trees that were unhealthy and expected to die in the near future, old-growth trees, and/or trees that overtopped/shaded vigorous regeneration. It was not uncommon to utilize the same harvest methods and systems on thousands of contiguous acres. This type of harvest activity could neither be clearly classified as even-aged or uneven-aged forest management, because there was no real area control (even-aged) or volume control (uneven-aged) associated with this harvesting approach.

By the mid 1980s, all 11 National Forests in FS's Region 3 had either completed or were close to completing their individual forest plans. All of the plans at that time emphasized: 1) even-aged management; 2) discrete stand-size treatment units; and, 3) short rotation ages, generally 100-140 years. This management regime called into question whether old growth could be developed and maintained in large blocks scattered over the landscape. Although even-aged management applied in stand-size areas across the landscape might provide horizontal vegetative structural diversity, within-stand vertical diversity could not have been maintained.

In the early 1980s, timber harvesting approached 80,000 ha/yr (200,000 ac/yr) across Region 3 of the Forest Service. By the time the last forest plan was completed in 1987, annual harvest rates throughout Region 3 had dropped to approximately 60,000 ha/yr (150,000 ac/yr). By 1990, total harvest rates in the region dropped to approximately 40,000 ha/yr (100,000 ac/yr), or half what it was in the early 1980s. Since the early 1990s, commercial harvest rates have steadily declined to their current level of approximately 4,000 ha/yr (10,000 ac/yr).

With the incorporation of the Goshawk Management Guidelines into all 11 southwestern forest plans in 1996, management of most of the ponderosa pine type and much of the mixed conifer type outside of areas managed for spotted owls shifted to 0.04- to 1.6-ha (0.1- to 4-ac) groups consisting of 6 vegetative structural stages (Reynolds et al. 1992). Since this time, Region 3 has developed desired conditions for forest management. These desired conditions are not finalized at the time of this writing, and how they will translate into on the ground management, particularly for the owl, is unknown.

Beginning in the early 2000s after the Cerro Grande, Rodeo Chedeski, and other large destructive wildland fires, and after completion of the National Fire Plan, most silvicultural treatments within the region were designed to reduce BA and the number of trees per acre by thinning forests from below (removing most smaller-diameter trees) within the WUI areas (see discussion above).

Another form of intermediate cut performed in the FS's Region 3 is sanitation/salvage cutting. Sanitation/salvage has been performed since commercial logging first began prior to the 1900s. This type of intermediate treatment has declined in recent years; however, today salvage harvesting treatment is getting greater attention due to the increasing number of large, stand-replacing fires and increased insect-induced mortality in ponderosa pine and mixed conifer

forests. Those treatments are generally located in high severity burned areas and areas of extensive beetle-killed trees. In addition, FS Region 3 salvage operations generally involve no new road construction, logging only on slopes <30–40%, and removing only trees that are completely dead or determined to be dying. Region 3 data show that, between 2000 and 2009, 18,259 ha (45,100 ac) of harvested timber were sold as salvage sales.

There is considerable controversy over the effects of salvage logging following stand-replacing fire, and most salvage projects are appealed and/or litigated in the courts (Karr et al. 2004). Proponents of salvage logging believe that harvesting dead trees will reduce the need to harvest live trees and see the failure to log some of the dead trees as a waste of a valuable natural resource; many also see salvage logging as a way to help reduce future burn severity or provide biomass to the forest floor to help minimize erosion. Others think that the severe fire had already caused substantial environmental harm and that salvage logging may result in more environmental damage (e.g., Donato et al. 2006, Lindenmayer et al. 2008).

In summary, non-salvage even-aged timber-harvest activities that were the primary threat leading to listing of the owl as a threatened species have been greatly reduced in extent and severity since 1996 from the levels implemented at the time of listing in the FS's Region 3. The majority, but not all, of selection harvesting in Region 3 is group selection where small (0.04- to 1.62-ha [0.1- to 4-ac]) openings are created to encourage natural regeneration. These group openings generally comprise 10-20% of the stand. The remaining 80-90% of the stand is either thinned to encourage more vigorous tree growth or treated to reduce stocking by use of group selection to favor more seral tree species, or to reduce existing fuel loading. We have no definitive information on harvest levels and prescriptions on non-NFS lands; however, based on the current situation in the FS's Region 3, we do not consider even-aged timber harvest (i.e., activities designed to capture wood volume or provide for even-aged stand regeneration) to be a significant threat to the species.

Fuelwood collection for personal and commercial use occurs throughout the forested range of the Mexican spotted owl in both coniferous and riparian forests. Fuelwood harvest can result in the loss of habitat components such as hardwoods (especially Gambel oak), snags, large logs, and large woody riparian vegetation. Owl researchers have recommended the prohibition of this activity in owl habitat to protect these habitat components (Seamans and Gutiérrez 1999, May and Gutiérrez 2002, Block et al. 2005). We do not have information regarding the scale of this activity, but provide some management recommendations in Appendix C.

vi. Insects and Disease

Native forest insects and diseases are natural ecosystem processes with which the owl has evolved. The influences of these ecosystem processes on owls can be either negative or positive, depending on intensity and extent, both within and among forest-pathogen types. For example, patches of mixed conifer subjected to bark beetle outbreaks can deteriorate to the point that they are of little use to Mexican spotted owls and are vulnerable to severe wildland fire. This may be especially significant in areas, such as those described above, where significant habitat has already been lost and where remaining habitat is under environmental stress. However, scattered patches of beetle-infested forest may provide for forest heterogeneity, resulting in abundant and

diverse prey. Similarly, dwarf mistletoe likely has some beneficial effect in providing nest sites for spotted owls as well as supporting the life-history requirements of spotted owl prey, while it also acts synergistically with other forest stressors to induce tree mortality (Lundquist and Ward 2005, Stubblefield et al. 2005, Hedwall and Mathiason 2006, Hedwall et al. 2006).

Native insects and disease likely are an issue for owl habitat only when they reach epidemic levels. Species of primary interest in this context in the southwestern U.S. include several species of bark beetles and defoliating insects (names given below), dwarf mistletoe, and root decay fungi (USDA FS 2004). An intensive and ongoing drought-induced bark beetle outbreak has caused extensive fatalities in pinyon-juniper woodlands and ponderosa pine and mixed-conifer forests (Breshears et al. 2005, 2011; Negrón et al. 2009). In some cases tree fatality has been nonrandom, with greater mortality rates in the larger trees favored by owls than in smaller trees (Mueller et al. 2005; J. L. Ganey, RMRS, unpubl. data).

Defoliators, sapsuckers, and beetles have reached outbreak proportions in areas such as the White and Pinaleno mountains, Arizona, and Sacramento Mountains, New Mexico. The Pinaleno outbreak included spruce aphid (Koprowski et al. 2005, Lynch 2009), Janet's looper (Lynch 2007), spruce beetle, and western balsam bark beetle. The Pinaleno event covered at least 162 ha (400 ac) with an estimated mortality in affected areas of 85%; mortality rates ranged from 15-20% in the Sacramento and White mountains, respectively (Lynch 2004, Koprowski et al. 2005, Lynch 2007). There is some evidence that outbreaks were associated with increasingly warm temperature regimes (Lynch 2003), suggesting that such outbreaks may increase if the climate becomes warmer in the Southwest (e.g., Seager et al. 2007).

Douglas fir dwarf mistletoe inducted witches' brooms can be beneficial to owls in mixed conifer forest by providing nest-site platforms (Ganey 1988, Fletcher and Hollis 1994, Seamans and Gutiérrez 1995, May et al. 2004) and supporting important prey species (Hedwall and Mathiasen 2006, Hedwall et al. 2006). As stated above, in many areas across the Southwest dwarf mistletoe levels have likely increased over the last century due to greater tree density resulting from fire suppression and cattle grazing (Conklin and Fairweather 2010). This greater density allows for easier tree-to-tree spread of misteletoe (Mathiasen et al. 1990) and lack of surface fire allows more branches to exist in the lower crowns of trees than would be present if these forests burned frequently. These lower branches help to increase levels of dwarf mistletoe infection, and the resulting witches brooms provide fuel ladders that allow fire to move into the canopy more easily. So, though dwarf mistletoe is a positive feature of Mexcian spotted owl habitat, it can also increase the risk of high-severity fire in owl habitat.

Decay fungi can kill trees or predispose trees to death by other agents. However, heartrot fungi, which decay the inner core of living trees, are essential in providing cavities for owl nests in both snags and living trees. Decay levels by heartrot fungi are typically proportional to tree and stand age (Lightle and Andrews 1968, Abella 2008, Worral and Fairweather 2009), so retaining old trees on the landscape with this type of decay is essential to maintaining owl habitat.

In summary, insects and diseases, while naturally occurring, can pose some risk to spotted owls when they involve exotic species or when native-species infestations are exacerbated by unnatural stand conditions, drought, climate change, or other factors. If the range of the owl becomes hotter and drier (see Part II.H.3.e.*iv* below), insect and disease outbreaks can be

expected to increase in frequency, extent, intensity, and duration. We provide recommendations to manage this potential threat in Appendix C.

vii. Grazing

Effects on Mexican spotted owls from grazing by wild ungulates and domestic livestock are complex, and multiple factors may determine specific influences. These factors include local and regional climatic patterns, biotic community associations and ecology, soil types and conditions, and the timing, intensity, and duration of vegetation removal associated with the presence of grazing animals. Adding to the complexity are the interrelationships of grazing and other ecological processes, such as changes in herbaceous plant composition, woody vegetation structure, soil stability and ecology, and fire regimes. Although the effects of grazing on owls are complex, they generally fall into two categories: 1) those that result in relatively short-term effects requiring short recovery periods to restore suitable habitat characteristics; and, 2) those that result in long-term alterations in plant-species composition and vegetation structure. For example, properly managed grazing in key owl foraging areas that consistently maintains residual herbaceous biomass of forage species, sufficient to allow for individual plants to recover and reproduce during most growing seasons, should provide cover and food sources for some prey species (especially during drought periods). In contrast, grazing that allows for moderate- to high-intensity grazing throughout several successive growing seasons may result in impaired vegetation productivity and ultimate changes in species composition, density, and vigor, which can degrade spotted owl prey habitat characteristics over the long-term.

Although we lack direct information relating livestock grazing to spotted owls, we can draw inferences based various pieces of information. Improper management of livestock grazing may adversely affect the owl primarily through four indirect effects: 1) diminished prey availability and abundance (Ward 2004, Willey 2007, Willey and Willey 2010); 2) increased susceptibility of habitat to fire; 3) degradation of riparian and meadow plant communities; and, 4) impaired ability of plant communities to recover or develop into more suitable spotted owl habitat. These impacts are most likely to affect owls where individual owls forage in or adjacent to grazed areas preferred by wild and domestic ungulates, including montane meadows, riparian corridors, or canyon bottoms (Ward and Block 1995, Willey 2007, Willey and Willey 2010).

Similar effects occur where large wild ungulates, such as elk, congregate or remain with little or no seasonal migration. Browsing impacts of wild ungulates on deciduous woody species (e.g. maple, locust and aspen) have been shown to be greater in areas where wild ungulates overwinter (Martin 2007). Seasonal migration of elk is greatly influenced by winter snowfall (Martin 2007), resulting in situations where higher elevation summer ranges may receive little if any seasonal deferment from elk grazing and browsing pressure during low snowfall winters. The impacts of elk browsing on aspen communities has been studied extensively (Bartos et al. 1994, Rolf 2001, Kaye et al. 2005, Bailey et al. 2007, Fairweather et al. 2007, Beschta and Ripple 2010,), and is less seasonally influenced than the predominantly winter browsing on other deciduous species (Martin 2007). Browsing impacts on heavily utilized elk ranges have compounded the effects of historical fire suppression policies and resulted in forest stand structures that are more susceptible stand-replacing wildland fires (Cocke et al. 2005).

Domestic livestock and wild ungulate management that results in consistent heavy to severe utilization levels during the growing season reduces height and horizontal distribution of herbaceous plants that serve as protective cover and food sources for some of the owl's prey species, most notably voles (Birney et al. 1976, Getz 1985, Peles and Barrett 1996). Reduction of herbaceous plant biomass may also influence the food of other prey species (e.g., *Peromyscus* spp.) by removing or reducing the availability of plant seeds. Over time, without sufficient opportunities for growing season biomass recovery and seed production within these plant communities, their ecological condition will not be maintained or improved (Holechek et al. 2001), and some sites may fall into a degraded ecological condition (Kothmann 2009). Where limited herbaceous cover and seed production persist in preferred owl foraging areas over several breeding seasons, reduction of prey availability can limit the energy intake of those owls, particularly when other prey species are concurrently limited. These conditions can contribute to reduced reproduction and declines in some owl populations (Willey and Willey 2010).

In areas that are heavily grazed over long periods of time, reductions in herbaceous ground cover and increased density of shrubs and small trees can decrease the potential for beneficial low-intensity surface fires while increasing the potential for destructive, high-intensity crown fires (Zimmerman and Neuenschwander 1984). Likewise, in areas where continuous heavy browsing has occurred as a result of reduced snowpack observed over the past 20 years, suppression of juvenile hardwood and aspen recruitment into the overstory of riparian and upland forests has contributed to ecological changes in forest structure (Martin 2007).

Heavy grazing intensity in riparian areas, particularly within canyons, can reduce or eliminate important shrub, tree, forb, and grass cover, all of which in some capacity support the owl or its prey. Poorly managed grazing of riparian plant communities can also physically damage stream channels and banks (Ames 1977, Kennedy 1977, Kauffman et al. 1983, Blackburn 1984, Clary and Webster 1989, Platts 1990). Deterioration of riparian vegetation structure can allow channel widening. This event, in turn, elevates water and soil temperatures and thus evaporation and lowering of water tables, as well as significantly increasing the potential for accelerated flood damage (Platts 1990). These processes alter the microclimate and vegetative development of riparian areas, potentially impairing its use by spotted owls. Prolonged use of these key habitats by large ungulates can alter plant reproduction and recruitment (e.g., cottonwoods, oaks), along with other negative habitat impacts including alteration of stream corridor morphology and hydrology, compaction of soil, and removal of stabilizing vegetation such as willows, sedges, and other native plants (Kennedy 1977, Rickard and Cushing 1982, Kauffman and Krueger 1984, Fleischner 1994, Krueper 1996). These impacts retard development of riparian, oak, and other plant communities into habitat that can be used by owls for roosting, nesting, or dispersal. Where riparian areas act as refuges for small mammals during drought periods, the impacts of grazing also may influence future prey abundance.

In summary, we view grazing by domestic and wild ungulates as a potential threat to spotted owls when managed insufficiently as to its effects on prey species habitat (e.g., reducing herbaceous ground cover), nest/roost habitat (e.g., limiting regeneration of important tree species, especially in riparian areas), and the capacity for resource managers to restore and maintain conditions supporting natural fire regimes within an array of habitat types. Grazing by domestic and wild ungulates is prevalent and recurring within most Mexican spotted owl habitat

types. Thus, this potential threat occurs throughout the owl's range and often during periods of its reproductive cycle when prey availability is most critical. The magnitude of the threat is greatly dependent on the duration, timing, and intensity of grazing, and if insufficiently managed, both short-term and long-term adverse affects on the owl's habitat and that of its prey species may occur in the future. We provide management recommendations (Appendices C and D) because management of both domestic and wild large ungulates will likely continue in the owl's habitat.

viii. Energy Development

Energy development includes oil, gas, wind, and solar extraction/harvest activities, exploration, and associated infrastructure developments (e.g., construction, maintenance, and expansion of power lines, pipelines, and roads). These activities may affect owls through alteration of habitat (effects from electrocutions, collisions, and disturbance are discussed under the relevant threat factors). Habitat alteration may be caused by facility (e.g., well pads, pipelines, power lines, wind turbines) and/or road construction, as well as exploration equipment and, rarely, by subsidence (e.g., collapsing of caves). Construction activities often involve use of large equipment potentially directly impacting habitat through removal of large trees, dead and down materials, etc. Such activities may also increase accessibility, opening areas to increased human disturbance.

There is little information on the extent of energy development activities in Mexican spotted owl habitat; however, information on oil and gas activities and wind energy development is available for the four states that make up the majority of the Mexican spotted owl's range. This information is only reported by state, and therefore includes information from outside of the owl's range (e.g., Colorado plains east of the Rocky Mountains). We include this information here as a crude (but the best available) index of current trends and relative magnitude of oil, gas, solar, and wind energy activities.

In the four-corner states, the number of active oil and gas wells increased by approximately 86% between 1993 (when the owl was listed) and 2009 (the most recent year for which data are available). In 2009, there were an estimated 110,021 wells, up from 59,200 wells in 1993 (Energy Information Administration 2011). The harvest of wind energy is also growing rapidly in the western U.S.; as of September 2009, there were 794 wind turbines either built or under construction in the four-corner states (AWEA 2009). We are unable to quantify the acreage of owl habitat impacted by these development activities, but make recommendations to address the effects of oil, gas, and wind energy development in Appendix C.

Another component of energy development is the construction and long-term maintenance of utility lines. Construction of utility lines can result in removal of owl habitat (e.g., trees, snags, logs) and disturbance to breeding owl from vegetation removal and construction activities. In addition, power line maintenance involves low-level air flights to inspect lines, tree and vegetation clearing to protect lines, and removal of coarse woody debris to reduce fire risk. These actions can result in loss or modification of nest/roost habitat and disturbance. We cannot quantify the extent of habitat lost to powerline construction and maintenance, but the FWS

consulted on powerline maintenance activities on four National Forests in Arizona that resulted in incidental take of owls associated with 16 PACs.

ix. Roads and Trails

Construction of roads and trails can indirectly affect Mexcian spotted owls through loss and fragmentation of habitat (we discuss the effects of increased noise potential, human access, and direct fatality in Part II.H.3.e.*iii* below). In general, habitat loss to road construction is minor on a rangewide scale when compared to more massive habitat losses observed from other causes (e.g., wildland fires, past harvest practices); however, on a local scale, roads and trails through PACs may fragment habitat continuity, alter natural movement patterns, and increase disturbance to resident owls. Roads in nest/roost, forested, and riparian recovery habitat may also result in loss of habitat components (e.g., large logs, large snags, hardwoods) as people access these areas for fuelwood cutting, and in sensitive riparian areas, roads and trail can inhibit hydrological processes that affect proper functioning ecological conditions. Management recommendations regarding roads are provided in Appendix C.

x. Land Development

Land development is the conversion of natural land covers to non-natural surfaces for human use, including housing, commercial enterprises, and the associated infrastructure such as roads, trails, and utility structures. Land development occurs along a gradient from urban development to exurban and rural development. Exurban development is defined by either population or housing density, but it is commonly considered to be low-density, large lot residential development (i.e., one house per 0.4–1.6 ha [1–4 ac]; Theobald 2004). Exurban development probably poses a greater threat to Mexican spotted owl populations than other forms of land development, particularly in forest environments where private lands are adjacent to or located within Federal lands, although the extent of this threat is unknown. In addition, several studies have suggested that housing development threatens species occurring within many "protected" areas within the U.S. (e.g., Radeloff et al. 2010, Wade and Theobald 2010). Nationally, 80% of all developed land is at exurban densities (Wade and Theobald 2010), and exurban development is increasing at a greater rate in forested lands of the western U.S. than any other form of development, or in other regions of the country (Brown et al. 2005, Theobald and Romme 2007). This rapid growth away from urban areas, termed "rural sprawl," appears to be due to the attractions of the environmental and recreational amenities of these areas, retirement of "baby boomers," and the increasing separation of home and work locations due to better communications networks (Hansen et al. 2002, Brown et al. 2005, Radeloff et al. 2010).

Much of this exurban development is occurring in proximity to NFS and other Federal lands. Housing development within 1 km (0.6 mi) of National Forests increased by an average of 20.8% per decade from 1940-2000 and has been above the national average for housing growth since the 1970s (Radeloff et al. 2010). This pattern of greater-than-average development near and within Federal lands is expected to continue within the range of the owl, with a greater than 25% increase projected for the states of Arizona, Colorado, New Mexico, and Utah from 2000 to 2030 (Wade and Theobald 2010).

Exurban development is a potential threat in all Mexican spotted owl EMUs in the U.S. In an analysis of WUI, Radeloff et al. (2005) provide county-level data on area developed at several intensities and arrangements. Based on this information, 2.6% of all land area in counties with designated PACs falls within their definition of WUI, with 64.5% of this development being low-density intermix development. The SRM and BRE EMUs have the highest proportion of land area as WUI (5% and 4%, respectively), although the BRW EMU has the largest areal extent of land affected by this form of development. By restricting analysis to counties with at least 10 designated PACs, the BRW EMU still ranks highest in amount of land impacted by WUI development, with the UGM EMU lands also substantially impacted.

Land development adjacent to non-developed areas can influence species distribution and abundance, as well as ecological function, within those areas by a number of mechanisms, most notably by reduction in effective size of the area, alteration of ecological processes (e.g., predation, competitive interactions), loss of important habitat features or seasonally important use areas for the species, and disturbance (Hansen and DeFries 2007). Habitat loss and fragmentation due to development usually impacts species on a landscape-scale, but development also has local-scale impacts, particularly due to disturbance and vegetation change (Schlesinger et al. 2008).

No studies have evaluated the influence of land development on use of habitat by spotted owls or effects on habitat quality. Although most known owls occur on Federal lands, specific developments in Arizona and New Mexico have been suspected to impact spotted owl habitat. In addition, the extent to which these owls forage or winter on lands subject to development is unknown, but it is likely that the development of private lands within and surrounding Federal lands directly affects habitat used by spotted owls. Further, there have been a number of land exchanges, both completed and proposed, where the primary economic driver was to acquire Federal lands for development. Working with California spotted owls, Manley et al. (2009) projected that current levels of development in the Tahoe Basin has reduced the amount of area that met "territory" criteria by 28% to 38%. The majority of this loss was the result of indirect changes to the landscape that are typical of exurban development, rather than the actual conversion of area to structures. Development leads to declines in vegetative features important to owls, especially dead woody debris (Fraterrigo and Wiens 2005, Heckmann et al. 2008). In addition, fragmentation by development may lead to owls requiring larger areas. For example, working with northern spotted owls, Carey et al. (1992) found that owls utilized three times the amount of mixed-conifer forest in areas of high fragmentation than in areas of limited fragmentation.

Ecological processes influencing Mexican spotted owl populations might be altered by development. Forest fragmentation may lead to increases in potential predators, such as great horned owls, which increase in abundance with high levels of habitat heterogeneity caused by fragmentation (Grossman et al. 2008). Fragmentation was found to increase the spatial overlap between great horned owls and barred owls, and it may increase the threat of predation on barred owls by great horned owls (Laidig and Dobkin 1995). Development also alters ecological processes associated with fire regimes, by increasing the probability of fire and activities associated with suppression or mitigation of risk (e.g., WUI). The threats from these activities are discussed elsewhere in this five-factor analysis (e.g., see Part II.H.3.a.*i* and *ii*).

Increasing development leads to greater impacts on species due to increased use of surrounding areas by humans (Riebsame et al. 1996). Behavioral responses can be a more important factor in loss of species to development than habitat alteration (Schlesinger et al. 2008). The threat of recreation disturbance to Mexican spotted owls is evaluated elsewhere in this five-factor analysis (see Part II.H.3.a.*xi*).

A major question not answered at present is the extent and importance of wintering habitat for Mexican spotted owls, particularly in the northern periphery of their range. In Colorado, this question may have substantial bearing on whether land development is a serious threat to continued presence of the species, as land development may disproportionately affect wintering areas there. These lower-elevation areas are more likely to be privately owned and impacted by exurban development, and in these areas exurban housing densities have shown the greatest increase (Riebsame et al. 1996, Theobald 2000).

In summary, land development poses a potential threat to Mexican spotted owls primarily through habitat fragmentation, alteration of ecological processes (e.g., predation, fire regimes), and increased potential for disturbance. The threat exists in all EMUs but the magnitude is highly variable due to the variation in amount and configuration of developable land in proximity to current spotted owl habitat. Land development probably threatens foraging and wintering habitat more than nest/roost habitat, although the level of threat is unknown. We provide management recommendations (Appendix C) to mitigate threat of land development to the spotted owl.

xi. Recreation

Recreational activities may affect owls directly through disturbances caused by human activity (e.g., hiking, shooting, and OHV use at nesting, roosting, or foraging sites; discussed under other sections of this five-factor analysis) or indirectly through alteration of habitats such as damage to vegetation, soil compaction, illegal trail creation, and increased risk of wildland fires. Whether managed or unmanaged (i.e., user-created), development of new recreational facilities (e.g., trailheads, and OHV and mountain bike trails) and expansion of existing facilities (e.g., campgrounds and hiking trails) may alter owl habitat.

The potential for recreation-related impacts to the owl is relatively high. Visitation at the 18 national parks, monuments, and recreation areas within the owl's U.S. range has doubled from approximately 7 million to over 14 million visits from 1971 (representing the first year data were available for all 18 park units) to 2009 (USDI NPS 2010). NPS-administered lands make up approximately 2.5% of the owl's U.S. range (USDI FWS 1995). While only a fraction of visitors are likely to recreate in PACs, the overall high level of visitation demonstrates the scale of recreation-related human activities within the owl's range.

Depending on the extent, intensity, and duration, recreational disturbance may have negative impacts on owl habitat. For example, the number of people who drive OHVs off road has increased over 109% in the U.S. since completing the 1995 Recovery Plan (Cordell 2004). In addition, from 1997 to 2001, the number of OHVs in use increased by almost 40%, OHV drivers increased by 36%, and OHV driving hours increased by 50% (68 FR 19975; April 23, 2003).

The significant increase in OHV use, OHV-associated impacts to natural resources, and a desire to provide better OHV management have precipitated development of Travel Management Plans for all NFS lands as well as implementation of a 2009 Arizona OHV Law (SB1167). These actions illustrate that both Federal and state agencies have identified OHV recreational activity as a concern.

There have been significant increases in the extent and intensity of recreational activities within the owl's range since the development of the original Recovery Plan (USDI FWS 1995). Impacts are most likely to occur at the level of individual owls and/or PACs. Since the owl's listing in 1993, the canyonlands in southern Utah have experienced a steady increase in visitation and, as a result, a significant increase in canyoneering. This sport encompasses boulder scrambling and rock-climbing to descend through canyons, including those where Mexican spotted owls are known to nest (USDI FWS 1995, Rinkevich and Gutiérrez 1996, Swarthout and Steidl 2001). For example, human recreational-use levels were measured for canyons by the NPS in Zion National Park by quantifying requests for use permits. Canyoneering permits for popular canyons occupied by the owl increased significantly between 1998 and 2002 (Zion National Park, unpubl.data). Recreational use of canyons has continued to rise; the number of permits issued for narrow slot canyon day use has increased 42% and overnight permits increased 26% since 2003. Currently, however, recreation disturbances such as these are not known to affect regional or range-wide owl populations. Management recommendations to address the threat posed by recreation are provided in Appendix C.

xii. Water Development

Water development includes dams, permanent flooding of riparian habitats, bed degradation below dams, stream dewatering, diversions, altered-flow regimes, and artificial watering ponds (e.g., stock tanks). Effects of development on owls vary, but can include loss or degradation ofhabitat, habitat fragmentation, disruption of migration corridors, inhibited gene flow, and altered grazing patterns by wild and domestic ungulates.

Previously occupied riparian communities in the southwestern U.S. and Mexico have undergone significant habitat alteration since the historical owl sightings (USDI FWS 1993). For example, in southern Utah and northern Arizona, inundation of Glen Canyon by Lake Powell in 1963 created a 299-km (187-mi) long and 40-km (25-mi) wide reservoir that flooded habitat for a potentially large population of owls (McDonald et al. 1991, Willey and Spotskey 2000). In addition to inundating habitat, dams can alter hydrologic conditions below the dam and strongly influence the structure and function of riparian ecosystems (Poff et al. 1997). Dams often regulate the timing, magnitude, and duration of floods that are the primary natural disturbances in riparian ecosystems (Poff et al. 1997). Natural floods deposit sediment on flood plains that create seed beds for riparian plants, and they flush salts and redistribute nutrients. Regulation of floods below dams can reduce or eliminate these critical processes. Salinity increases can be biologically significant. Most native willows and cottonwoods are relatively intolerant of salt (Jackson et al. 1990, Shafroth et al. 1995), whereas germination of the non-native tamarisk increases with salinity (Busch and Smith 1995, Smith et al. 1998). Thus, it has a competitive

advantage over native cottonwoods and willows on regulated rivers. Increase in tamarisk and decline in native vegetation may have implications for owl habitat quality.

Stock tanks are artificial watering holes established primarily for domestic livestock that also are used by wild ungulates such as deer and elk. Effectively, these tanks have allowed both domestic and wild ungulates to expand their geographic range, thereby allowing them to graze over a wider area than they might have with limited water. Depending on the intensity, seasonality, and location of where these animals graze, potential exists for them to affect habitat for owls and their prey (see II.H.3.a.*vii*).

In summary, effects of water development can range from site-specific habitat loss or degradation to habitat fragmentation through inundation and altered hydrological function, disruption of migration corridors, and inhibited gene flow across larger landscapes. Much of our knowledge concerning effects is indirect and inferential given that no studies have specifically addressed these threats. For example, studies in Grand Canyon National Park have recorded a number of owl sites and have resulted in predictions of potential owl habitat (Bowden 2008). Many of the canyons inundated by Lake Powell likely possessed similar characteristics as those occupied by owls in Grand Canyon, thus it is conceivable that some would have been occupied. Not only was there probable habitat loss but given the size of the lake, movements of birds between Grand Canyon and other parts of the CP EMU may have been disrupted. Effects of dams on downstream habitat have not been investigated, but the replacement of native cottonwood forests with non-native tamarisk stands may effectively represent a loss of owl habitat. The extent and severity of this threat warrant additional study. We provide management recommendations specific to this threat in Appendix C.

b. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes (Factor B)

i. Commercial Exploitation

We are unaware of any commercial exploitation of Mexican spotted owls.

ii. Recreational Exploitation

The southwestern U.S., particularly southeastern Arizona, is one of the premier destinations in the U.S. for birdwatching. Unfortunately, the high visitation level of birdwatchers has begun to result in recreational exploitation of Mexican spotted owls as birders attempt to "collect" sightings and/or pictures of rare species for their life lists. Recreational birders have been observed regularly visiting several owl territories in the Huachuca and Chiricahua Mountains of southern Arizona. The FWS frequently receives reports of people continuously playing audio recordings of spotted owls to elicit responses, shining lights repeatedly at owls to take pictures, and other acts of harassment. Though it is unlikely that these actions are impacting large numbers of owls, it is a threat at the site-specific level and is usually illegal absent appropriate Federal and state or Tribal permits issued for research or inventory purposes. We therefore provide management recommendations in Appendix C, that address management, education, and enforcement actions to minimize effects of recreational exploitation.

iii. Scientific Exploitation

The information obtained through scientific studies is instrumental in devising appropriate recovery strategies for threatened and endangered species, as well as in monitoring progress toward recovery goals. In the case of the Mexican spotted owl, obtaining the types of ecological information required sometimes involves trapping, handling, and marking owls either with color bands or radio transmitters. These activities have been conducted for many years on all three subspecies of spotted owls. Many hundreds of owls have been trapped and handled, with a limited number of injuries or mortalities resulting from these activities. Therefore, we generally consider these activities to be acceptable for the study of owls and do not consider research and monitoring activities to pose a significant threat to population persistence. Nevertheless, trapping and handling wildlife has certain inherent risks that can never be eliminated entirely, and efforts should be undertaken to minimize any potential impacts to the owl. To aid in this process, we provide management recommendations in Appendix C. These recommendations address permitting and reporting requirements, as well as essential safeguards to minimize potential impacts of the research activities.

iv. Educational Exploitation

We are unaware of any exploitation of Mexican spotted owls for educational purposes.

c. Disease or Predation (Factor C)

i. West Nile Virus (WNV)

Mexican spotted owls are not known to have suffered population declines from disease. However, The U.S. Center for Disease Control (CDC) has identified over 300 avian species (both native and non-native, wild and captive) in which dead specimens have tested positive for infection by WNV in the U.S. (www.cdc.gov). The virus first appeared in North America in 1999, with encephalitis reported in horses and humans. It has since been documented in all U.S states except Alaska and Hawaii (www.cdc.gov).

The virus is commonly spread by transmission between mosquito vectors and bird reservoir hosts. However, birds can also become infected by means other than arthropod transmission (Marra et al. 2004). Komar et al. (2003) reported that ingestion of WNV in aqueous solution resulted in infection in several bird species, including great horned owls. It is not known whether ingestion of infected prey by raptors has resulted in bird fatality, but the risk exists (Marra et al. 2004). Finally, contact transmission has been documented in the laboratory in caged birds (McLean et al. 2001; Komar et al. 2003), perhaps from such behaviors as mutual preening and beak-to-beak contact.

Avian fatality from WNV has been extensive in North America (www.cdc.gov). Natural fatal infections were detected between 1999 and 2002 in over 28,000 bird carcasses representing 198 species, including a captive spotted owl (subspecies not identified; www.cdc.gov). However, we are unaware of any records of wild spotted owls being infected with WNV. Hull et al. (2010) tested 209 California spotted owls in the Sierra Nevada of California between 2004 and 2007 and detected no antibodies in those specimens. The authors remarked that these results were

"somewhat unexpected" given that the California Department of Public Health had recorded numerous infection incidences in other avian species in the region during that time. Hull et al. (2010) expressed doubt that this absence of detection was simply an inadequate sampling scheme; rather, given the large number of specimens sampled, they conclude that WNV infection is absent in the area's spotted owls. However, they alternatively hypothesize that an absence of detections could be because spotted owls exhibit such a high mortality rate that they do not survive long enough to develop a detectable immune response.

We are unaware of any incidence of WNV in Mexican spotted owls, or of any surveillance program (systematic or otherwise) for this disease. Nonetheless, the potential impact of the disease on threatened species and those of ecological importance is of great concern (Joyner et al. 2006). Marra et al. (2004) point out that, although no regional declines of imperiled avian species have been documented, species already affected by other population stressors may be at particular risk of extinction from WNV. They further state that determining a given species' susceptibility to WNV is critical for understanding the pathogen's ecology and protecting threatened wildlife populations.

The scientific panel that reviewed the status of and threats to the northern spotted owl was unanimous in regarding WNV as a potential future threat (Courtney et al. 2004). Their concern was based on the spread of the disease to within the range of that subspecies and the fact that the disease has been fatal to spotted owls. However, that conclusion predates the work of Hull et al. (2010) and we do not know if the panel would reach the same conclusion considering Hull et al.'s results. In addition, the final Recovery Plan for the Northern Spotted Owl (USDI FWS 2008) does not recognize WNV as a current threat and recommends only monitoring for the disease as a recovery action. We also do not consider this disease to be a significant threat to the owl at this time. However, there remains much uncertainty about the potential impact of this disease in the future, particularly when considering the effects such as climate change on ecological variables of events such as mosquito distribution. We, therefore, make management recommendations similar to those in the northern spotted owl plan (Appendix C).

ii. Predation

Predation is a common mortality factor of spotted owls, accounting for at least 5 of 11 deaths documented among radio-marked adult and subadult owls (Ganey et al. 2011), and 14 of 29 documented mortalities of radiomarked juveniles (Ganey et al. 1998, Willey and Van Riper 2000). Predation may account for more deaths than indicated because the cause of death of recovered spotted owls is often unknown. The specific predator involved is also typically unknown. Procyonid mammals were observed attempting to raid cliff-site nests occupied by spotted owls in southern Arizona (R. Duncan, Southwestern Field Biologists, pers. comm.), suggesting that they may prey on spotted owls. However, avian predation is suspected to be the main form of predation. Potential avian predators of Mexican spotted owls include great horned owls, northern goshawks, red-tailed hawks, golden eagles, and barred owls (where they are sympatric; Leskiw and Gutiérrez 1998). Some of these predators occupy the same general habitats as the Mexican spotted owl, but there is little direct evidence that they prey on spotted owls (Gutiérrez et al. 1995). Ganey (1988) reported one instance of apparent great horned owl predation on an adult spotted owl, but Ganey et al. (1997) did not document predation on spotted

owls in a study involving sympatric spotted and great horned owls. Reynolds (RMRS, pers. comm.) reported a golden eagle preying on a spotted owl.

Results from radiomarked Mexican spotted owls indicate that all age classes are preyed upon (Ganey 1988, Ganey et al. 1998, 2005; Willey 1998b, Willey and Van Riper 2000). We suspect that predation may have localized effects on spotted owl abundance, particularly due to effects on fledging rates and post-fledging juvenile survival. While predation is a documented fatality factor, there is no evidence that current predation rates are abnormally high. In summary, we do not view predation as a significant threat and provide no threat-specific management recommendations.

d. Inadequacy of Existing Regulatory Mechanisms (Factor D)

The National Environmental Policy Act (NEPA), land-management statutes like the National Forest Management Act, and state regulations governing direct taking of species were evaluated in the final rule listing the Mexican spotted owl. We discuss these statutes and regulations further in Appendix F of this Recovery Plan, and we incorporate them here by reference. We are unaware of any changes in these statutes and regulations other than those we specify below, and the previous conclusion that they convey little protection of habitat, in absence of ESA influence, remains valid. We also note that the discussion below merely describes the relevant laws influencing spotted owls and their habitat, and inclusion of these laws does not necessarily imply inadequacy. We discuss several recent laws, regulations, and policies potentially influencing forest management below.

i. National Fire Plan and Policy

The interagency Federal Wildland Fire Policy, adopted by the FS, FWS, BLM, BIA, and NPS in 1995 states, "Fire, as a critical natural process, will be integrated into land and resource management plans and activities on a landscape scale, and across agency boundaries. Response to wildland fire is based on ecological, social, and legal consequences of fire." The National Fire Plan was developed in August 2000 with the intent of improving active response to wildland fires and their impacts to communities through development of a 10-year strategy and goals in 5 key areas: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability. The plan consists of a report to the President of the U.S., the subsequent comprehensive strategy plan, and congressional appropriations. The strategy is to reduce wildland fire risks to communities and the environment by correcting problems stemming from the long-term disruption of natural fire cycles.

A 2009 revision of the 2003 Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy distinguished between two kinds of wildland fire: prescribed fire (planned ignitions), and wildland fire (unplanned ignitions). The revision allows fire managers to manage a wildland fire for multiple objectives to increase managers' flexibility in responding to changing incident conditions and firefighting capabilities, while strengthening strategic and tactical decision implementation to support public safety and resource management objectives. Hazardous fuels reduction treatments are designed to reduce the risks of wildland fire to firefighters, people, communities, and natural resources while restoring forest and rangeland

ecosystems to their historical structure, function, diversity, and dynamics. Although the intent of the National Fire Plan and Policy is also to protect habitats for the owl and other species over the long-term by reducing habitat loss from severe fire, short-term effects to owls may occur during and following treatments, and cumulative effects may possibly occur in more intensely WUI-managed landscapes. Our fire- and fuels-management recommendations in Appendix C are compatible with the National Fire Plan.

ii. Healthy Forests Initiative

President George W. Bush announced the Healthy Forests Initiative in August 2002 to streamline regulatory processes for Federal agencies, to provide for more timely decisions and greater efficiency in reducing fire risk through increased fuels-reduction treatments. The initiative consists of administrative changes related to fire and fuels treatment projects, including the establishment of two new categorical exclusions from NEPA analysis, changes to administrative appeal rules, and new Council for Environmental Quality guidance for environmental assessments. Administrative actions that may affect management and treatment of owl habitat include:

- Joint counterpart regulations were developed that eliminated required consultation with and written concurrence from FWS and National Marine Fisheries Service (collectively "the Services") for National Fire Plan projects that the action agency had determined would not adversely affect listed species. The action agencies took on the responsibilities of the Services for these projects (USDI FWS and USDC NOAA 2004). However, those regulations were withdrawn and are no longer in effect.

- Guidance was developed to evaluate net benefits of hazardous fuels treatment projects. During consultations, the Services evaluate the long-term benefits of these projects, including benefits of restoring natural fire regimes and native vegetation and long-term risks of severe wildland fire, against the short- or long-term adverse effects of these projects (USDI FWS and USDC NOAA 2002).

Our fire- and fuels-management recommendations in Appendix C are compatible with the Healthy Forests Initiative.

iii. Healthy Forests Restoration Act of 2003

The Healthy Forests Restoration Act of 2003 (HFRA; P.L. 108-148) applies to hazardous-fuels-reduction projects on National Forest System and BLM lands. The objectives of the HFRA are to reduce wildland fire risk to communities and municipal water supplies; authorize grant programs to improve the commercial value of forest biomass; enhance efforts to protect watersheds and address threats to forest and rangeland health; identify and address the impact of insect and disease infestations on forest and rangeland health; and protect, restore, and enhance forest ecosystem components, including promoting the recovery of threatened and endangered species (HFRA 2003). The HFRA does not authorize treatments in federally designated wilderness, wilderness study areas, or other areas where vegetation removal is prohibited through congressional or Presidential protection.

Title I requires the Secretaries of Interior and Commerce to comply with any applicable guidelines specified in any management or recovery plan for threatened and endangered species. It requires that HFRA projects maintain or contribute toward restoration of the structure and composition of old-growth stands according to pre-fire-suppression, old-growth conditions. It also requires that projects maximize retention of larger trees in areas other than old-growth stands, consistent with the objective of restoring fire-resilient stands and protecting at-risk communities. Other aspects of the HFRA provide for expedited environmental review and administrative review of proposed projects. It also requires collaboration between Federal agencies and local communities in development of Community Wildfire Protection Plans that identify and prioritize areas for hazardous-fuels-reduction treatments, recommend treatment methods, and recommend measures to reduce ignition of structures in the at-risk community.

Title III provides grant programs to states, tribes, small communities, and individuals for projects that provide watershed restoration and conservation, wetland restoration, and establishment of riparian vegetative buffers. Title V established the Healthy Forests Reserve Program. Private landowners may enroll their lands in this program if their lands will restore, enhance, or otherwise measurably increase the likelihood of recovery of federally listed, candidate, or state-listed species or special-concern species. Landowners who enroll may receive financial assistance to restore or enhance habitat for these species.

Fire- and fuels-management recommendations are given in Appendix C and are compatible with the HFRA.

iv. Omnibus Public Land Management Act of 2009, Title IV Forest Landscape Restoration Act

The purpose of the Collaborative Forest Landscape Restoration Act (CFLRA) is to encourage the collaborative, science-based ecosystem restoration of priority forest landscapes through a process that encourages ecological, economic, and social sustainability; leverages local resources with national and private resources; facilitates the reduction of wildland-fire management costs, including through reestablishing natural fire regimes and reducing the risk of uncharacteristic wildland fire; and demonstrates the degree to which various ecological restoration techniques achieve ecological and watershed health objectives. To be eligible to receive funding, a collaborative forest-landscape-restoration proposal must be based on a landscape-restoration strategy that identifies and prioritizes ecological restoration for a 10-year period on a landscape that is at least 20,243 ha (50,000 ac). The CFLRA states that vegetation treatments should focus on removal of small-diameter trees, retain large trees to the extent that the trees promote fire-resilient stands, and improve fish and wildlife habitat, including for endangered, threatened, and sensitive species.

The Southwestern Region of the FS is currently developing landscape-scale restoration projects that qualify for CFLRA funding. One example of this is the Four Forest Restoration Initiative. The Apache-Sitgreaves, Coconino, Kaibab, and Tonto National Forests are working with stakeholders to develop a collaborative restoration plan in the ponderosa pine forest type across the four forests. These four forests include a significant portion of the UGM EMU and will likely include a considerable amount of Mexican spotted owl PAC and recovery habitat. Fire- and fuels-management recommendations in Appendix C should facilitate implementation of such

large-scale treatments as envisioned under the CFLRA. Examples of other projects receiving CFLRA funding within the range of the owl include the Southwest Jemez Mountains Landscape Restoration Project in the Southwestern Region of the FS, and the Colorado Front Range Collaborative Forest Restoration Project in the Rocky Mountain Region of the FS.

iiv. Stewardship Contracting Authority

Through the Consolidated Appropriations Resolution of 2003, Congress enacted legislation expanding stewardship contracting authority for the FS and BLM. This authority allows these agencies to enter into long-term (up to 10 yrs) contracts with small businesses, communities, and nonprofit organizations to reduce wildland fire risk and improve forest resiliency. Stewardship contracts can be used for projects that will provide benefits to local and rural communities and meet goals such as road or trail maintenance to improve water quality; improvement of soil productivity; improvement or protection of habitat for wildlife and fisheries or other resource values; use of prescribed fire or other treatments to improve forest health or wildlife habitat and reduce fire hazards; restoration and maintenance of watersheds; and control of noxious and exotic weeds coupled with reestablishment of native plant species. This stewardship authority can be useful in implementing the management recommendations in Appendix C.

e. Other Natural or Manmade Factors Affecting the Mexican Spotted Owl's Continued Existence (Factor E)

i. Noise and Disturbance

Infrequent, noise-producing activities are generally assumed to have relatively little long-term impact on spotted owls. However, owls will react to noise disturbances by changing behavior and/or flushing from their perches (Delaney et al. 1999a; Swarthout and Steidl 2001, 2003). These behavioral responses may alter nesting and roosting activities, thus increasing vulnerability to predators and heat-related stress.

Variables such as distance to and frequency of a noise disturbance, habitat type, topography, and sound source may influence spotted owl responses (Delaney and Grubb 2004). For example, noises close to nests are likely to be more disruptive than those far from nests (Delaney et al. 1999a) and noise disturbances close (96 m [315 ft]) to owl nests may have affected prey delivery rates Delaney et al. (1999b).

Also with respect to distance and noise levels, Delaney et al. (1999a) determined that the proportion of owls flushing was negatively related to distance (owls flushed more often to closer sounds) and positively related to noise level (owls flushed more often to louder sounds). Pater et al. (2009) quantified this in part by determining that noises ≥80 dBO (i.e., decibels weighted for middle sound frequencies where owl hearing is the most sensitive), had a greater than 0.60 probability of causing an owl to flush). This noise level (80 dBO) is roughly equivalent to 69 dBA (i.e., decibels weighted for human hearing) or approximately twice as loud as ordinary conversation.

The origin or type of noise may also be a factor in disturbing owls. Mexican spotted owls in forested environments reacted more to chainsaws (operated out of sight of owls) than to the sound of helicopters at the same distance (Delaney et al. 1999a). While little research is available comparing the relative impact of various noise types, it is likely that persistent noises are more disruptive than infrequent disturbances, and intensity of disturbance is proportional to noise level (i.e., sound volume).

There is also the potential for noise pollution (i.e., consistent noise-causing activities as opposed to the sporadic noise disturbances discussed above) to impact spotted owl nocturnal breeding and foraging habits. Because owls are active at night when it is difficult or impossible to see other owls, audio communication is a critical component of the owl's social system (Frid and Dill 2002; e.g., territorial defense, pair bonding and maintenance, feeding nestlings, and post-fledging activities). Further, owls depend heavily on sound to locate and capture prey in near darkness (Payne 1971, Martin 1986, Norberg 1987).

No studies have been conducted on the influence of habitat type (canyon vs. forest) on noise disturbance to owls. While both forest- and canyon-dwelling owls respond to human presence, potentially disruptive interactions between humans and owls may be more likely in canyons because canyons can amplify noises (especially in caves) and provide limited escape routes for owls. In addition, the number of sites in canyons that afford spotted owls adequate thermal protection for nesting and roosting may be more limited than in forested environments. Finally, canyons may lack visual barriers between owls and noise sources that are common in dense forests, and this also may influence owl responses.

Noise impacts are most likely to occur at the level of individual owls and/or PACs, and they may be important to small isolated populations. We believe that disturbance should be avoided when practicable during the nesting season (see noise disturbance recommendation in Appendix C).

ii. Barred Owls

Prior to the twentieth century, the barred owl was restricted to eastern North America, from southeastern Canada, through the eastern U.S., and into eastern Mexico (Mazur and James 2000). Over the past 100 years, and particularly over the past few decades, the nominate subspecies of the barred owl has expanded its range westward across Canada to the Northern Rocky Mountains and the Pacific Northwest, where it has rapidly invaded the range of the northern spotted owl (Dark et al. 1998, Mazur and James 2000, Courtney et al. 2004). The barred owl was recognized as a potential threat of considerable concern in the Final Rule listing the northern spotted owl (55 FR 26114) and it was addressed as a threat in the Draft Recovery Plan for that taxon (USDI FWS 1992). More recently, the barred owl has been judged as representing an even greater threat to the northern spotted owl than earlier believed and, currently, it is negatively impacting the subspecies in some areas where the two owls overlap (Courtney et al. 2004). Compared to the spotted owl, the larger, more aggressive barred owl appears to be at a competitive advantage because it feeds on a broader range of prey, occupies a wider range of habitats, and has been recorded displacing (and even killing) northern spotted owls (Dark et al. 1998, Mazur and James 2000, Hamer et al. 2001, Courtney et al. 2004, Gutiérrez et al. 2007). In addition, interbreeding

between the two has been documented (Hamer et al. 1994) and such hybridization is a further threat to the northern spotted owl.

Historically, the barred owl was unknown within the U.S. range of the Mexican spotted owl. Hence, it was not considered a threat when the taxon was listed and was not addressed in the 1995 Recovery Plan (USDI FWS 1995). However, barred owls have been verified within three of the five states where the Mexican spotted owl occurs: Colorado, Texas, and New Mexico. In addition, there have been two unconfirmed reports of barred owls in Utah. The first verified record of a barred owl in Colorado is from 1897, when an adult and a set of two eggs were collected on the plains of northeastern Colorado in the Town of Holyoke, Phillips County (L. Semo, Chair, Colorado Bird Record Committee, pers. comm.). Another verified record was of two barred owls observed in January 2000 a few miles from the Oklahoma border along the Cimarron River in Baca County (L. Semo, pers. comm.). There are also two unconfirmed reports of barred owls from Colorado: two were reported on 21 May 1960 from Bonny Reservoir, Yuma County (near the Kansas border), and another was reported nearby on 16 May 1964 (L. Semo, pers. comm.). None of the Colorado barred owl records was within the range of the Mexican spotted owl; most spotted owl records in that state have been from the central and southern mountain ranges.

Similarly, no barred owls have been detected within the spotted owl's range in Texas, although the barred owl is common in parts of that state (C. Shackelford,Texas Parks and Wildlife Department, pers. comm.). Spotted owls have been documented only in three mountain ranges in the Trans-Pecos region of Texas (Guadalupe, Davis, and Chisos mountains), while the barred owl is common only in the eastern half of the state and reaches its range limits well east of the Pecos River. The treeless areas east of 100°W longitude appear to be limiting the barred owl's expansion into western mountains occupied by spotted owls (C. Shackelford, Texas Parks and Wildlife Department, pers. comm.).

Unlike barred owl detections in Colorado and Texas, in New Mexico, a barred owl has been verified in proximity to occupied Mexican spotted owl habitat. The barred owl was discovered in May 2004 in cottonwood riparian habitat along Galisteo Creek at Galisteo, Santa Fe County (Williams 2004). The location is only approximately 24 km (15 mi) from the southern Sangre de Cristo Mountains and 48 km (30 mi) from the Jemez Mountains, and it is within flying distance of occupied Mexican spotted owl habitat in both mountain ranges. The barred owl, which was occasionally vocal, remained in that area at least through early October 2004. In addition, an apparent New Mexico record from 1993 resulted from a freshly dead barred owl that was hit by a truck, perhaps somewhere from Albuquerque north to Raton (Williams 1993). Examination indicated that the owl was not the nominate subspecies, but instead a geographically closer barred owl subspecies, of adjacent Texas and Oklahoma.

In Mexico, the range of the Mexican subspecies of the barred owl is known to overlap the southern extremity of the Mexican spotted owl, but both owls are apparently scarce in that area. The ecological relationship between the two owls where they might overlap in Mexico has not been investigated; they might or might not occupy similar elevation and/or habitat zones.

Given that few barred owls have been detected within the range of the Mexican spotted owl, that even fewer barred owls have been verified where spotted owls are known to occur, and that there does not appear to be a trend of increasing abundance of barred owls in the southwestern U.S., we currently do not recognize an incursion of barred owls as being imminent. However, we believe the situation warrants observation, because barred owls could extend their distribution into the range of the Mexican spotted owl if there are additional increases in their required habitats, but we make no management recommendations associated with barred owls.

iii. Direct Fatalities

Causes of fatalities other than those we previously discussed include vehicle collisions, electrocution, and possibly direct effects associated with wildland fires. Direct fatality from collisions with vehicles has been documented (R. Skaggs, Glenwood, New Mexico, pers. comm.; R. Duncan, Southwestern Field Biologists, pers. comm.; E. Brekke, BLM Royal Gorge Field Office, pers. comm.; J. L Ganey, RMRS, unpubl. data: S. Hedwall, FWS, unpubl. data), but the extent of this is unknown. There is at least one record of electrocution, where a color-banded adult female owl was found electrocuted near Deming, New Mexico (Gutiérrez et al. 1996). There is also a documented fatality from an encounter with a pasture fence (S. Hedwall, FWS, unpubl. data). Fatality from wildland fires through heat and smoke exposure may include, in order of increasing vulnerability, loss of eggs, nestlings, and fledglings. Deaths at active roost sites and nests from fire suppression activities (e.g., water and retardant drops) also may have occurred (D. Salas, Lincoln National Forest, pers. comm.). In summary, fatalities from these causes are not likely a substantial influence on Mexican spotted owl persistence.

iv. Climate Change

Strong evidence exists that global climates are changing in response to increasing emissions of greenhouse gases (IPCC 2007), and that changing climates are affecting forest ecosystems throughout the world either directly or indirectly through altered disturbance regimes (e.g., Ayres and Lombardero 2000; Breshears et al. 2005, 2009; Bonan 2008; Hogg et al. 2008; Raffa et al. 2008; Floyd et al. 2009; Negrón et al. 2009; van Mantgem et al. 2009; Allen et al. 2010). Understanding the effects of climate change on forests is critical to informing forest management and conservation planning for the future (Allen et al. 2010). This includes recovery planning for the Mexican spotted owl, which inhabits forests throughout much of its range.

Models of projected climate change typically focus on two variables: temperature and precipitation. In general, model predictions appear to be more robust with respect to temperature than precipitation (Sheppard et al. 2002). How climate change will affect summer monsoonal precipitation in the southwestern U.S. is even less certain, because precipitation predictions are based on continental-scale general circulation models (GCMs) that do not yet account for regional phenomena such as those that control monsoonal rainfall (Weiss and Overpeck 2005, Archer and Predick 2008).

The southwestern U.S. exhibits high climatic complexity and variability in general. This is due to both complex topography and proximity to the Pacific Ocean, the Gulf of California, and the Gulf of Mexico (Sheppard et al. 2002, Brown and Comrie 2002). Because of this complexity

and steep environmental gradients, many ecosystems within the southwestern U.S. may be particularly vulnerable to climate change (Archer and Predick 2008). For example, recent temperature increase in the southwest is among the most rapid in the nation, and is significantly greater than the global average (Guido et al. 2008). Projections for the southern Colorado Plateau area describe a warmer future climate, with annual temperatures likely increasing by 1.5^{o} to 3.6^{o} C by mid-century (Garfin et al. 2010). Predicted climate change impacts in the southwest include warmer temperatures, fewer frost days, greater water demand by plants, and an increased frequency of extreme weather events such as heat waves, droughts, and floods (Weiss and Overpeck 2005, Archer and Predick 2008). Further, warmer nights and projected declines in snow pack, coupled with earlier spring snow melt, will reduce water supply, lengthen the dry season, create conditions for drought and insect outbreaks, and increase the frequency and intensity of wildland fires as well as the duration of the wildland fire season (Allen et al. 2010). Areas within the southwest are currently experiencing a severe, multiple-year drought, and current models suggest that a 10 to 20 year (or longer) drought is anticipated (Woodhouse and Overpeck 1998, McCabe et al. 2004, Seager et al. 2007). Prolonged drought, combined with warmer temperatures, may cause increases in insect outbreaks and increased wildland fires in southwestern forests (Betancourt 2004, Allen et al. 2010). Severe or prolonged drought may cause mature trees to be more susceptible to insects and disease (Hanson and Weltzin 2000, Mueller et al. 2005, Floyd et al. 2009, van Mantgem et al. 2009; see also Negrón et al. 2009: Fig. 3; Ganey and Vojta 2011).

The effects of climate change on rare, endangered, and endemic species are highly variable (Galbraith and Price 2009) and will differ depending upon life-history characteristics (Travis 2003) and dispersal abilities. Climate change has already resulted in significant effects on species and ecosystems (Gitay et al. 2002, Hannah and Lovejoy 2003, Root et al. 2003, Harris et al. 2006, Parmesan 2006). Mawdsley et al. (2009) identified a number of effects that could impact the Mexican spotted owl. These include: 1) shifts in the distribution of the owl itself, along with major prey species and potential competitors and predators, possibly along elevational or latitudinal gradients; 2) effects on demographic rates, such as survival and reproduction; 3) changes in coevolved interactions, such as prey-predator relationships; 4) direct loss of habitat due to increased fire severity, bark beetle outbreaks, and direct warming of habitats; 5) increased population or range expansion of species that are direct competitors; and, 6) reductions in population size. All of these effects are addressed in Appendix C.

Shifts in Distribution. Shifts in Mexican spotted owl distribution could occur in response to predicted warming in the southwestern U.S. that may cause elevation shifts in tree species distribution, with many forest and woodland types requiring less precipitation moving up in elevation in response to warmer and drier conditions. This could lead to the local loss of some tree species and/or forest types in much of the southwest, because these forest types frequently occur at the highest elevations available and thus would have no local refugia to which to migrate (DeGomez and Lenart 2006, Archer and Predick 2008). Owls occur in mixed-conifer and pine-oak forests at the tops of many of the Sky Island ranges in Arizona and New Mexico. Conifers within some of the Sky Islands may be eliminated as temperatures increase and snowpack runoff decreases (Archer and Predick 2008). Loss of these forest types would eliminate or greatly reduce habitat for owls in these ranges. This in turn could reduce connectivity and viability of Mexican spotted owl populations (e.g., Keitt et al. 1995, 1997;

Barrowclough et al. 2006; see also Ganey et al. 2008). To date however, there is more evidence for species-range expansion than for range contraction driven by climate change (see Dawson et al. 2011). Climate change may also impact owls in canyons if these areas become hotter and drier. Owls in canyons may move up in elevation and microhabitats change, possibly into mixed conifer forest habitat adjacent to canyons and/or northward into currently unoccupied canyon habitat.

Changes in Demographic Rates. Climate change also could affect demography of spotted owls as well as their prey, competitors, and predators. Annual weather patterns are known to affect survival and reproduction of spotted owls (Franklin et al. 2000, 2004; North et al. 2000; Seamans et al. 2002; LaHaye et al. 2004; Olson et al. 2004; Dugger et al. 2005). For example, Seamans et al. (2002) found positive relationships between precipitation (i.e., precipitation during the previous year, during the previous winter, or during the previous monsoon season) and survival and reproductive output in two populations of Mexican spotted owls.

Temperature and precipitation may influence the owl's reproductive output directly, or indirectly through effects on prey abundance. Examples of direct effects could include: 1) negative effects of increased temperature on energy and water use (e.g., Ganey et al. 1993, Weathers et al. 2001), or 2) negative effects of increased precipitation during the nesting period on survival and especially reproduction (e.g., Franklin et al. 2000, North et al. 2000, LaHaye et al. 2004; note that this has not been documented in Mexican spotted owls). Seamans et al. (2002) speculate that precipitation was probably important in providing indirect benefits to Mexican spotted owls. Specifically, germination and sprouting of annual plants during the monsoon may extend the breeding season of small mammals in the Southwest, and may increase overwinter survival and therefore abundance of prey. Principal prey species in habitats occupied by Mexican spotted owls typically exhibit high temporal variability in abundance (Ward and Block 1995, Ward 2001, Block et al. 2005), and Ward and Block (1995) noted that a year of high reproductive output by spotted owls in the Sacramento Mountains of New Mexico was accompanied by an irruption of deer mice. Interactions among temperature and moisture regimes may differ across elevational gradients, thus affecting small mammal populations differently in different areas (Seamans et al. 2002).

Perry et al. (2011) modeled how population dynamics and extinction risk might be affected by climate change for three spotted owl populations in the southwest. The authors used stochastic, stage-based matrix models parameterized with vital rates linked to annual variation in temperature and precipitation to project owl populations forward in time under three IPCC emission scenarios relative to contemporary climate. Their results suggested that Mexican spotted owls may be highly vulnerable to climate change, even in the core of the subspecies range in central Arizona and west-central New Mexico, whereas California spotted owls in southern California may be comparatively more resilient to climate change. Warm temperatures and low precipitation appeared to have a negative influence on both reproduction output and survival rates in Arizona and New Mexico. Perry et al (2011) conclude that fecundity and survival generally were more sensitive to increases in temperature than declines in precipitation.

Changes in Co-evolved Interactions. Changing climates also could influence distribution patterns and abundance of major prey species, as well as potential competitors with and

predators on spotted owls. It seems likely that prey species, which are strongly influenced by weather (Vickery and Bider 1981) and have shorter generation times than spotted owls, would respond to such changes more quickly than would the owls themselves. The magnitude and direction of such potential changes remain unknown at this time, however. Similarly, changes in forest composition could strongly influence abundance and distribution of owl competitors and predators (see below). Again, however, the magnitude and direction of such potential changes remain unknown at this time.

In rocky canyon habitats in southern Utah, Willey (2007) conducted demographic studies of potential spotted owl prey within three owl territories in the Paria River watershed. Severe drought occurred during the onset of research (2000-2003), followed by significant increases in local precipitation during 2004-2006. Prey abundance and species richness increased with increased precipitation. During the 2000-2003 dry period, spotted owl reproduction dropped, females were no longer detected, and by 2003, only males were detected at the sites. Increased precipitation during 2004-2006 resulted in recolonization of all three sites by females. Thus, precipitation appeared to exert strong effect on prey abundance, site occupancy, and reproductive rates by owls (Willey 2007).

Direct Loss of Habitat. Mexican spotted owls may experience direct loss of habitat due to increased frequency of high severity fires (Westerling et al. 2006), bark beetle outbreaks, and direct warming of habitats as a result of climate change. Using tree-ring data, Swetnam and Lynch (1993) and Ryerson et al. (2003) examined the relationships between western spruce budworm outbreaks and climate variability over multi-century periods. They found that periods of increased and decreased budworm activity coincided with wetter and drier periods, respectively. Allen et al. (2010) and Breshears et al. (2009) documented recent examples of drought- and heat-related forest stress and dieback (defined as tree mortality noticeably above usual mortality levels) from all forested continents. Drought-related mortality occurred in forest types with tree species that included conifer and hardwood tree species found within spotted owl habitat. Ganey and Vojta (2011) documented high and accelerating tree mortality in mixed-conifer and ponderosa pine forests within the range of Mexican spotted owls in northern Arizona. This drought-mediated mortality was nonrandom with respect to tree species and size classes, and is rapidly changing the composition of these forests. Increasing levels of drought, along with associated insect outbreaks and wildland fires, could rapidly and dramatically affect the distribution, amount, and composition of spotted owl habitat.

Interactions with Competitors and Predators. As discussed above, northern spotted owls are being affected by a direct competitor, the barred owl, which recently expanded its range into the Pacific Northwest and California (Dark et al. 1998, Courtney et al. 2004, Monahan and Hijmans 2007, Livezey 2009a). Barred owls appear to be competitively excluding northern spotted owls from preferred habitats in parts of their range and hybridize with spotted owls, and barred owls have been identified as a serious threat to continued persistence of northern spotted owls. Reasons for the recent range expansion by barred owls are unclear. Some authors have implicated climate change as a significant factor facilitating the range expansion (Monahan and Hijmans 2007), whereas other authors dispute this conclusion, citing anthropogenic changes as likely drivers (Livezey 2009a, b). In addition, it is possible that warmer, drier conditions might

favor such potential predators as great-horned owls (see predation discussion under Factor C, in II.H.3.c. above).

Reduction in Population Size. At this time, little evidence exists suggesting that climate change is causing reductions in Mexican spotted owl population size. Seamans et al. (1999) estimated that two populations within the conifer forests of the UGM EMU (formerly RU) were declining at roughly 10% per year, but the causes of the declines were unknown. The owl remains well distributed in the area, suggesting that this estimated decline has not been borne out in subsequent years. As mentioned above, however, both survival and reproduction were positively correlated with precipitation in two populations studied (Seamans et al. 1999). This suggests that increasingly warmer and drier climates may not benefit spotted owls.

We explored the vulnerability of Mexican spotted owls to climate change using current knowledge of Mexican spotted owl ecology and three tools designed to allow assessment of effects of climate change on species of interest. The assessment tools used included: 1) NatureServe *Climate Change Vulnerability Index* (see Young et al. 2010); 2) Environmental Protection Agency *Framework for Categorizing the Relative Vulnerability of Threatened and Endangered Species to Climate Change* (Galbraith and Price 2009); and, 3) Rocky Mountain Research Station's *Species Vulnerability Assessment Method* (Bagne and Finch 2008). These tools use different approaches to evaluate vulnerability to climate change, and results varied somewhat among tools. All three tools indicated at least moderate vulnerability to climate change for the Mexican spotted owl, however, along with fairly high uncertainty in the ratings. Thus, these assessments, although crude, provide further support for the hypothesis that the owl and its habitat are vulnerable to changing climates.

In summary, climate change will likely influence spotted owl habitat significantly, but the nature of such influence is difficult to predict. Further, addressing the causes of climate change is beyond the scope of this Recovery Plan. Therefore, our recommendations in Appendix C include mitigation strategies (i.e., actions that reduce causes of stress) and adaptation strategies (i.e., actions that help forested ecosystems accommodate change) designed to enhance forest resiliency and provide sustainable habitat so that Mexican spotted owls may better withstand the impacts of climate variability.

4. Factors Affecting the Status of the Mexican Spotted Owl in Mexico

Habitat modification is the main threat to biodiversity in Mexico and in many parts of the world. Data through 1993 show that primary vegetation has decreased 54% in the entire country, considering the original potential coverage of primary vegetation (CONABIO 2009). Based on this, habitat loss and fragmentation are the main threats to the Mexican spotted owl (Márquez-Olivas et al., 2002). Habitat modifications include land-use changes for agriculture and cattle production, wildland fires, and illegal logging, which have negative effects on its reproduction and dispersal (Márquez-Olivas et al. 2002, CONABIO 2009).

In southwestern Chihuahua and the rest of the Sierra Madre Occidental, activities by local residents are the main threats to the Mexican spotted owl; e.g., legal and illegal logging, overgrazing, and firewood harvest (Tarango et al. 1997). A study by CONANP and

PRONATURA-SUR in 2008 concluded that in the Sierra Madre Occidental, large-scale logging operations have destroyed large areas of tree coverage to supply the cellulose industry (paper production) and forest clearing has been conducted to prevent wildland fires and the spread of pests (CONANP-Pronatura Sur, 2008). Several researchers also had suggested that the clearing of trees on this area, especially cutting of mature forests, caused the disappearance of the imperial woodpecker and declines in western thick-billed parrot populations (CONANP-Pronatura Sur, 2008).

In the Sierra Madre Oriental, wildland fires scorched areas of old-growth forests. Two hundred ha (494 ac) of mature forest were lost in El Taray in 2006, and 400 ha (988 ac) were burned in the Municipio de Santiago Nuevo León in 2008 (CONANP-Pronatura Noreste, 2008).

In some areas like the Parque Nacional Sierra de San Pedro Mártir, another threat to forest habitat of *Strix occidentalis lucida* is the spread of bark beetles during the dry season. Since these insects are part of the ecology of the area, the full scope of this problem should be studied (CONANP 2006).

In the area in the Transvolcanic Range where this species is reported, it faces problems related to the proximity to urban areas and increased habitat modification and decreased original tree coverage (Navarro-Sigüenza et al. 2007). Human over-population and anthropogenic activities like agriculture and cattle raising and other land-use changes are threats to the different species of birds and other organisms on this area (Navarro-Sigüenza et al. 2007). This area also faces deforestation, illegal mining, poaching, burning of natural vegetation to increase cattle forage, and wildland fires by arson, all of which increase damage to the region (Navarro-Sigüenza et al. 2007).

There is extensive overlap between the range and habitat used by the Mexican spotted owls and thick-billed parrots in Mexico, and potentially in the United States. As an obligate cavity nester, the thick-billed parrot uses large-diameter trees and snags within mixed conifer forests for nesting. As described in this Recovery Plan, the maintenance and creation of large diameter trees and snags is an important factor in managing for nesting and roosting habitat for the owl. There is potential for collaboration regarding the implementation of conservation actions, particularly in Mexico, for the spotted owl and the thick-billed parrot, as actions taken to promote and maintain habitat in mature mixed conifer forest and reduce the risk of high-severity fire will benefit both species where their ranges overlap.

B. Crosswalk Between Threats and Management Recommendations (see table below)

Table 11.2. Crosswalk Between Threats and Management Recommendations

Table II.2. Crosswalk Between Threats and Management Recommendations											
		MANAGEMENT ACTION									
	Appendix Section	C.3.a	C.3.a	C.3.a.v	C.3.b.i	C.3.b.i	C.3.b.ii	C.3.c	C.4.a	C.4.a	C.4.a
Part II Section	**THREAT**	Within PACs, outside cores	Within PACs, within cores	Within PACs, post disturbance salvage	Recovery habitat, nest/roost habitat	Recovery habitat, foraging/non-breedinghabitat	Recovery Riparian habitat	Other forest and woodland types	Wildland fire suppression	Burned area emergency response and rehabilitation	Prescribed fire and hazardous fuels treatments
	FACTOR A										
II.H.3.a.*i*	Stand-replacing Fire	X	X	X	X	X	X	X			X
II.H.3.a.*ii*	Fire Suppression								X		
II.H.3.a.*iii*	Burned Area Response			X						X	
II.H.3.a.*iv*	Wildland-urban Interface (WUI) Treatments	X	X		X	X	X	X			X
II.H.3.a.*v*	Silvicultural Treatments	X	X		X	X	X	X			X
II.H.3.a.*vi*	Insects and Disease	X	X		X	X					
II.H.3.a.*vii*	Grazing	X	X		X	X	X				
II.H.3.a.*viii*	Energy Development	X	X		X	X					
II.H.3.a.*ix*	Roads and Trails	X	X		X	X	X				
II.H.3.a.*x*	Land Development	X	X		X		X				
II.H.3.a.*xi*	Recreation	X	X		X		X				
II.H.3.a.*xii*	Water Development					X	X				
	FACTOR B										
II.H.3.b.*i*	Commericial Exploitation										
II.H.3.b.*ii*	Recreational Exploitation										
II.H.3.b.*iii*	Scientific Exploitation										
II.H.3.b.*iv*	Educational Exploitation										

Table of Crosswalk Between Threats and Management Recommendations											
		MANAGEMENT ACTION									
	Appendix Section	C.3.a	C.3.a	C.3.a.v	C.3.b.i	C.3.b.i	C.3.b.ii	C.3.c	C.4.a	C.4.a	C.4.a
Part II Section	**THREAT**	Within PACs, outside cores	Within PACs, within cores	Within PACs, post disturbance salvage	Recovery habitat, nest/roost habitat	Recovery habitat, foraging/non-breeding habitat	Riparian habitat	Other forest and woodland types	Wildland fire suppression	Burned area emergency response and rehabilitation	Prescribed fire and hazardous fuels treatments
	FACTOR C										
II.H.3.c.*i*	West Nile Virus										
II.H.3.c.*ii*	Predation										
	FACTOR D										
II.H.3.d.*i*	National Fire Plan and Policy	X	X	X	X	X	X	X			X
II.H.3.d.*ii*	Healthy Forests Initiative	X	X		X	X	X	X			X
II.H.3.d.*iii*	Heathy Forests Restoration Act of 2003	X	X		X	X	X	X			X
II.H.3.d.*iv*	Omnibus Public Land Management Act of 2009, Title IV Landscape Restoration	X	X		X	X	X	X			X
II.H.3.d.*v*	Stewardship Contracting Authority										
	FACTOR E										
II.H.3.e.*i*	Noise and Disturbance	X	X	X							X
II.H.3.e.*ii*	Barred Owls										
II.H.3.e.*iii*	Direct Fatalities										
II.H.3.e.*iv*	Climate Change	X	X		X	X	X	X			X

Table of Crosswalk Between Threats and Managament Recommendations												
		MANAGEMENT ACTION										
	Appendix C Section	C.4.b	C.4.c	C.4.d	C.4.e	C.4.f	C.4.g	C.4.h	C.4.i	C.4.j	C.4.k	C.4.l
Part II Section	**THREAT**	Insects and disease	Grazing	Energy related development	Land development	Water development	Recreational exploitation	Recreational disturbance	Scientific exploitation	Noise	Climate change	West Nile virus
	FACTOR A											
II.H.3.a.*i*	Stand-replacing Fire	X									X	
II.H.3.a.*ii*	Fire Suppression											
II.H.3.a.*iii*	Burned Area Response											
II.H.3.a.*iv*	Wildland-urban Interface (WUI) Treatments										X	
II.H.3.a.*v*	Silvicultural Treatments	X									X	
II.H.3.a.*vi*	Insects and Disease	X										
II.H.3.a.*vii*	Grazing		X									
II.H.3.a.*viii*	Energy Development			X								
II.H.3.a.*ix*	Roads and Trails		X									
II.H.3.a.*x*	Land Development				X							
II.H.3.a.*xi*	Recreation							X				
II.H.3.a.*xii*	Water Development					X						
	FACTOR B											
II.H.3.b.*i*	Commericial Exploitation					X						
II.H.3.b.*ii*	Recreational Exploitation						X					
II.H.3.b.*iii*	Scientific Exploitation								X			
II.H.3.b.*iv*	Educational Exploitation								X			

Table of Crosswalk Between Threats and Management Recommendations												
		MANAGEMENT ACTION										
	Appendix C Section	C.4.b	C.4.c	C.4.d	C.4.e	C.4.f	C.4.g	C.4.h	C.4.i	C.4.j	C.4.k	C.4.l
Part II Section	**THREAT**	Insects and disease	Grazing	Energy development	Land development	Water development	Recreational exploitation	Recreational disturbance	Scientific exploitation	Noise	Climate change	West Nile virus
	FACTOR C											
II.H.3.c.*i*	West Nile Virus											X
II.H.3.c.*ii*	Predation											
	FACTOR D											
II.H.3.d.*i*	National Fire Plan and Policy	X									X	
II.H.3.d.*ii*	Healthy Forests Initiative	X									X	
II.H.3.d.*iii*	Heathy Forests Restoration Act of 2003	X									X	
II.H.3.d.*iv*	Omnibus Public Land Management Act of 2009, Title IV Landscape Restoration	X									X	
II.H.3.d.*v*	Stewardship Contracting Authority											
	FACTOR E											
II.H.3.e.*i*	Noise and Disturbance			X	X			X		X		
II.H.3.e.*ii*	Barred Owls											
II.H.3.e.*iii*	Direct Fatalities											
II.H.3.e.*iv*	Climate Change										X	

PART III. RECOVERY STRATEGY, GOAL, OBJECTIVES, AND RECOVERY CRITERIA

A. Recovery Strategy

This Recovery Plan presents realistic and attainable goals for recovering the owl and its ultimate delisting, involving forest habitat management and vigilant monitoring. Implementing this Recovery Plan involves balancing conflicting risks (see Box III.1). The goals are flexible in that they allow local land managers to make site-specific decisions. Although the Mexican spotted owl was originally listed due to threats from destruction and modification of habitat caused by timber harvest and fires (Listing Factor A), increased predation associated with habitat fragmentation (Listing Factor C), and lack of adequate protective regulations (Listing Factor D), the threats of timber harvest and inadequate regulations have been largely addressed since the time of listing. Currently, the Mexican spotted owl is threatened primarily by habitat degradation and loss of old growth nesting habitats through stand-replacing wildland fire (Listing Factor A). Threats of predation, disease, parasites (Listing Factor C), starvation, accidents, and potential interactions of threat factors with climate change (Listing Factor E) also areconsidered to be issues. To accomplish the recovery of the Mexican spotted owl, the recovery strategy has six key elements designed to conserve the Mexican spotted owl throughout its range: 1) protecting existing owl sites (PACs); 2) managing for recovery nest/roost habitat to replace that lost to fire and other events and to provide additional sites for an expanding population; 3) managing threats; 4) monitoring population trends and habitat; 5) monitoring plan implementation; and, 6) building partnerships to facilitate recovery.

Success of the plan, however, hinges on the commitment and coordination among the Mexican government, U.S. Federal and state land-management organizations, sovereign Indian nations, and the private sector to ensure that the spirit and intent of the plan is executed as envisioned by the Recovery Team. Although much of the recovery strategy is focused on the U.S. range of the bird, this strategy can and should be implemented in Mexico. At this time, a PACE (Program of Conservation Actions for listed species, similar to a recovery plan) has not been developed for the Mexican spotted owl in Mexico. Under the proposed recovery criteria, the owl could be recovered within 10 years of implementing this revised Recovery Plan. Maintaining and restoring forest health to reduce the threat of stand-replacing wildland fire, while creating a mosaic of suitable Mexican spotted owl habitats and protecting existing populations, will be achieved by land use management, facilitated by section 7 consultations and agreements. The recovery criteria require monitoring. Without careful and rigorous application of monitoring, there would be no objective basis for delisting the owl.

B. Recovery Goal

The ultimate goal of the Recovery Plan is to sustain owl populations to the point that the owl can be removed from the list of endangered and threatened species.

C. Recovery Objectives

Objectives are to support the population of the Mexican spotted owl in the foreseeable future, and to maintain habitat conditions necessary to provide roosting and nesting habitat for the Mexican spotted owl.

D. Objective and Measurable Recovery Criteria

Section 4 of the ESA requires that recovery plans "list objective, measurable criteria which, when met, would result in a determination that the species be removed from the list." Ultimately, a delisting determination is based on a species no longer meeting the definition of "threatened" under the ESA. Such a determination requires the five-factor analysis we describe in Part II.H, where all threats are evaluated.

The recovery criteria in this plan are not binding, and it is important to note that meeting the recovery criteria provided below does not automatically result in delisting the species. Rather, a delisting decision is under the authority of the FWS Director and must undergo the rulemaking process and analyses. Both anthropogenic and non-anthropogenic threats to the Mexican spotted owl must be considered in a five-factor analysis to be sufficiently acceptable, with adequate regulatory mechanisms in place, to ensure that the species will persist into the foreseeable future. The management recommendations in this plan are believed to be necessary and advisable to achieve this goal, but the best scientific information derived from research, management experiments, and monitoring conducted at the appropriate scale and intensity should be used to test this assumption.

Two recovery criteria must be met before the Mexican spotted owl can be delisted:

(1) *Owl occupancy rates must show a stable or increasing trend after 10 years of monitoring*. The study design to verify this criterion must have a power of 90% (Type II error rate $\beta = 0.10$) to detect a 25% decline in occupancy rate over the 10-year period with a Type I error rate (α) of 0.10. The monitoring approach recommended in Part V.B and in Appendix E suggests how this might be determined. (Listing Factors A, C, and E).

(2) *Indicators of habitat conditions (key habitat variables) are stable or improving for 10 years in roosting and nesting habitat* (key habitat variables—see Table C.2 or Table C.3 in Appendix C). Habitat monitoring should be conducted concurrently with owl occupancy monitoring. Trends in all key habitat variables must be shown stable or increasing with a power of 90% (Type II error rate $\beta = 0.10$) to detect a 25% decline over the 10-year period with a Type I error rate (α) of 0.10. (Listing Factors A, C, and E).

To delist the owl, we recommend both criteria be met. Once the two criteria have been met, we would then review the regulations and known distribution of Mexican spotted owls to determine if the delisting process should proceed. At this time, we cannot describe the future desired distribution of owls across their range. For example, changes in the species' range may occur due to factors such as climate change which could result in shifts in the owl population to the northern portion of its range. In addition, anthropogenic and non-anthropogenic threats to the Mexican spotted owl must be sufficiently moderated and/or regulated for the foreseeable future,

as evidenced by the best scientific information available. The best scientific information is derived from research, management experiments, and monitoring conducted at the appropriate scale and intensity. An analysis of the five ESA listing factors must be conducted to verify that threat levels are acceptable for likely persistence of owl populations into the future.

We use the existing population and distribution of owls as the baseline for the delisting criteria. This is not an assumption that the existing population is adequate for recovery, but absent information on historical populations it is the only data point that we can use to determine population trend from this point forward. If occupancy monitoring indicates the population is stable or increasing and the habitat trend is stable or increasing, we will accept this as evidence that the population is self-sustaining. In contrast, if occupancy monitoring demonstrates a declining owl population, it will be known that the existing population is not at an adequate level to persist under the stressors the owl is undergoing on the landscape, and continued protection and/or remedial action will be needed.

E. The Delisting Process

Section 4 of the ESA governs the listing, delisting, and reclassification of species, the designation of critical habitat, and recovery planning. A codification of the general and permanent regulations regarding listing, delisting, reclassification, and critical habitat designation are published in the *Code of Federal Regulations* at 50 CFR 424. The process of delisting a species or subspecies is essentially the same as that of listing: a proposed rule describing the justification for the action is published in the *Federal Register*; a public comment period is opened, including public hearings if requested; and, within one year of the proposal, either a final rule delisting the species or a notice withdrawing the proposed rule is published in the *Federal Register*.

The Mexican spotted owl is listed as a threatened species, defined in the ESA as "…likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." According to the ESA, an endangered species is one that "…is in danger of extinction throughout all or a significant portion of its range…" Thus, to delist the Mexican spotted owl, it must be found to be sufficiently secure into the foreseeable future so that it does not meet the definition of a threatened species. In considering whether to delist a species, the same five factors considered in the listing process are evaluated (see Part II.H). While emphasis may be given to those factors leading to the species' listing, all of the factors must be evaluated in making a delisting determination.

Another factor to consider when contemplating delisting is whether a listed entity may be delisted throughout a portion of its range while other portions remain listed. The ESA definition of "species" includes "…subspecies…and any distinct population segment of vertebrate fish or wildlife…" The term "distinct population segment" (DPS) is not defined in either the ESA or its implementing regulations, but rather is described in the Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act (DPS Policy; 61 FR 4722). The DPS Policy describes a series of tests for determining whether a vertebrate population qualifies as a DPS.

The Mexican spotted owl is currently listed as a threatened subspecies throughout its range, including Mexico. However, a species may be delisted throughout a part of its range if both the delisted portion and the portion remaining in listed status meet the criteria for a DPS as set forth in the DPS policy. For example, the FWS could determine that both the U.S. and Mexican populations meet the DPS criteria and delist or otherwise reclassify one or the other separately. It is beyond the purview of this Recovery Plan to address the question of whether the U.S. or Mexico populations, or any subdivisions thereof, would qualify as a DPS. Such a determination would be made by the FWS if and when appropriate. This Recovery Plan therefore provides delisting criteria only for the subspecies as a whole.

F. Post-Delisting Monitoring

Section 4(g) of the ESA directs the FWS to implement a system, in cooperation with the states, to monitor effectively for not less than five years the status of a species or subspecies that has been delisted due to recovery. The provisions of the ESA do not apply to the delisted species during this monitoring period. However, the FWS could relist a species through the standard listing process, should monitoring or other information indicate that the species has again become threatened or endangered absent the Act's protection. Once delisting occurs, managers should consider continuing the monitoring suggested in Appendix E for consistency in continuing to assess population trends. Such policy would provide additional assurance that the results of the 10-year monitoring program are reliable assessments of population and habitat trends.

Box III.1. BALANCING CONFLICTING RISKS: MECHANICAL TREATMENTS IN OWL HABITAT

Both this Recovery Plan and the original plan (USDI FWS 1995) rest heavily on the assumption that PACs (i.e., nest and roost habitat) are important to Mexican spotted owls. Available information suggests that these areas provide special habitat features for owls, and that in many cases these PACs may be occupied for long time periods (R. J. Gutiérrez, University of Minnesota, pers. comm.). Consequently, USDI FWS (1995) largely recommended minimizing treatments in PACs (recommended thinning from below, prescribed burning), arguing that we did not understand how best to manage these areas for owls and therefore should leave them alone. This is the strategy that has largely been followed by land management agencies for the past two decades.

This strategy presents a dilemma, however. We know that the risk of stand replacing fire has increased over time. As a result, large areas have experienced such fires in recent years. Further, Mexican spotted owls nest and roost in areas featuring high canopy cover and relatively decadent stands of multi-aged and sized trees. Thus, these areas contain relatively continuous canopies and high loads of surface fuels, large numbers of snags, and multi-storied stands. These are all features that can predispose these areas to experience stand replacing fire under certain weather conditions, especially extended dry periods featuring high winds. Such conditions appear likely to become more common in the southwestern U.S., based on current climate projections (Seager et al. 2007).

Reducing fire risk in southwestern forests frequently involves mechanical thinning treatment, prescribed fire, or both activities in concert. USDI FWS (1995) recommended prescribed fire and thinning from below in PACs. However, little thinning occurred and some fire managers opted to avoid burning because the high fuel loads and seasonal restrictions combined to create an unacceptable risk that fires would escape prescription. Consequently, little fuels reduction has occurred in PACs, most remain in a fire prone condition, and many PACs have undergone significant degradation following these wildland fires.

BOX III.1, Continued

We view this situation as unsustainable in the long term. Although many owls continue to occupy burned areas, at least in the short term (summarized in Appendix B), we do not view the long-term cumulative loss of large areas of owl habitat to stand replacing fire as conducive to recovery. Further, where large numbers of PACs occur in degraded landscapes, it can place the overall landscape at risk from high severity fire. We have always tried to balance protection of owls and their habitat with minimizing impacts to those other resources, including human communities. This requires managing fire risk on the landscape, and in some cases that will require mechanical treatments in PACS. Consequently, we recommend limited treatments in PACs.

We do not view this strategy as risk free, and do not assume that all types and extents of fuels treatments will be neutral or beneficial to owls.

Unfortunately, empirical data on the effects of thinning and other mechanical forest treatments on Mexican spotted owls are nonexistent, and empirical data on effects of forest treatments on other subspecies of spotted owls (summarized in Appendix B) are sparse and difficult to interpret. Understanding how these treatments affect Mexican spotted owls is one of the major questions faced in integrating recovering this owl with plans for restoring southwestern forests. Although this has been clearly noted for years (e.g., USDI FWS 1995, Beier and Maschinski 2003, Ganey et al. 2011), no studies on this topic have been funded to date. Consequently, we can only extrapolate from the sparse data available on this topic resulting from studies of other subspecies of spotted owls. Collectively, these studies suggest that at least some kinds of mechanical forest treatments may negatively affect spotted owls. No clear guidance emerges from these studies relative to types, extents, or spatial arrangement of treatment that might minimize effects to owls. Such information is needed if management is to proceed in owl habitat. Lacking such information, managers should proceed cautiously in terms of treatment intensity and extent. That is, initial treatments should be limited in spatial extent and treatment intensity, and should be aimed at balancing reduced fire risk with maintaining the mature forest structure that seems to be favored by spotted owls. Treatments in owl habitat should be linked to rigorous monitoring of owl response, to allow us to evaluate the effects of different types and extents of treatments in an adaptive management context (see Box C.6 for details on how such monitoring might be structured). **The Recovery Team recommends mechanical treatment in PACs only if such monitoring occurs**.

PART IV. RECOVERY PROGRAM

A. Recovery Action Outline and Narrative

This outline contains *abbreviated* descriptions of actions recommended to achieve recovery as specified in the Mexican Spotted Owl Recovery Plan-First Revision. **Users should refer to the indicated section of Appendix C for detailed recommendations.** Only those recommendations implemented specifically as recovery tasks for the owl are captured in this outline; recommendations designed to lessen or avoid adverse effects of standard operational activities (e.g., minimizing erosion during road-construction activities) are not listed here. Further, specific threats with only general guidelines (see 1-5 below) are not specifically listed, but are covered under the general guidelines.

1. Establish or amend, as appropriate, land-management-planning documents to adopt the Recovery Plan recommendations as agency policy.

2. Survey planned project areas for Mexican spotted owl presence before conducting activities that may affect the Mexican spotted owl, following the Survey Protocol (Appendix D). See Appendix C for when and where surveys are recommended.

3. Maintain or enhance existing nesting/roosting habitat for Mexican spotted owls.
   - 3.1. Establish PACs at known owl sites from 1989 through the life of the Recovery Plan, including new sites located during surveys (see Appendix C for PAC-establishment procedures). Exceptions to PAC establishment or continuance are possible and are discussed in detail in Appendix C. PACs should be at least 243 ha (600 ac) in size.
   - 3.2. Conduct fuels-reduction treatments or other management actions to reduce the risk of compromising the ability of PACs to provide for successful owl nesting, following the procedures outlined in sections Appendix C (see Box III.1 for rationale). Much of the work needed to reduce fire risk in and to owl habitat can be achieved by treating areas around owl habitat.
     - 3.2.1. Conduct restoration/fuels treatments in up to 20% of the total non-core PAC area within each EMU that exhibits high fire-risk conditions, following the guidelines in section Appendix C.
     - 3.2.2. Establish a scientific committee to develop a plan for monitoring the effects of mechanical treatments on PACs.
   - 3.3. Avoid conducting activities that may disturb nesting spotted owls during the breeding season unless protocol surveys allow inference of non-nesting.

4. Manage for nesting/roosting habitat on the landscape.
   - 4.1. Identify and map nest/roost recovery habitat throughout each planning area, subregion, and/or region (see Appendix C). Recovery nest/roost habitat should be identified so that the landscape percentages recommended in Appendix C - Table C.3 are delineated.
     - 4.1.1. Where appropriate, implement management actions necessary to move recovery nest/roost habitat toward the component values recommended in Appendix C - Table C.3. The Recovery Team suspects that most nest/roost stands will achieve those values with minimal manipulation, but acknowledges that treatment may be desirable in some circumstances.

4.1.2. Conduct fuels-reduction treatments or other management actions to reduce the risk of losing important components for future spotted owl nesting/roosting habitat. Much of the work needed to reduce fire risk in and to owl habitat can be achieved by treating areas around owl habitat.

5. Manage for foraging and dispersal habitat.
   5.1. Identify and map foraging/dispersal recovery habitat (mixed-conifer, pine-oak, and riparian forests) outside of PACs and nest/roost recovery habitat (see Appendix C).
      5.1.2. Conduct fuels-reduction treatments or other management actions to reduce the risk of losing important components of owl foraging and dispersal habitat as described in Appendix C. Much of the work needed to reduce fire risk in and to owl habitat can be achieved by treating areas around owl habitat.

6. Manage specific threats as described in Appendix C – Threat-specific management recommendations.
   6.1. Implement fire-management recommendations (other than those for fuels-reduction purposes).
      6.1.1. Implement fire-suppression recommendations as described in section Appendix C.
         6.1.1.1. Conduct landscape-level fire behavior assessments to strategically locate and prioritize fire suppression activities/tactics to mitigate the effects of high-severity fire and suppression activities on PACs and recovery habitat.
         6.1.1.2. Where possible, wildland fire suppression activities should be applied that limit high-severity fire and loss of key habitat elements within PACs and recovery habitats.
         6.1.1.3. Research should be conducted to evaluate the short- and long-term correlates of wildland fire severities and their spatial extent on Mexican spotted owls and their habitat.
      6.1.2. Implement post-fire rehabilitation recommendations as described in sections Appendix C.
   6.2. Implement recommendations for forest insects and diseases as described in Appendix C.
      6.2.1. When considered a threat to owl or prey habitat, various tools—prescribed fire, thinning, other silvicultural treatments—should be used to limit the spread of insects or diseases.
   6.3. Manage livestock-grazing operations and wild ungulate impacts as described in Appendix C.
      6.3.1. As detailed in Appendix C, conduct site-specific assessments to determine appropriate utilization and/or residual levels of forage.
      6.3.2. Using the information gathered under 6.3.1. above, establish allowable-use criteria through allotment-management plans, annual operating instructions, or other appropriate mechanism, to achieve the goals described in Appendix C.
      6.3.3. Implement monitoring as described in Appendix C.
      6.3.4. Implement management actions regarding livestock and wild ungulate grazing to promote riparian health as described in Appendix C.
   6.4. Implement the land-development recommendations as described in Appendix C.

6.4.1. Managers are encouraged to pursue voluntary consultation on a case-by-case basis with local governments and developers to encourage development in areas least likely to directly influence habitat use of known owls. Development of positive incentive programs may be a feasible approach.

6.5. Implement recommendations for water development (see Appendix C).

6.5.1. Collect materials for genetic analyses to evaluate if large water developments are impeding movements and gene flow.

6.5.2. Discharge water from dams in such a way to sustain and enhance native riparian vegetation.

6.6. Manage against recreational exploitation (see Appendix C).

6.6.1. Report continued issues due to recreational exploitation of owls to the appropriate FWS Law Enforcement Office.

6.7. Minimize recreation disturbance in PACs.

6.7.1. Any construction within PACs during the non-breeding season should be considered on a case-specific basis. Modifications to existing facilities pertaining to public health, safety, and routine maintenance are excepted; however, when implementing such activities, those conducting the work should use all measures possible to avoid potential effects on owls.

6.7.2. In areas of owl occupancy, assess the impacts of currently allowed (both permitted and non-permitted) recreational activities and institute limitations as described in section Appendix C.

6.7.3. Seasonal closures of specifically designated recreational activities should be considered where disturbance to breeding owls seems likely.

6.7.4. Conduct education through signing, interpretation events, access permitting, or other information sources to inform the public of proper and legal behaviors when encountering owls.

6.8. Monitor and minimize effects of scientific exploitation as described in section Appendix C.

6.8.1. Quality-assurance and quality-control procedures should be applied to all scientific studies that may directly or indirectly affect owls or owl habitat. Quality assurance requires that study plans undergo appropriate levels of review, revision, and approval.

6.8.2. Contingency plans (e.g., how an injured owl will be treated or transported and where an injured owl will be taken) for dealing with injured owls should be included as part of the study proposal submitted with the permit application. In addition, many researchers must undergo approval of animal care and use by their employing institutions.

6.8.3. If a particular study or a particular activity results in an undue number of mortalities, FWS should convene an independent expert panel to evaluate the situation and propose recommendations to continue, adjust, or cease the activity resulting in fatalities.

6.8.4. Radio-marking spotted owls likely poses the highest risk among typical research activities. This risk may be alleviated partially by adhering to marking requirements issued by the Bird Banding Lab. We recommend that transmitter packages used on Mexican spotted owls not exceed 16 g for female owls and 14 g for male owls.

6.8.5. Any attachment methods other than backpack and tail mounts should be viewed as experimental and should be tested on captive owls before deployment in the field. If this option is not available, then experimental attachments should be tested on a very small sample of wild spotted owls, and results should be monitored before allowing widescale use of the method.

6.8.6. All radios should be attached by researchers with demonstrated expertise in handling raptors and attaching transmitter packages to raptors.

6.9. Implement actions to minimize noise disturbance within PACs during the breeding season (1 Mar - 31 Aug). If non-breeding is inferred or confirmed during approved-protocol surveys in a PAC during the breeding season, restrictions on noise disturbances should be relaxed depending on the nature and extent of the proposed disturbance.

6.9.1. Managers should, on a case-specific basis, assess the potential for noise disturbance to nesting owls.

6.9.2. Breeding-season restrictions should be considered if noise levels are estimated to exceed 69 dBA (A-weighted noise level) (~80 dBO [owl-weighted noise level, Delaney et al. 1999a]) consistently (i.e., >twice/hour) or for an extended period of time (>1 hr) within 50 m (165 ft) of nesting sites (if known) or within entire PAC if nesting sites are not known.

6.10. Implement actions to detect and, if present, monitor WNV activity as described in Appendix C.

6.10.1. Carry out well-distributed demographic studies to detect significant downward population trends.

6.10.2. Conduct spotted owl surveillance to detect the disappearance of birds from a given area.

6.10.3. Local biologists should monitor reports of avian mortality on the CDC website (www.cdc.gov) as well as those of state and county health departments.

6.10.4. If any of the above situations lead to suspicion of a WNV epizootic, conduct surveillance for the disease using standard arbovirus surveillance techniques.

6.10.5. Biologists who become aware of spotted owl captures for other purposes should look into asking researchers to collect saliva swabs or other minimally invasive samples. If researchers are also collecting blood or other tissue samples, testing of those for WNV antibodies is advised.

7. Monitor owl population as described in Part V.B and Appendix E – Monitoring.

7.1. Coordinate among administrative units to develop occupancy-monitoring design and secure funding. FWS will assume the initial lead role by convening representatives from appropriate administrative units in addition to appropriate scientific expertise.

7.2. Conduct a landscape analysis to define the sampling frame to include all possible owl habitat.

7.3. Develop sampling strata for the allocation of samples to reduce sampling variance.

7.4. Develop sampling protocols.

7.5. Have monitoring design reviewed by scientific experts and revise accordingly.

7.6. Implement the monitoring design.

8. Develop and implement habitat monitoring as described in Appendix E – Monitoring.

8.1. Coordinate among administrative units and FIA to develop habitat-monitoring design

and secure funding.

8.2. Conduct a landscape analysis to define the sampling frame to include all possible owl habitat.
8.3. Develop sampling strata for the allocation of samples to reduce sampling variance.
8.4. Develop sampling protocols.
8.5. Have monitoring design reviewed by scientific experts and revise accordingly.
8.6. Implement the monitoring design.

9. Implement research to inform recovery as described in Part V.F in the U.S. and Mexico.
   9.1. Conduct research to answer questions related to habitat.
      9.1.1. Which habitat features directly influence reproduction and/or survival of Mexican spotted owls?
      9.1.2. Which habitat features indirectly influence reproduction and/or survival of Mexican spotted owls by enhancing prey availability?
      9.1.3. How should these features be arranged spatially on the landscape to optimize owl fitness and habitat quality?
      9.1.4. How do stochastic environmental disturbances (particularly unplanned wildland fire) alter key habitat constituents and owl demography?
      9.1.5. Which habitat features help buffer the influence of weather effects on reproduction and survival?
      9.1.6. How do various planned management activities alter key habitat constituents (including prey) and owl demography?
      9.1.7. What is the probability that nest/roost conditions recommended in the plan will become recovery habitat for roosting and/or nesting by Mexican spotted owls?
      9.1.8. Which silvicultural prescriptions are best suited for creating and sustaining habitats used by Mexican spotted owls for various activities like roosting, nesting, foraging, and dispersal?
      9.1.9. Which types of planned burning regimes and methods will promote development of the owl's roosting, nesting, and foraging habitat?
      9.1.10. What proportion of Mexican spotted owl populations migrate seasonally, where are winter habitats located, what habitat features do owls use to select these areas, and how important are these areas for owl dispersal and survival?
      9.1.11. How will climate change alter distribution, structure, and composition of owl habitat?
      9.1.12. How will climate change influence owl and prey distribution and abundance?
      9.1.13. If livestock grazing occurs within owl nesting, roosting, and foraging habitats, what livestock grazing strategies can be implemented to best maintain suitable habitat conditions for owl prey species and alleviate grazing impacts on the development of future owl nesting/roosting habitats (e.g., oak/cottonwood/willow/alder trees)?
      9.1.14. What are the effects of various recreational activities (hiking, climbing, OHV use) on Mexican spotted owl behavior, habitat use and demography? How can managers mitigate potential effects in high-use areas?

9.1.15. If salvage logging is needed after a disturbance event (e.g., fire, insect/disease outbreak), how can it be implemented to maintain and protect existing habitat features or accelerate the development of future owl habitat?

9.2. Conduct research related to biological community interactions.
- 9.2.1. Are parasites, disease, predation, and competition limiting Mexican spotted owl populations?
- 9.2.2. What are the effects of invasive pathogens like WNV?
- 9.2.3. What is the relative influence of other predators on common prey of the Mexican spotted owl?
- 9.2.4. What environmental conditions will lead to increased effects of community-level interactions?
- 9.2.5. What types of management actions are necessary to alleviate deleterious community-level interactions?
- 9.2.6. How might climate change alter these factors and/or their impacts on Mexican spotted owls?
- 9.2.7. How will planned habitat treatments influence different biological interactions that can limit Mexican spotted owl populations, and how do these effects vary across spatial and temporal scales?

9.3. Conduct research involving population structure.
- 9.3.1. What are the relative numerical and genetic contributions of core and exterior populations?
- 9.3.2. Are subpopulations within and between EMUs connected?
- 9.3.3. What habitats and large-scale habitat configurations are required to maintain adequate survival rates during juvenile dispersal or adult migration?
- 9.3.4. What is the optimal arrangement of owl numbers and genetic mix that will lead to persistent populations at various time scales?
- 9.3.5. Which management activities help to ensure a well distributed set of functioning subpopulations? Which hinder this goal?
- 9.3.6. What are the potential impacts of climate change on connectivity of owl populations throughout their range?

9.4. Conduct research involving ecosystem function.
- 9.4.1. What are the effects of implementing this Recovery Plan on ecosystem structure and functions like soil erosion, water yield, and nutrient flow?
- 9.4.2. What are the effects of implementing this Recovery Plan on plant community structure, composition, and sustainability?
- 9.4.3. How has the implementation of this Recovery Plan affected long-term restoration of forested systems?
- 9.4.4. How are other focal wildlife species responding to conservation guidelines in this Recovery Plan?
- 9.4.5. How might this Recovery Plan be adjusted to mitigate potentially deleterious effects on other ecosystem attributes?
- 9.4.6. What are the potential implications of climate change to resilience of the ecosystems that support Mexican spotted owls, and how can we best balance increasing resilience in those systems with maintaining owl habitat?

9.5. Conduct research specific to Mexico, where less research has been conducted.

9.5.1. What is the range, distribution, and abundance of the Mexican spotted owl in Mexico?
9.5.2. What is the population trend in Mexico?
9.5.3. What factors are threatening the status of the Mexican spotted owl in Mexico?
9.5.4. What actions can remedy factors negatively affecting the Mexican spotted owl and encourage factors positively affecting the species?
9.5.5. What is the most effective approach to creating an education and outreach program about the Mexican spotted owl in Mexico?

10. Develop and conduct plan implementation oversight and coordination.
    10.1. Ensure that EMU Working Teams have primary implementation oversight.
        10.1.1. Review current Working Team membership and broaden as appropriate.
        10.1.2. Develop charter and operating procedures.
        10.1.3. Meet with members of the Recovery Team to ensure consistent interpretation of the Recovery Plan.
        10.1.4. Conduct workshops with parties responsible for implementing the Recovery Plan.
        10.1.5. Provide feedback to FWS and the Recovery Team on implementation of the Recovery Plan, including impediments and recommendations.
    10.2. Implement continuing functions of the Recovery Team.
        10.2.1. Coordinate regularly with Working Teams to receive feedback on Recovery Plan implementation.
        10.2.2. Meet annually or as needed to consider Working Team recommendations, review new research findings, and generally assess plan implementation.
        10.2.3. Make recommendations to FWS on plan clarifications and adjustments.
    10.3. Establish a centralized Mexican spotted owl information repository.

PART V. IMPLEMENTATION AND OVERSIGHT

A. Implementation Schedule

Disclaimer: The Implementation Schedule that follows outlines actions and estimated costs for the Recovery Plan for the Mexican spotted owl, as set forth in this Recovery Plan. It is a guide for meeting the recovery goals outlined in this plan. This schedule indicates action priorities, action numbers, action descriptions, duration of actions, the parties responsible for actions (either funding or carrying out), and estimated costs. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. When more than one party has been identified, the proposed lead party is indicated by an (*). The listing of a party in the Implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s). For further information on selected columns see the Key to the Implementation Schedule (Table V.1) by Column (below).

Key to the Implementation Schedule (Table V.1) by Column:

Priority Number:

1) Actions necessary to prevent extinction or irreversible decline.
2) Actions necessary to prevent extinction or a significant decline in population or habitat, or other effect short of extinction.
3) All other actions necessary to provide for full recovery.

Action Number:

Refers to corresponding action number in the Recovery Action Outline and in Appendices.

Recovery Criterion Number:

Corresponds to the appropriate recovery criteria which the action will help achieve.

Action Duration:

Continual, Ongoing, Unknown, or actual number of consecutive years. If periodic, then the frequency should be noted under Comments (e.g., "every 3 years"). Numerical values are the anticipated number of years to complete the action. “Ongoing” refers to actions that are currently being implemented and are recommended to continue. “Continuous” actions are those not currently being implemented, but that are recommended to be implemented over the course of Recovery Plan implementation.

Responsible Party:

All = all interested parties, as applicable
BLM = Bureau of Land Management
BR = Bureau of Reclamation
Counties = applicable counties within the range of the Mexican spotted owl
FS = U.S. Forest Service
RMRS = Rocky Mountain Research Station, Forest Service
FWS = U.S. Fish and Wildlife Service
MX = Mexico

NPS = National Park Service
RT = Mexican Spotted Owl Recovery Team
States = States of AZ, CO, NM, TX, and UT as applicable via their agencies:
AGFD = Arizona Game and Fish Department
CDOW = Colorado Department of Wildlife
NMDGF = New Mexico Department of Game and Fish
TXPWD = Texas Parks and Wildlife Department
UDWR = Utah Division of Wildlife Resources
Tr. = Native American Tribes
Univ. = Universities
USGS = U.S. Geological Survey
WTs = Ecological Management Unit Working Teams

Cost Estimate:
Figures given may vary substantially depending on scope of implementation.
When zero cost is shown it is under the assumption that the action is part of ongoing land-management activities to which owl considerations add little or no cost.
"Costs captured below" indicates that costs of an activity are broken down into the costs for the relevant subactivities.
"Costs captured above" indicates that costs for individual subactivities are aggregated into a total cost for the larger activity, since the subactivities have no independent utility apart from collectively supporting the larger effort.

Table V.1. Implementation Schedule for the Mexican Spotted Owl Recovery Plan, First Revision

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
2	1.	Adopt Recovery Plan recommendations through land-management-planning documents.	1, 2	1	FS, NPS, BLM, MX, Tr.	No	1,000	1,000	0	0	0	0	
2	2.	Survey project areas for Mexican Spotted Owls.	1, 2	Ongoing	Feds, Tr., MX	No	2,500	250	250	250	250	250	
1	3.	Maintain/enhance nesting/roosting habitat.	1, 2	Ongoing		No	0	0	0	0	0	0	
1	3.1.	Establish PACs.	1, 2	Ongoing	Feds, Tr., MX	No	1,000	100	100	100	100	100	
1	3.2.	Conduct treatments to reduce fire risk.	1, 2	Ongoing	FS, NPS, Tr., MX	No	0	0	0	0	0	0	
1	3.2.1.	Treat up to 20% of high risk PAC areas.	1, 2	Continuous	FS, MX, NPS, Tr.	No	0	0	0	0	0	0	
2	3.2.2.	Scientific committee to develop monitoring plan for treated PACs	1, 2	Continuous	FWS	Yes	0	0	0	0	0	0	
2	3.3.	Avoid disturbing nesting owls (seasonal restriction).	1	Ongoing	Feds, Tr., MX	No	1,000	100	100	100	100	100	
2	4.	Manage for nesting/roosting recovery habitat.	2	Ongoing		No							Costs captured below.
2	4.1.	Identify and map recovery nest/roost habitat.	2	Ongoing	BLM, FS, NPS, Tr., MX	No	2,000	200	200	200	200	200	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
2	4.1.2.	Manage fuels in recovery habitat.	2	Ongoing	FS, NPS, Tr., MX	No	0	0	0	0	0	0	
2	5.	Manage for recovery foraging/non-breeding habitat.	2	Ongoing	BLM, FS, NPS, Tr., MX	No							Costs captured below.
2	5.1.	Identfy and map foraging/non-breeding recovery habitat.	2	Ongoing	BLM, FS, NPS, Tr., MX	No	2,000	200	200	200	200	200	
2	5.1.2.	Conduct treatments to improve resiliency of foraging/non-breeding components.	1, 2	Ongoing	BLM, FS, NPS, Tr., MX	No	0	0	0	0	0	0	
2	6.	Manage specific threats.	1, 2	Ongoing									Costs captured below.
2	6.1.	Implement fire-management recommendations.	1, 2	Continuous	FS, NPS, Tr., MX	No							Costs captured below.
2	6.1.1.	Implement fire-supression recommendations.	1, 2	Continuous	FS, NPS, Tr., MX	No							Costs captured below.
3	6.1.1.1.	Conduct landscape-level fire-behavior assessments.	1, 2	5	All	No	1,000	200	200	200	200	200	
3	6.1.1.2.	Limit supression activities within PACs and recovery habitats.	1, 2	Ongoing	BLM, FS, NPS, Tr., MX	No	1,000	100	100	100	100	100	
3	6.1.1.3.	Conduct research to evaluate fire severities related to owl habitat.	1, 2	5	FS, NPS, Tr., MX	No	500	100	100	100	100	100	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
3	6.1.2.	Implement post-fire rehabilitation recommendations.	2	Continuous	FS, NPS, Tr., MX	No	100	10	10	10	10	10	
2	6.2.	Implement forest insects and diseases recommendations.	1, 2	Ongoing									No costs (see below)
2	6.2.1.	Implement actions to limit spread of deleterious insects and diseases.	1, 2	Ongoing	FS, NPS, Tr., MX	No	0	0	0	0	0	0	
2	6.3.	Manage livestock-grazing operations and wild ungulate impacts.	1, 2	Ongoing									Costs captured below.
2	6.3.1.	Conduct assessments to determine appropriate utilization and/or residual levels of forage.	1, 2	Ongoing	FS, BLM, Tr., MX	No	0	0	0	0	0	0	
2	6.3.2.	Establish allowable-use criteria.	1, 2	Continuous	FS, BLM, Tr., MX	No	0	0	0	0	0	0	
2	6.3.3.	Implement range monitoring.	1, 2	Ongoing	FS, BLM, Tr., MX	No	0	0	0	0	0	0	
2	6.3.4.	Implement actions to promote riparian health.	1, 2	Ongoing	Feds, States, Tr., MX	No	500	50	50	50	50	50	
2	6.4.	Implement land-development recommendations.	1, 2	Continuous									Costs captured below.
2	6.4.1.	Pursue voluntary measures to reduce development impacts.	1, 2	Continuous	States, Counties	No	200	20	20	20	20	20	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
3	6.5.	Implement recommendations for water development.	1, 2	Continuous									Costs captured below.
3	6.5.1.	Conduct studies to evaluate impediment of movement and gene flow.	1	3	USGS	No	300	100	100	100	0	0	
2	6.5.2.	Discharge water from dams to sustain/enhance native riparian vegetation.	1, 2	Continuous	BR	No	100	10	10	10	10	10	
3	6.6.	Manage against recreational exploitation.	1	Ongoing									Costs captured below.
3	6.6.1.	Report continued issues due to recreational exploitation of owls to FWS Law Enforcement Office.	1	Ongoing	Feds	Yes	10	1	1	1	1	1	
3	6.7.	Minimize recreational disturbance in PACs.	1	Ongoing									Costs captured below.
2	6.7.1.	Evaluate construction within PACs on a case-specific basis.	1	Ongoing	FS, NPS, BLM, Tr., MX	No	100	10	10	10	10	10	
2	6.7.2.	Assess the impacts of currently allowed recreational activities and institute limitations.	1	Ongoing	FS, NPS, BLM, Tr., MX	No	100	10	10	10	10	10	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
2	6.7.3.	Consider seasonal closures of specifically designated recreational activities.	1	Ongoing	FS, NPS, BLM, Tr., MX	No	100	10	10	10	10	10	
3	6.7.4.	Inform the public of proper and legal behaviors when encountering owls.	1	Continuous	FWS, FS, NPS, BLM, Tr., MX	No	10	1	1	1	1	1	
2	6.8.	Monitor and minimize effects of scientific exploitation.	1	Continuous									Costs captured below.
2	6.8.1.	Apply quality-control procedures to scientific studies.	1	Continuous	FWS	Yes	10	1	1	1	1	1	
3	6.8.2.	Require contingency plans for dealing with injured owls.	1	1	FWS	Yes	20	20	0	0	0	0	
2	6.8.3.	Convene an independent expert panel to evaluate mortalities, make adjustments.	1	2	FWS	Yes	20	10	10	0	0	0	
2	6.8.4.	Ensure that radio-marking adheres to FWS Bird Banding Lab recommendations.	1	1	FWS	Yes	5	5	0	0	0	0	
2	6.8.5.	Ensure that attachment methods other than tail and backpack mounts are tested on captive owls then a small sample of wild spotted owls.	1	2	FWS	Yes	20	10	10	0	0	0	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
2	6.8.6.	Ensure that only experienced personnel attach radios.	1	Continuous	FWS	Yes	0	0	0	0	0	0	
2	6.9.	Implement actions to minimize noise disturbance within PACs during breeding season.	1	Ongoing									Costs captured below.
2	6.9.1.	Assess potential for noise disturbance to nesting owls.	1	Ongoing	FS, NPS, BLM, Tr., MX	No	100	10	10	10	10	10	
2	6.9.2.	Consider breeding-season restrictions.	1	Ongoing	FS, NPS, BLM, Tr., MX	No	100	10	10	10	10	10	
3	6.10.	Implement actions to detect/monitor West Nile Virus activity.	1	Continuous									Costs captured below.
3	6.10.1.	Carry out demographic studies to detect possibility of downward population trends.	1	10	FS-RMRS, FWS	No	2,000	200	200	200	200	200	
3	6.10.2.	Conduct owl surveillance and report extirpations.	1	Ongoing	FS, NPS, BLM, Tr., MX	No	500	50	50	50	50	50	
3	6.10.3.	Monitor avian mortality on CDC, state, and county health department websites.	1	Continuous	Counties	No	10	1	1	1	1	1	
2	6.10.4.	If suspicion of West Nile Virus presence, implement arborvirus surveillance techniques.	1	Continuous	Counties	No	0	0	0	0	0	0	Likely done for human health purposes.

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
3	6.10.5.	Request collection of samples from captured owls and test for West Nile Virus antibodies.	1	Continuous	FWS	Yes	10	1	1	1	1	1	
2	7.	Monitor owl occupancy.	1	10			11,900	200	1,300	1,300	1,300	1,300	
2	7.1.	Develop occupancy-monitoring design and secure funding.	1	Continuous	FS, RMRS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.
2	7.2.	Conduct a landscape analysis to define the sampling frame.	1	1	FS, RMRS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.
2	7.3.	Develop sampling strata.	1	1	FS, RMRS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.
2	7.4.	Develop sampling protocols.	1	1	FS, RMRS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.
2	7.5.	Have monitoring design reviewed and revised accordingly.	1	1	FS, RMRS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.
2	7.6.	Implement the monitoring design.	1	10	FS, NPS, BLM, Tr., MX, RMRS	No							Costs captured above.
2	8.	Develop and implement habitat monitoring.	2	Continuous			8,750	200	75	75	75	75	
2	8.1.	Develop FIA-based monitoring design and secure funding.	2	Continuous	FS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
2	8.2.	Conduct a landscape analysis to define the sampling frame.	2	1	FS, FWS, NPS, BLM, Tr., MX	No							Costs captured above.
2	8.3.	Develop sampling strata.	2	1	FS, NPS, BLM, Tr., MX	No							Costs captured above.
2	8.4.	Develop sampling protocols.	2	1	FS, NPS, BLM, Tr., MX	No							Costs captured above.
2	8.5.	Have monitoring design reviewed and revised accordingly.	2	1	FS, NPS, BLM, Tr., MX	No							Costs captured above.
2	8.6.	Implement the monitoring design.	2	10	FS, NPS, BLM, Tr., MX	No							Costs captured above.
3	9.	Implement research.	1, 2	Continuous									Costs captured below.
3	9.1.	Conduct research related to habitat.	2	10	FS, NPS, BLM, Univ, USGS, States, Tr., RMRS, MX	No	1,000	100	100	100	100	100	
3	9.2.	Conduct research related to biological community interactions.	1	10	FS, NPS, BLM, Univ, USGS, States, Tr., RMRS, MX	No	500	50	50	50	50	50	
3	9.3.	Conduct research involving population structure.	1	10	FS, NPS, BLM, Univ, USGS, States, Tr., RMRS, MX	No	1,500	150	150	150	150	150	
3	9.4.	Conduct research involving ecosystem function.	1, 2	10	FS, NPS, BLM, Univ, USGS, States, Tr., RMRS, MX	No	1,500	150	150	150	150	150	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
3	9.5.	Conduct research specific to Mexico.	1, 2	10	MX	No	1,000	100	100	100	100	100	
3	10.	Develop and conduct plan implementation oversight and coordination.	1,2	Ongoing									Costs captured below.
3	10.1.	Ensure that EMU Working Teams have primary oversight.	1,2	1	FWS	Yes	0	0	0	0	0	0	
3	10.1.1.	Review current Working Teams and broaden as appropriate.	1,2	1	FWS	Yes	2	2	0	0	0	0	
3	10.1.2.	Develop charter and operating procedures.	1,2	1	WTs	No	3	3	0	0	0	0	
3	10.1.3.	Meet with Recovery Team to ensure consistent interpretation of Recovery Plan.	1,2	Continuous	WTs	No	30	3	3	3	3	3	
3	10.1.4.	Conduct workshops with parties responsible for implementing the Recovery Plan.	1,2	1	FWS, RT	Yes	10	10	0	0	0	0	

Priority Number	Action Number	Action Description	Recovery Criterion Number	Action Duration (Years)	Responsibility		Total Cost ($1,000s)	Cost Estimate by FY (by $1,000s)					Comments
					Parties	Is FWS Lead?		FY12	FY13	FY14	FY15	FY16	
3	10.1.5.	Provide feedback to Recovery Team including impediments and recommendations.	1,2	Continuous	WTs	No	20	2	2	2	2	2	
3	10.2.	Implement continuing functions of the Recovery Team.	1,2	Continuous	RT	Yes							Costs captured below.
3	10.2.1.	Coordinate regularly with Working Teams to receive feedback on Recovery Plan implementation.	1,2	Continuous	RT	Yes	10	1	1	1	1	1	
3	10.2.2.	Meet annually or as needed to consider Working Team recommendations, review new research findings, generally assess plan implementation.	1,2	Continuous	RT	Yes	50	5	5	5	5	5	
3	10.2.3.	Make recommendations to FWS on plan clarifications and adjustments.	1,2	Continuous	RT	Yes	10	1	1	1	1	1	
3	10.3.	Establish and maintain a centralized Mexican spotted owl information repository.	1,2	Continuous	FWS	Yes	28	10	2	2	2	2	

B. Population and Rangewide Habitat Monitoring Procedures

Part III of this Recovery Plan lists specific criteria that must be met before the Mexican spotted owl can be delisted. Meeting two of these criteria will require large-scale monitoring of trends in owl abundance (or a surrogate for owl abundance) and habitat quantity and distribution. Here, we provide a brief overview of one approach that might be used to implement such monitoring, with technical details provided in Appendix E. We provide this approach as an example, noting that other approaches are possible and that future advances in monitoring techniques may result in other, more efficient approaches. Ultimately, any approach that can satisfactorily address the recovery criteria should be acceptable.

In USDI FWS (1995), we advocated a population monitoring scheme based on mark-recapture sampling. That design would provide rigorous demographic data on spotted owls as well as estimates of population trend. However, a pilot study conducted to evaluate those methods identified several potential problems. These included high cost and difficulty in finding sufficient numbers of highly qualified field workers. Perhaps more importantly, the mark-recapture approach required capture and banding of large numbers of owls. Although capture techniques for spotted owls are relatively safe, they are not risk-free. Further, many captures likely would be carried out by seasonal field crews, and many of these individuals likely would be inexperienced. As a result, the risk of injury to owls was deemed unacceptable.

Fortunately, advances in monitoring techniques since 1995 provide a viable alternative to mark-recapture sampling, specifically occupancy monitoring (e.g., MacKenzie et al. 2006). Occupancy monitoring does not require capture and banding of owls but is based on mark-recapture theory and does allow for estimation of detection probability. This is a critical detail, because (1) it is likely that not all resident owls will be detected in a given year, and (2) detection probabilities may change over time. Such changes in detectability of owls could result in erroneous trend estimates and misguided conservation efforts. Consequently, we propose a monitoring program based on occupancy monitoring. Such a program will not provide the detailed demographic data that mark-recapture sampling would provide, but it should be safer and cheaper to implement while still providing valid population trend estimates.

Before describing the proposed monitoring program further, we repeat the following statements to summarize pertinent discussion from elsewhere in the Plan:

- While monitoring habitat is important, numerous factors other than habitat conditions can influence owl populations. Therefore, it is necessary to monitor trends in both habitat and the owl population.
- We are assuming that the existing owl population is adequate in numbers and distribution to maintain the viability of the species (see Part III.D. Objective and Measurable Recovery Criteria, to explain this assumption). However, we are willing to accept a stable or increasing population or site occupancy trend over a period ≥10 years as evidence that the owl population is sustaining itself and therefore is likely to persist. The selection of a 10-year period is explained in Part V.B.1.b below.
- A number of approaches are possible for monitoring owl habitat. One possibility is to use data from the USDA Forest Inventory and Analysis (FIA; http://fia.fs.fed.us)

program. The FIA program is attractive because it is an existing and well-funded program that provides repeat sampling of habitat conditions throughout the range of the owl. We explain details of the FIA sampling protocols and resulting data in Appendix E - Monitoring.

- How ever habitat data is obtained, we envision: 1) using habitat data to aid in stratifying the sample of areas where owl occupancy rates are estimated, and 2) relating habitat data to owl occupancy rates, to allow for better understanding of relationships between specific habitat features and/or landscape composition and owl population trends (see Appendix E for further details).
- The proposed monitoring of owl occupancy rates likely will monitor only the territorial population of owls. The non-territorial portion of the owl population likely will not be sampled adequately (see below for further discussion of this issue).
- We think the minimum trend period of 10 years is a reasonable time span for monitoring the trend in owl occupancy (see discussion below).

1. Monitoring Mexican Spotted Owl Occupancy Rates

Although we support the idea of estimating population size directly and collecting associated demographic data as described in USDI FWS (1995), we propose this alternative monitoring program based on monitoring occupancy rates as an index of population size and distribution, for reasons discussed above. We define occupancy rate for Mexican spotted owls as the proportion of sample plots occupied by the species. The sample plots will consist of square blocks of 100 ha (247 ac). We propose using existing Universal Transverse Mercator (UTM) blocks that can be easily mapped using GIS. Appendix E - Monitoring provides a detailed discussion of the statistical aspects of using the occupancy rate to estimate owl population trend, as well as a discussion of how the owl occupancy rate would be related to habitat conditions.

One limitation of the proposed monitoring is that owl occupancy monitoring (and all known approaches) likely will monitor primarily territorial birds. This is because non-territorial "floaters" (Franklin 1992) may not respond readily and consistently during calling surveys. The proportion of non-territorial floaters in the population of Mexican spotted owls remains unknown, but may not be large. Evidence for Mexican spotted owls suggests that: (1) the proportion of birds <2 years old (i.e., subadults) holding territories is relatively high, (2) territory vacancies typically are filled by birds 1 to 2 yrs old, and (3) density of territorial Mexican spotted owls appears to track reproduction with a short lag period (Seamans et al. 1999: Fig. 5; Gutiérrez et al. 2003, J. P. Ward and J. L. Ganey, unpublished data). All of these factors suggest that large numbers of non-territorial floaters typically are not present within the range of the Mexican spotted owl. Consequently, we do not view this limitation as fatal to the monitoring program.

a. Steps to Population Monitoring

We envision monitoring a random sample of blocks (see above) for the presence of owls. Non-detection of owls within a sample does not always imply owls are absent. In some situations observers fail to detect owls when present because owls may not vocalize or an observer fails to hear them. Thus, probability of detecting an owl or owls must be estimated as part of the

monitoring process. Recent models (MacKenzie et al. 2002, 2003, 2006) provide viable methods to estimate detection probability and thus rigorously monitor site occupancy.

We assume that occupancy rate provides a valid index of population size, although the exact relationship between abundance and occupancy rate remains unknown (Royle and Nichols 2003). Presumably, however, monitoring site-occupancy rates will allow detection of important changes in the owl population.

In Appendix E, we outline a suitable framework and statistical estimation approach for monitoring owl populations via directly estimating the site occupancy rate of territorial owls, and we discuss how FIA measurements could be incorporated into the occupancy monitoring plan so that microhabitat variables can be related to owl occupancy rates. Accurate and efficient protocols for monitoring owl occupancy will require pilot studies to estimate occupancy rates and detection probabilities and their statistical variances. These estimates then can be used to determine variables such as the number of plots required and number of call points required per plot, and to evaluate tradeoffs between greater numbers of visits per plot versus increasing spatial replication by sampling more plots fewer times. Given sample data, all of these factors can be optimized to design a monitoring program that will most efficiently satisfy the quantitative targets in the delisting criterion for population monitoring.

b. Time Period for Population Monitoring

Recovery criterion 1 for delisting (Part III) specifies that the owl population trend should be monitored for at least 10 years. Monitoring for a longer period is desirable, given the owl's long lifespan, the fact that it frequently occurs in forested and canyon ecosystems that change slowly, and the pronounced temporal variability in climate that characterizes the American southwest. We believe that 10 years is a reasonable minimum time span for owl occupancy monitoring for the following reasons. First, given current estimates of owl survival rates, more than half of the adult population should turn over during a 10-year period. Vacancies created by deaths of territorial resident owls may be filled by unpaired, non-territorial birds or, more likely, by subadult birds recruited from the previous year or two. The extent to which new owls fill territory vacancies will provide evidence on whether or not sufficient reproduction is occurring to sustain the owl population. A 10-year period should be sufficient to test whether adequate recruitment is occurring.

Second, we expect that the owl population will be subjected to considerable environmental variation during this 10-year period, including both dry and wet years and major fire events.

Third, even if occupancy rates are stable or increasing and the species is delisted, the ESA requires a minimum additional five years of monitoring post-delisting. This time period would provide further opportunity for evaluating population and distribution trends.

Fourth, we hope that the 10-year period will appear achievable to managers and thus provide incentive to implement population monitoring and acquire the monitoring data required to evaluate the potential for proposing to delist the owl.

2. Monitoring Mexican Spotted Owl Rangewide Habitat

The primary objective of habitat monitoring is to validate results of occupancy monitoring. For example, if occupancy monitoring indicates stable (or increasing) occupancy rates, habitat monitoring will provide a general measure of whether there will be sufficient nest and roost habitat for occupancy rates to remain stable. We advocate no specific method for habitat monitoring and leave it up to management agencies to determine the best method(s) to use. Again, one possible approach is to use data from the existing FIA program. We provide a brief overview of that program in Appendix E.

C. Ecological Management Unit Working Teams

The FWS intends to continue or reform Working Teams whose responsibility would be to oversee and guide implementation of the Recovery Plan. These Working Teams would coordinate with and report to the Recovery Team, which would consider and evaluate Working Team recommendations before passing them on to FWS. Working Teams for each EMU should be appointed by FWS as subunits under the Recovery Team umbrella. Working Teams should include as a minimum of one representative from each of the following:

1) Each involved FWS Ecological Services Office
2) Each involved FS Region
3) Each involved state
4) Each involved Indian nation
5) Any other involved agency (e.g., BLM, NPS)
6) At least one researcher/scientist who can provide specialized expertise related to owl biology, forest ecology, fire ecology, monitoring, or other relevant topics.

Working Teams should recommend to FWS the appointment of additional members as needed or desired. For example, representatives of local governments, affected industries, and conservation advocacy groups should be considered for appointment. If other interested parties express interest in participating on a Working Team, they should be allowed to do so pending FWS approval. Working Teams should strive to have a diversity of members to represent ecological, economic, social, conservation, and management interests.

Functions of Working Teams should include, but not be limited to, the following:

1) Provide technical assistance to agencies and landowners on topics related to project designs, spotted owl management, and Recovery Plan implementation. The Recovery Team encourages Working Teams to hold Recovery Plan implementation workshops to provide a common understanding of the plan to all interested parties.
2) Provide guidance and interpretation on implementation and recommendations contained within the Recovery Plan.
3) Recommend Recovery Plan revisions based on lessons learned from implementation.
4) Coordinate landscape analyses among management agencies and private landowners. The landscape analyses are recommended to identify areas needing management intervention to protect and develop owl habitat. Coordinate occupancy and habitat monitoring among management agencies and private landowners.

5) Promote communication among local interests and help to resolve conflicting interpretations of the Recovery Plan if they arise.
6) Track plan implementation and report success, problems, and progress to the FWS and Recovery Team periodically.

D. Continuing Duties of the Recovery Team

The FWS intends that the Recovery Team be continued throughout implementation of the Recovery Plan. Once the Recovery Plan is finalized, the Recovery Team should meet annually to review plan implementation, confer with Working Teams, and report to FWS. If changes or adjustments to the Recovery Plan are warranted, the Recovery Team will forward recommendations for those changes to FWS for their consideration.

E. Centralized Mexican Spotted Owl Information Repository

The Recovery Team recommends development of a central repository for data related to Mexican spotted owl recovery. Historically, data have been retained in dispersed locations prohibiting meta-analyses to understand the status of the owl range-wide. Given that the owl inhabits lands under multiple jurisdictions, this central repository is critical to addressing pressing information needs about owl recovery. The primary purpose of such a facility would be to collate a spotted owl GIS database, occupancy monitoring data, habitat monitoring data, and other programs recommended in this Recovery Plan.

F. Research Needs

Despite the considerable interest in and research on the ecology of the Mexican spotted owl, much remains unknown, particularly in Mexico. Research is needed to develop long-term management strategies that assure predominant threats to the persistence of Mexican spotted owls will be alleviated. The primary focus of such research should be to elucidate factors that influence change in Mexican spotted owl distribution and abundance. Emphasis should be placed on identifying those factors that can be manipulated through social or natural resource management.

Communication and collaboration among scientists, land managers, and interested publics should play a key role in shaping future research. Managers need to understand the methods, problems, and uncertainties involved with gaining reliable knowledge from ecological research. Scientists, on the other hand, must rely on managers to identify appropriate questions and political and legal constraints, to implement experimental treatments, and to develop appropriate implementation of knowledge derived from research results in an adaptive management context. Too often scientists design and implement studies that do not directly address critical management issues. By working together, managers and scientists can bridge this gap and better focus research efforts by identifying relevant objectives and approaches. Involving and informing interested publics may facilitate implementation of important research activities without administrative or legal challenges.

Clearly, all research questions cannot be answered, given limited time and money. Similarly, we know that some population processes will vary among EMUs. It is therefore imperative that landscapes used for research study areas be considered for particular questions to maximize gain. For example, three studies of habitat requirements conducted within mixed-conifer forest in a single EMU will likely yield less information than studies in other habitat types or regions. Here, we recommend research on questions about Mexican spotted owls that still need answers. Clearly, a large number of research questions could be developed that address all aspects of Mexican spotted owl biology for which knowledge is lacking. Others have reviewed research agendas for conservation of spotted owls or other forest wildlife (DeStefano 2002, Noon and Franklin 2002). The topics we recommend here are similar. However, we pose what we believe are the most crucial questions that need to be addressed in terms of long-term resource management and recovery of Mexican spotted owls. Studies designed to answer these questions could be descriptive, experimental, or a combination of both. We do not repeat questions that will be answered through population and habitat monitoring.

1. Habitat and Demography

Recovering the Mexican spotted owl will require detailed knowledge of the habitat constituents (including food resources) required at various scales to maintain viable populations. Past research has scratched the surface of this topic and primarily concentrated on roosting and nesting microhabitat features and, to a lesser degree, on prey requirements. In particular, habitat requirements of spotted owls that dwell in canyon-type environments are poorly known. We also recognize that spotted owl nesting habitat in forested environments is not static over time and that many currently used nesting sites eventually will be lost due to various disturbance agents. We therefore recognize a need to hone management tools that can be used to develop recovery habitat. This will necessarily entail studies of long duration, given the temporal nature of forest development, for example, or the potential for climate change to alter thermal regimes and habitat conditions in arid canyonlands. Consequently, these studies should begin as soon as possible. Important questions that remain to be answered include:

1) Which habitat features directly influence reproduction and/or survival of Mexican spotted owls?
2) Which habitat features indirectly influence reproduction and/or survival of Mexican spotted owls by enhancing prey availability?
3) How should these features be arranged spatially on the landscape to optimize owl fitness and habitat quality?
4) How do stochastic environmental disturbances (particularly unplanned wildland fire) alter key habitat constituents and owl demography?
5) Which habitat features help buffer the influence of weather effects on reproduction and survival?
6) How do various planned management activities alter key habitat constituents (including prey) and owl demography? This question is particularly important relative to landscape-scale restoration projects currently in planning, because these projects have the potential to impact vast acreages in short time frames.
7) What is the probability that threshold nest/roost conditions recommended in the plan will become recovery habitat for roosting and/or nesting by Mexican spotted owls?

8) Which silvicultural prescriptions are best suited for creating and sustaining habitats used by Mexican spotted owls for various activities like roosting, nesting, foraging, and dispersal?
9) Which types of planned burning regimes and methods will promote development of the owl's roosting, nesting, and foraging habitat?
10) What proportion of Mexican spotted owl populations migrate seasonally, where are winter habitats located, what habitat features do owls use to select these areas, and how important are these areas for owl dispersal and survival?
11) How will climate change alter distribution, structure, and composition of owl habitat?
12) How will climate change influence owl and prey distribution and abundance?
13) If livestock grazing occurs within owl nesting, roosting, and foraging habitats, what livestock grazing strategies can be implemented to best maintain suitable habitat conditions for owl prey species and alleviate grazing impacts on the development of future owl nesting/roosting habitats (e.g., oak/cottonwood/willow/alder trees)?
14) What are the effects of various recreational activities (hiking, climbing, OHV use) on Mexican spotted owl behavior, habitat use and demography? How can managers mitigate potential effects in high-use areas?
15) If salvage logging is needed after a disturbance event (e.g., fire, insect/disease outbreak), how can it be implemented to maintain and protect existing habitat features or accelerate the development of future owl habitat?

The effects of different severities of wildland fire (Question 4 above) on Mexican spotted owls are still poorly understood. Stochastic disturbances and activities like wildland fire that may not be readily tested with experiments for lack of suitable control can be examined through development and analysis of simulation models and comparison with observational (retrospective) analyses. Planned management activities that should be studied for effects on owls, prey, and habitat include forest restoration, forest thinning prescriptions, and domestic livestock grazing. A number of Collaborative Forest Landscape Restoration Projects are pending implementation within the range of the owl. These projects offer an excellent opportunity to overlay research to understand effects of restoration prescriptions on owl populations and habitats.

2. Biological Interactions

Although recovery plans are mostly written for a single species, they must consider a wide array of interactions within biological communities and ecosystems. Community-level interactions that can affect Mexican spotted owl populations include parasitism, disease, predation, and competition. These factors are omnipresent in shaping population processes. However, the combined influence of these factors under particular environmental conditions can prove deleterious, resulting in significant and unrecoverable population decline. Important questions include:

1) Are any of these factors limiting Mexican spotted owl populations?
2) In particular, what are the effects of invasive pathogens like WNV?
3) What is the relative influence of other predators on common prey of the Mexican spotted owl?

4) What environmental conditions will lead to increased effects of community-level interactions?
5) What types of management actions are necessary to alleviate deleterious community-level interactions?
6) How might climate change alter these factors and/or their impacts on Mexican spotted owls?
7) How will planned habitat treatments influence different biological interactions that can limit Mexican spotted owl populations, and how do these effects vary across spatial and temporal scales?

3. Population Structure

For populations to persist through time, there must be adequate numbers of individuals present within and among subpopulations. The ultimate distribution and abundance of individuals is influenced by a wide array of factors. Some of these factors can be influenced by management. For example, restoration of riparian corridors between core populations (i.e., Other Riparian) may ensure stronger connectivity and mixing of genotypes. Other factors, like the distribution of canyons on the landscape, cannot be influenced, with the possible exception of removing dams. The questions posed below relate more to longer-term, larger-scale processes than the previous questions. However, these questions will need to be addressed in a long-term management plan. Specifically, questions about metapopulation function like dispersal and connectivity must be answered, along with questions about gene flow and fitness.

1) What are the relative numerical and genetic contributions of core and exterior populations?
2) Are subpopulations within and between EMUs connected?
3) What habitats and large-scale habitat configurations are required to maintain adequate survival rates during juvenile dispersal or adult migration?
4) What is the optimal arrangement of owl numbers and genetic mix that will lead to persistent populations at various time scales?
5) Which management activities help to ensure a well distributed set of functioning subpopulations? Which hinder this goal?
6) What are the potential impacts of climate change on connectivity of owl populations throughout their range?

4. Ecosystem Function

Implementation of recovery measures for the Mexican spotted owl will affect numerous ecosystem attributes directly and indirectly. Research is needed to determine the extent of these effects on biotic and abiotic components, and on ecosystem processes and function. Key questions are:

1) What are the effects of implementing this Recovery Plan on ecosystem structure and functions like soil erosion, water yield, and nutrient flow?
2) What are the effects of implementing this Recovery Plan on plant community structure, composition, and sustainability?
3) How has the implementation of this Recovery Plan affected long-term restoration of forested systems?

4) How are other focal wildlife species responding to conservation guidelines in this Recovery Plan?
5) How might this Recovery Plan be adjusted to mitigate potentially deleterious effects on other ecosystem attributes?
6) What are the potential implications of climate change to resilience of the ecosystems that support Mexican spotted owls, and how can we best balance increasing resilience in those systems with maintaining owl habitat?

PART VI. LITERATURE CITED

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APPENDIX A - RECOVERY TEAM MEMBERSHIP

Current Team Members

BRENT BIBLES

Education: B.S., Fisheries and Wildlife, Utah State University, 1987;
M.S. Wildlife and Fisheries Science, University of Arizona, 1992;
Ph.D. Wildlife and Fisheries Science, University of Arizona, 1999.
Current Position: Assistant Professor, of Wildlife Ecology, Center for Narural Resource Management and Protection, Unity College, Unity, Maine
Expertise: Avian ecology; wildlife-habitat relationships; threatened and endangered species conservation

WILLIAM M. BLOCK, Team Leader

Education: B.A., Economics, San Diego State University, 1974
B.S., Wildlife Biology Michigan State University, 1981
M.S., Wildlife Biology, Humboldt State University, 1985
Ph.D., Wildland Resource Science, University of California Berkeley, 1989
Current Position: Program Manager, Wildlife and Terrestrial Ecosystems, US Forest Service, Rocky Mountain Research Station, Flagstaff, AZ
Expertise: Wildlife biology; prey ecology; fire effects on wildlife; effects of fuels reduction on wildlife

JON COOLEY

Education: B.S., Wildlife Ecology, University of Arizona, 1982
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APPENDIX B - ECOLOGY OF THE MEXICAN SPOTTED OWL

This Appendix provides details on the biology and ecological relationships of the Mexican spotted owl (*Strix occidentalis lucida*). These details provided the background for recovery planning, but a lengthy discussion of ecology in the body of this Recovery Plan was considered too distracting. Thus, we provide the information here for the interested reader.

This Appendix is intended to be an overview of this subspecies' biological characteristics and ecological relationships germane to recovering its populations. Emphasis is placed on information developed since the original Recovery Plan was published (USDI FWS 1995). Although major information gaps still exist, our understanding of the Mexican spotted owl's natural history has increased since 1995. In particular, the number of sites known to be occupied by Mexican spotted owls in canyon environments has greatly increased since that time. Thus, we also provide additional detail about the ecology of canyon-dwelling individuals, particularly when different from other Mexican spotted owls.

We have included results from both published and unpublished references, based on a search of the literature through 15 Dec 2011. Although we prefer to rely on published information, considerable information regarding the Mexican spotted owl resides in unpublished reports. This summary is not exhaustive, because it is impossible to include or even locate every unpublished report. We have attempted to make it reasonably comprehensive, however, realizing that most biologists, resource managers, or other interested parties may not have time to locate and read the numerous references summarized here. In addition, a wealth of information exists for two other subspecies of spotted owls. Although different in some respects, many aspects of the owl's biology and ecology are similar among subspecies. Where appropriate, information from other subspecies was included for comparison or where data were limited regarding the Mexican subspecies.

1. Taxonomy and Genetics

A. Systematics

Knowledge of taxonomic relationships of threatened species is critical to their protection and recovery, particularly where protection is based on subspecific status, as is the case with the Mexican spotted owl. This owl is one of three subspecies of spotted owl recognized by the American Ornithologists' Union (AOU) in its last checklist that included subspecies (AOU 1957:285). The other two subspecies are the northern (*S. o. caurina*) and the California (*S. o. occidentalis*) spotted owls.

Taxonomists have debated the systematics of the Mexican spotted owl for decades. The Mexican subspecies was first described from a specimen collected at Mount Tancitaro, Michoacán, Mexico and named *Syrnium occidentale lucidum* (Nelson 1903). All subspecies of spotted owl were later assigned to the genus *Strix* (Ridgway 1914) and the subspecific name for the Mexican spotted owl was changed to *lucida* to conform to taxonomic standards.
Swarth (1910, 1914) split the Arizona population of spotted owls out as *S. o. huachucae*, noting that they were paler than *S. o. lucida*. Ridgway (1914) applied the name *huachucae* to owls from Arizona east to the Guadalupe Mountains in Texas. In contrast, Oberholser (1915) concluded

that *huachucae* was a synonym of *lucida*, and this taxonomic designation was followed by the AOU (1957). Monson and Phillips (1981) continued to recognize *huachucae* for Arizona owls, however, and Dickerman (1997) split the Mexican spotted owl into three subspecies, based on plumage differences noted in an examination of museum specimens. He proposed recognizing owls from the southwestern U.S. and northern Mexico (Sonora and Chihuahua) as *huachucae*, with a new subspecies, designated as the volcano owl (*S. o. juanaphillipsae*), recognized in the state of Mexico, and *lucida* occurring between the ranges of *huachucae* and *juanaphillipsae*. This debate over the subspecific status of the Mexican spotted owl continues today (Haig et al. 2004a, Funk et al. 2008).

The Mexican subspecies is geographically isolated from both the California and northern subspecies (Fig. B.1), with only a trace of historical genetic contribution within the range of the northern spotted owl (Funk et al. 2008). Using electrophoresis to examine allozyme variation, Barrowclough and Gutiérrez (1990) found a major allelic difference between the Mexican spotted owl and the two coastal subspecies. They concluded from this difference that the Mexican spotted owl was isolated genetically from the other subspecies for considerable time, has followed a separate evolutionary history, and therefore could be considered a separate species (Barrowclough and Gutiérrez 1990:742). Most other recent studies (Barrowclough et al. 1999, Haig et al. 2001, Funk et al. 2008), as well as a recent review of all published and unpublished genetic data (Fleischer et al. 2004) also supported designation of the Mexican spotted owl as an Evolutionarily Significant Unit. In a somewhat divergent view, Haig et al. (2004a) found little evidence to support subspecific differences between the California and Mexican subspecies on the basis of molecular genetics. Nevertheless, they suggested that these populations should be managed separately because of their current geographic separation (Haig et al. 2004a). Most recently, Funk et al. (2008) reported evidence of introgression of Mexican spotted owls into the northern portion of the range of the northern spotted owl, and suggested that this resulted from long-distance dispersal of Mexican spotted owls. We are unsure how to interpret these results, as this would require dispersal over distances that greatly exceed any documented movements of spotted owls, and no other studies have reported similar findings. Funk et al. (2008) supported recognition of three subspecies of spotted owls despite this introgression, however.

Two other species within the genus *Strix* occur north of Mexico: barred (*S. varia*), and great gray (*S. nebulosa*) owls. The great gray owl is a northern species that does not occur within the range of the Mexican spotted owl. Historically, barred owls also did not occur in sympatry with Mexican spotted owls within the U.S. However, unconfirmed sightings of both species have been reported from the vicinity of Big Bend National Park in southern Texas in recent times (Wauer 1996), and there are recent confirmed records of barred owls in northern and eastern New Mexico (Williams 2005, cited in Cartron 2010; H. Walker, NMGFD, pers. comm.). Whether these confirmed records indicate a range expansion by barred owls or simply vagrant individuals is unknown at this time.

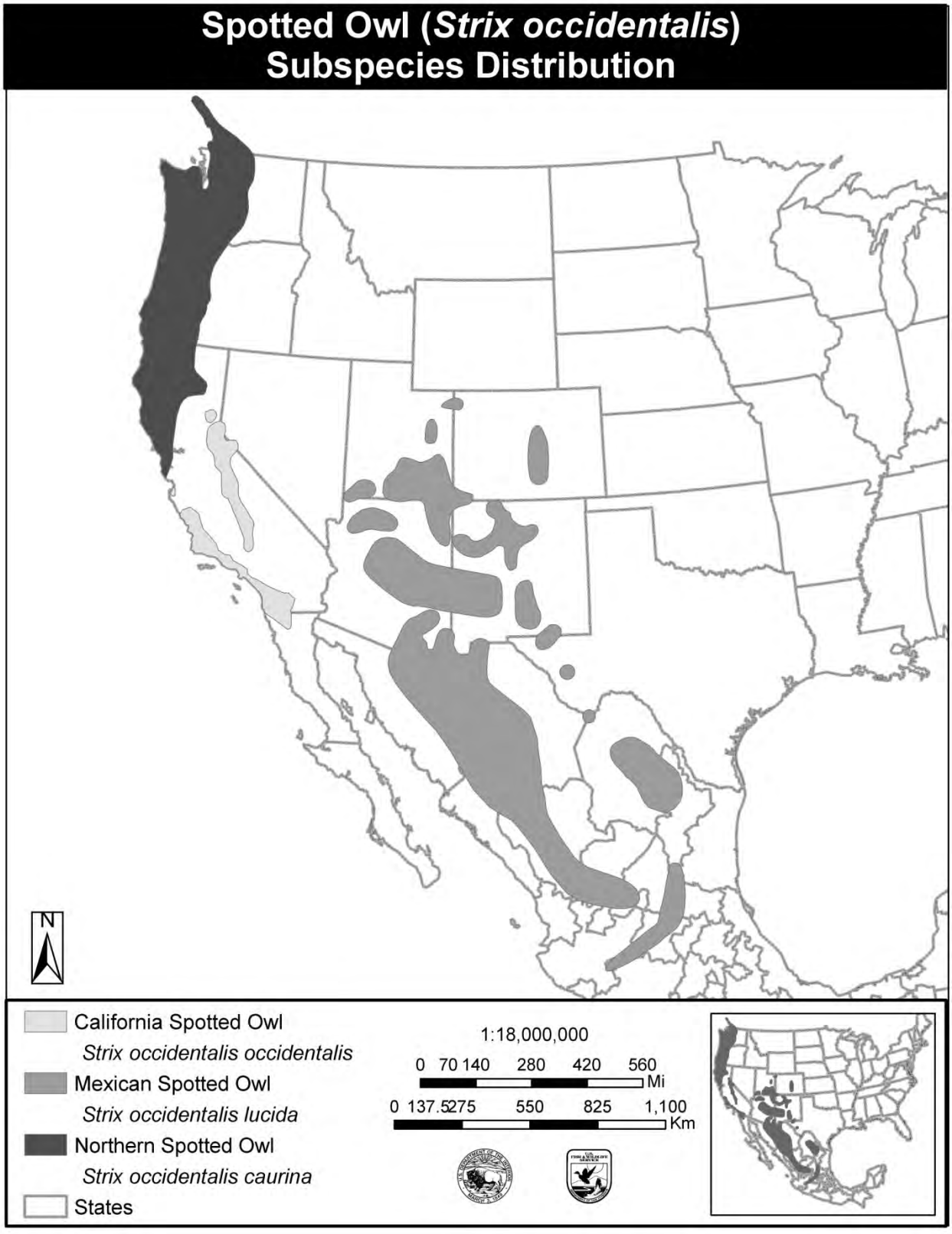


Figure B.1. Range map of three subspecies of spotted owls.

Mexican spotted, barred, and fulvous (*S. fulvescens*) owls all occur in Mexico, and they are sometimes considered as a "superspecies" (Holt et al. 1999:199-200). The ranges of the Mexican spotted and barred owl may or may not overlap in Mexico (Williams and Skaggs 1993, Howell and Webb 1995); little is known about local distributional patterns and habitats occupied in this zone of apparent overlap (Enriquez-Rocha et al. 1993). The fulvous owl does not appear to be sympatric with Mexican spotted owls in Mexico (but it may overlap the distribution of the barred owl slightly, Holt et al. 1999:198-200).

Patterns of range overlap may have significant implications for Mexican spotted owls. Barred owls are known to hybridize with northern spotted owls in the Pacific Northwest (Hamer et al. 1994; Dark et al. 1998; Haig et al. 2004b; Kelly and Forsman 2004; Funk et al. 2007; also see Gutiérrez et al. 2004, 2007). This hybridization is occurring in a relatively recent zone of contact caused by a rapid range expansion by barred owls into the range of the northern spotted owl in the Pacific Northwest (Taylor and Forsman 1976; Dark et al. 1998; Kelly 2001; Gutiérrez et al. 2004, 2007). Both hybrids between spotted and barred owls and backcrosses between these hybrids and the parental types have been found throughout much of the range of the northern spotted owl.

The implications of this hybridization for populations of northern spotted owls are currently unknown. Genetic analyses clearly indicate that spotted and barred owls are distinct species with no indication of previous gene flow across species boundaries (Haig et al. 2004b, Funk et al. 2007). Closely related species occasionally hybridize naturally, especially where habitat disruption has led to contact between previously geographically isolated species (Short 1965, 1972). Kelly and Forsman (2004) noted that relatively few hybrids of spotted and barred owls have been identified to date, and they suggested that other isolating mechanisms (e.g., behavior or habitat selection) may be working effectively to maintain hybridization at low levels.

Holt et al. (1999:198) reported occasional hybridization between spotted and barred owls in Mexico but did not elaborate on sources for this information. Given the situation in the recent zone of contact discussed above for the Pacific Northwest, it seems likely that hybridization between Mexican spotted and barred owls could increase if barred owls expand their range further into the range of the Mexican spotted owl. For discussion of other potential interactions between spotted and barred owls, see *Interspecific Competition*.

B. Genetic Structure of Mexican Spotted Owl Populations

Knowledge of genetic structure of threatened populations can aid in conserving and recovering those populations. Barrowclough et al. (2006) investigated genetic structuring in Mexican spotted owl populations. Genetic diversity was high in most populations sampled, with approximately 17 and 7.5% of observed genetic variation distributed among populations and physiographic regions, respectively. Their data suggested substantial gene flow among populations sampled in the Mogollon Rim – Upper Gila Mountains (UGM) region of central Arizona and New Mexico, with more restricted gene flow among other populations. The relatively dense population in the Sacramento Mountains showed evidence of isolation from other populations. Barrowclough et al. (2006) concluded that viability of the Sacramento Mountains population depends largely on internal population dynamics, suggesting that

managers should maintain sufficient habitat to support a viable population in this range. Some smaller populations appeared to depend on immigration from larger concentrations of owls in the UGM region. Barrowclough et al. (2006) concluded that maintaining stepping stone habitat fragments between the large UGM populations and other populations in the rest of the range would aid in maintaining viable populations of Mexican spotted owls (see additional discussion in sections on Landscape Connectivity and Metapopulation Ecology).

2. Description

A. Appearance

All three subspecies of the spotted owl are mottled in appearance with irregular white and brown spots on its otherwise brown abdomen, back, and head (Gutiérrez et al. 1995). White spotting on brown breast feathers is one characteristic that distinguishes the spotted owl from the barred owl, which has brown and white vertical streaks on its breast (Fig. B.2). Both spotted and barred owls have dark eyes in contrast to other medium to large North American owls that have lighter colored irises (the small flammulated owl [*Otus flammeolus*] also has dark irises). Both spotted and barred owls lack external ear tufts, and the head has a rounded appearance. The large round facial disk has indistinct concentric circles around both eyes.

The three subspecies of spotted owls exhibit color variation in their body plumage. White spots of the Mexican spotted owl are generally larger and more numerous than in the other two subspecies, giving it a lighter appearance (*Strix occidentalis* translates as "owl of the west" and *lucida* means "light" or "bright"; Ganey 1998). Both remiges (wing feathers) and retrices (tail feathers) are dark brown barred with lighter brown and white.

Adult male and female spotted owls are mostly monochromatic in plumage, but several age classes can be distinguished by plumage (Forsman 1981, Moen et al. 1991). Juvenile spotted owls (hatching to approximately five months) have a downy appearance (Fig. B.2), which persists around the head even after the flight feathers grow in (i.e., until late August or September of their hatch year). Subadults (5 to 26 months) closely resemble adults but have pointed retrices with a pure white terminal band (Forsman 1981, Moen et al. 1991). Two age classes of subadults (first- and second-year, respectively; Fig. B.3) generally can be recognized, based on the amount of wear to the tips of the rectrices and the date of observation (Moen et al. 1991). The retrices of adults (>27 months) have rounded tips, and the terminal band is mottled brown and white (Fig. B.3).

The spotted owl is a medium-sized owl and ranks fifth largest among the 19 North American owl species (Johnsgard 1988). Like many other raptors, spotted owls exhibit reversed sexual dimorphism where females are larger than males. Adult male Mexican spotted owls (n = 68) average 509 $\pm$ 33 (SD) g, and adult females (n = 68) average 569 $\pm$ 44 g (Gutiérrez et al. 1995). There appears to be clinal variation among the three subspecies in a number of morphological characteristics, with size (or mass) generally largest in the northern subspecies, intermediate in the California subspecies, and smallest in the Mexican subspecies (Gutiérrez et al. 1995).

Figure B.2. Appearance of adult Mexican spotted (top left) and barred (top right) owls. Note spotting on the breast of the Mexican spotted owl versus vertical barring on the breast of the barred owl. Lower photo shows a juvenile (young of the year) with downy body plumage. Compare downy head of juvenile to head of female adult visible behind the juvenile. Photos: Top left: J. L Ganey, Bottom: J P. Ward, Jr. Barred owl photo downloaded from: http://www.fws.gov/southeastlouisiana/images/habitat_mgt_images/barred_owl.jpg.

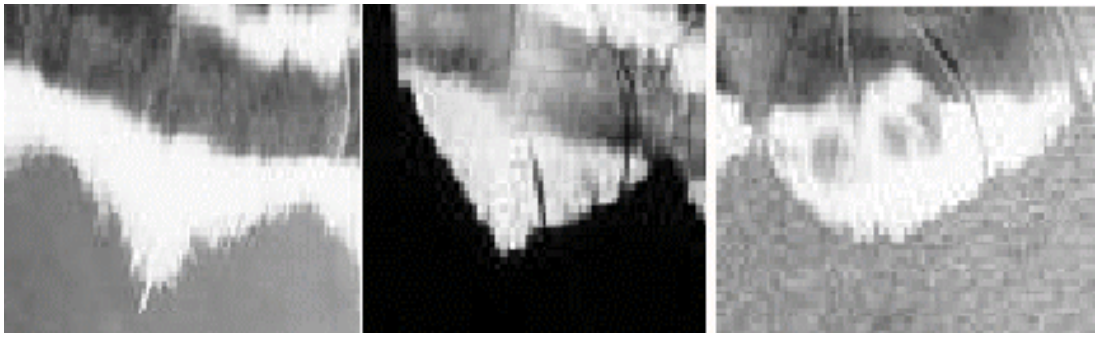


Figure B.3. Photos showing tips of tail feathers of three age classes of spotted owls with non-downy body or head plumage (photos from Moen et al. 1991). From left to right are: first-year subadult (note tips are pointed and tufted, and terminal band is pure white); second-year subadult (note tips are pointed and retain the pure white terminal band, but tufts have worn away); and, adult (note rounded tip, and mottled brown spots in white terminal band). Young of the year also have pointed and tufted tips but also have downy body or head plumage.

B. Vocalizations

The spotted owl, being territorial and primarily nocturnal, is heard more often than seen. It has a wide repertoire of calls (Forsman et al. 1984, Ganey 1990), most of which are relatively low in pitch and composed of pure tones (Fitton 1991). The low frequencies and pure tones characteristic of these calls suggest that they are well-suited for accurate long-distance communication through areas of relatively dense vegetation (Fitton 1991, see also Morton 1975, Forsman et al. 1984). This likely is important in a nocturnally active animal that ranges over large areas and that needs to communicate effectively with both its mate and neighboring owls across large distances (Ganey 1990).

Male and female spotted owls can be distinguished by their calls. Males have a deeper voice than females (Forsman et al. 1984) and generally call more often than females (Ganey 1990). There also appears to be intrasexual variation in calling rates (Laymon 1988, Ganey 1990).

Forsman et al. (1984) described 14 calls for the northern spotted owl, at least 10 of which also are used by Mexican spotted owls in Arizona (Ganey 1990). Both sexes use most calls, but the frequency with which call types are used varies among sexes (Forsman et al. 1984). The most common vocalization, used more often by males (Ganey 1990, Kuntz and Stacey 1997), is a series of four unevenly spaced hoots (four-note location call; Forsman et al. 1984, see also Fitton 1991). Females frequently use a clear whistle ending with an upward inflection (contact call; Forsman et al. 1984) as well as a series of sharp barks (bark series; Forsman et al. 1984, Ganey 1990).

Mexican spotted owls call mainly from March to November and are relatively silent from December to February (Ganey 1990). Calling activity increases from March through May (although nesting females are largely silent during April and early May) and then declines from June through November (Ganey 1990). Ganey (1990) reported that calling activity was greatest

during the 2-hour period following sunset, with smaller peaks 4 to 8 hrs after sunset and just before sunrise.

Mexican spotted owls studied by Ganey (1990) called more than expected during the last quarter and new moon phases of the lunar cycle, and they called most frequently on calm, clear nights when no precipitation was falling. Forsman (1983) reported that northern spotted owls also called most frequently on calm, clear nights, whereas the generality of the relationship between moon phase and calling rates is unknown. Calling bouts of Mexican spotted owls lasted approximately twice as long when the focal owls' mate also was calling and over three times as long when "other" owls were calling (Ganey 1990). In most cases, the other owls calling were neighboring Mexican spotted owls or great horned owls (*Bubo virginianus*).

Fitton (1991) and Kuntz (1998) studied variability among calls of spotted owls in northwestern California and New Mexico, respectively. Fitton (1991) found significant differences between call structure of neighboring and non-neighboring owls, with variance in call structure lower among neighboring owls than among non-neighbors. Similarly, Kuntz (1998) identified population-level differences among calls of populations of Mexican spotted owls in different mountain ranges. These findings suggest that spotted owls are able to use vocal learning to make fine adjustments to call structure (Fitton 1991). This development of a local dialect could allow owls to identify their neighbors without needing to be able to identify specific individuals. The ability to distinguish neighbors from non-neighbors by calls could provide a means to identify intruders, and thus trigger territorial defense when it is most needed. The ability to distinguish between neighboring and non-neighboring owls could be particularly important if owls are not able to identify individuals by their calls. Whether or not these owls can identify individuals by their calls is unknown at this time. However, researchers can recognize individual male Mexican spotted owls using multivariate analysis of call structure (Kuntz 1998). Given the frequent vocal communication that occurs between mated owls during the nesting season, and the overall importance of vocal communication to a nocturnal, territorial animal, we would be surprised if spotted owls could not identify individuals by their vocalizations.

The fact that spotted owls are territorial and respond to calls is important in the context of research and management. Acoustic lure surveys (Reid et al. 1999) are used to locate owls for both research and management activities (see Appendix D: Survey Protocol). These surveys are proven to be effective at locating spotted owls (Reid et al. 1999), but the influences of factors such as topography, vegetation, and distance on survey effectiveness are poorly understood. In a preliminary analysis, Bowles et al. (2002) demonstrated that Mexican spotted owls could be detected at distances up to 2 km (1.2 mi) under ideal conditions but that topography and ambient noise greatly affected detection distance (see also Denes et al. 2006). They suggested that incorporating the effects of such factors could improve estimates of effective area surveyed and inform survey protocols.

3. Distribution

The Mexican spotted owl occurs in forested mountains and rocky canyonlands throughout the southwestern U.S. and Mexico (Ligon 1926, Gutiérrez et al. 1995, Ward et al. 1995). It ranges from Utah, Colorado, Arizona, New Mexico, and the western portions of Texas south into

several States of Mexico (Fig. B.1). While this owl occupies a broad geographic area, it does not occur uniformly throughout its range (Ward et al. 1995). Instead, the owl occurs in disjunct areas that correspond with isolated mountain ranges and canyon systems (Fig. B.4).

The current distribution of Mexican spotted owls generally mimics its poorly known historical extent, with some exceptions (Ward et al. 1995). For example, the owl has not been reported recently as a breeding species from riparian corridors along most low- or mid-elevation rivers and creeks in Arizona and New Mexico (although it does use these areas during winter; see Movements and Migration, below). Nor has it been reported in recent times from historically occupied areas of southern Mexico (Williams and Skaggs 1993, Ward et al. 1995) or from some areas where recent habitat models suggest these owls should occur in canyons (see Habitat Models, below). Riparian communities and many previously occupied localities in the southwestern U.S. and southern Mexico have undergone significant habitat alteration since the historical sightings (USDI FWS 1993). These areas, when occupied, likely aided in maintaining connectivity among populations throughout the southwest.

In the United States, the majority of owls are found on U.S. Forest Service (FS)-administered lands (Table B.1). Exceptions to this general pattern occur in parts of the Colorado Plateau (CP) and Basin and Range-East (BRE) Ecological Management Units (EMUs), where owls are found primarily in rocky canyons on lands administered by the National Park Service (NPS) and Bureau of Land Management (BLM).

Surveys conducted since the 1995 Recovery Plan continue to locate new owl sites and increase our knowledge of owl distribution, but not necessarily of owl abundance. For example, 758 owl sites were recorded for the period 1990–1993 (Ward et al. 1995). During a recent review for establishing Critical Habitat, 1,222 owl sites were recorded for the period 1990–2004 (USDI FWS 2004). A more recent tally through 2008 indicated 1,301 cumulative sites occupied by one or more Mexican spotted owls (Table B.1). This increase is mainly a product of new surveys being completed within previously unsurveyed areas, however. This tally represents a cumulative tally of all sites where Mexican spotted owls have been located over time, does not provide any information on how many of those sites are occupied at any particular time, and does not account for any known sites lost due to high-severity wildland fire or natural site-extirpation processes. Thus, an increase in abundance cannot be inferred from these data. Likewise, the distribution of owl sites alone cannot indicate population density in various areas and may be more indicative of differences in survey effort than in owl density.

Information on the current status of Mexican spotted owls in Mexico is limited. This subspecies has been reported to occur within the mountain ranges of five general regions distributed through the Mexican states of Chihuahua, Sonora, Durango, Jalisco, Michoacán, Guanajuato, Sinaloa, San Luis Potosi, Nuevo Leon, Coahuila, Colima, and Aguascalientes (Williams and Skaggs 1993, Ward et al. 1995, Tarango et al. 2001). The majority of owls have been located in the Sierra Madre Occidental range, including in Sonora, Chihuahua, Sinaloa, Durango, Aguascalientes, and Zacatecas, and in the Sierra Madre Oriental range, including in Coahuila, Nuevo Leon, and San Luis Potosi; fewer have been found in the Transverse Volcanic Range in

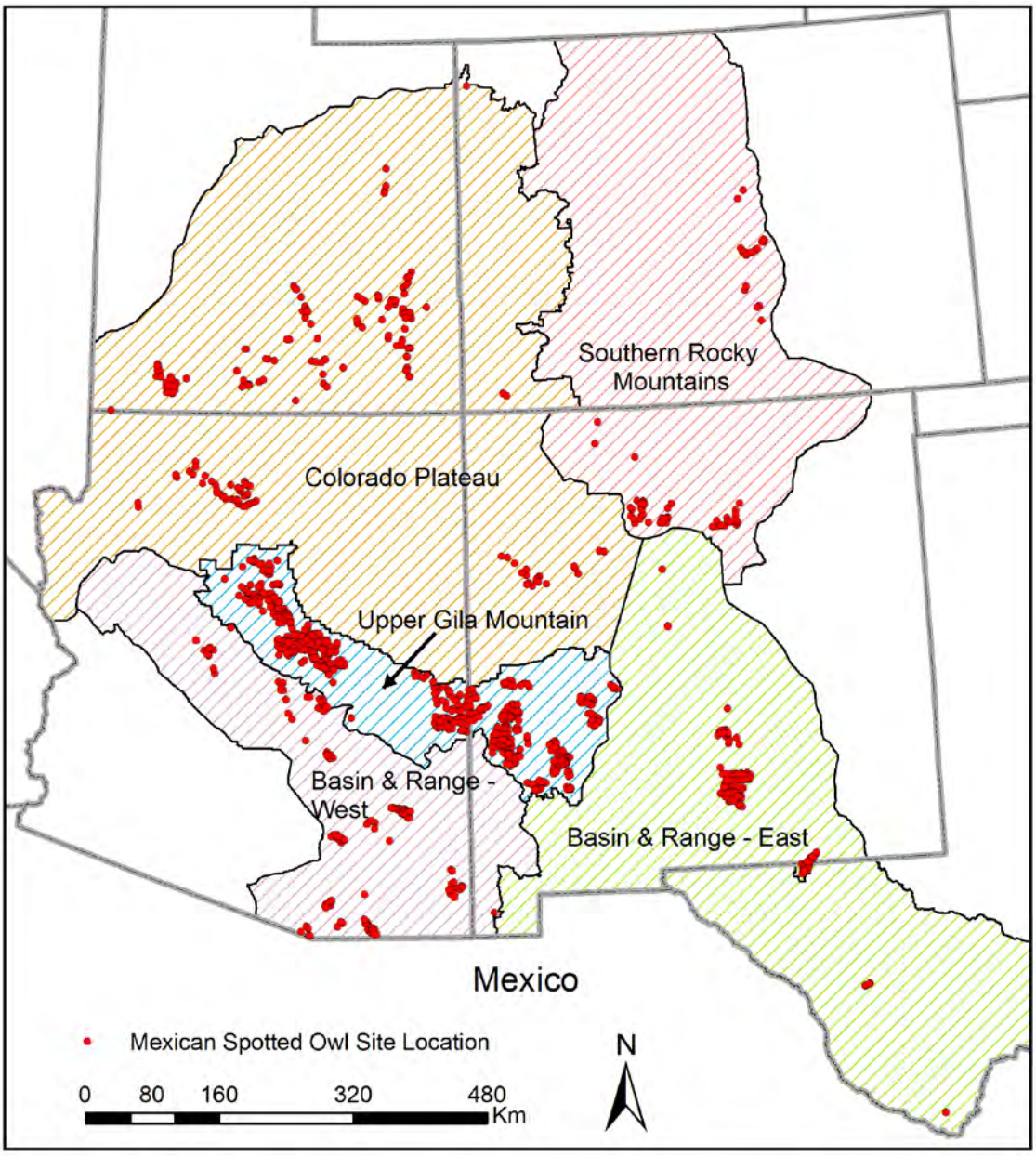


Figure B.4. General areas occupied by Mexican spotted owls within five EMUs within their range in the United States.

Table B.1. Number of Mexican spotted owl site records summarized by U.S. EMU and land ownership. Numbers are cumulative since 1989. A site could include a single owl or a pair of owls. These numbers are best interpreted as minimum cumulative numbers of locations where at least one owl was recorded during at least one breeding season since 1989. We do not know how many of these sites are currently occupied. Data are from USDA FS-PAC centers, Ward et al. (1995), Mullet (2008), and site locations provided by several people to the authors of this Recovery Plan.

EMU / Land Jurisdiction	Site records[1] Number	% of total
Colorado Plateau	206	15.6
USDA Forest Service	28	
USDI Bureau of Land Management	45	
USDI National Park Service	132	
State of Utah	1	
Southern Rocky Mountain[2]	**74**	5.6
USDA Forest Service	59	
USDI Bureau of Land Management	10	
USDI National Park Service	3	
Private	2	
Upper Gila Mountain	**688**	52.0
USDA Forest Service	684	
USDI National Park Service	4	
Basin and Range – East	**182**	13.7
USDA Forest Service	151	
USDI National Park Service	26	
Private	5	
Basin and Range – West	**174**	13.1
USDA Forest Service	155	
Department of Defense	11	
USDI National Park Service	8	
Total Among EMUs:	**1,324**	100.0

[1] Site as defined in Box 1 of the Recovery Plan.
[2] Colorado portion = 21 sites; New Mexico portion = 53 sites.

Jalisco, Michoacán, Guanajuato, and the state of Mexico (Williams and Skaggs 1993, USDI FWS 1995). Parts of the northern Sierra Madre area are similar ecologically to the Sky Island Mountains of southeastern Arizona (Marshall 1957, Cirett-Galan and Diaz 1993). It is not known if the distribution of Mexican spotted owls in Mexico has changed or how many additional sites have been recorded since 1994.

4. Habitat Use

The term habitat can convey many meanings (for a comprehensive discussion of the habitat concept as it applies to birds, see Block and Brennan 1993). Here, we follow the terminology summarized by Hall et al. (1997) and use the term habitat to mean the physical elements and biological resources required by the Mexican spotted owl to persist. This generalized definition includes climatic ranges, types of vegetation, food items, and non-biotic or physical features like topography or geologic structures. Habitat for a given organism is often explicitly defined by vegetative categories like cover-types with the implicit understanding that these categories are comprised of multiple resources that vary among categories. As organisms use habitats to meet multiple life history requirements, it is useful to describe habitat requirements according to activity of the organism or the function provided by the habitat. Doing so requires not only a discussion of habitat features associated with a particular activity but also the spatial scale at which that activity occurs. In the following sections, we describe Mexican spotted owl habitat according to scale and activity.

A. Landscape Scale

This owl's habitat occurs as patches within uninhabitable portions of a larger land base. The term landscape refers to the combined space of habitat patches and a matrix of unusable areas. For Mexican spotted owls to persist through time, there must be adequate dispersion of individuals throughout the landscape and a means for population connectivity. In addition, dispersing owls must be able to locate usable habitat if they are to survive and reproduce. Use of habitat at the landscape scale, then, includes use of patches and corridors for assuring connectivity among subpopulations as well as patch use by resident birds that form local populations. Here, we first discuss studies of landscape connectivity, then focus on studies of landscape composition around owl use areas (see also Home Range Features and Microhabitat Features).

a. Landscape Connectivity.—Keitt et al. (1995, 1997) attempted to identify those habitat clusters most important to overall landscape connectivity, using maps based on forest and woodland cover to define habitat clusters. They first ranked habitats to emphasize the importance of large patches in the landscape, and second, they modified this approach to emphasize positional effects (i.e., small clusters that are important because they act as "stepping stones" or bridges between larger habitat clusters).

In the first analysis, the largely contiguous forest habitat of the Mogollon Rim (UGM EMU) emerged as most important overall, because of its large area. In the analysis emphasizing cluster position, the UGM EMU again emerged as important, due to its central location. But a few small habitat clusters also emerged as particularly important. These included several fragments of the Cibola National Forest (Mount Taylor and Zuni Mountains, CP EMU) that may serve as stepping stones between other, larger clusters. These small patches may warrant particular management attention; they may be important to overall landscape connectivity despite supporting relatively few resident owls. However, conclusions about the importance of specific habitat clusters depend heavily on the underlying map of habitat clusters, and the true distribution of these clusters remains unknown.

In a separate analysis, Urban and Keitt (2001) used a graph-theoretic perspective to evaluate the effects of habitat loss on patch occupancy by Mexican spotted owls. They assumed that the Mexican spotted owl population functioned as a metapopulation (see Metapopulation Ecology, below) and used Hanski's incidence function (Hanski 1994, 1998) to simulate the effects of different patch-removal strategies on owl occupancy rates according to two different landscape models. The first model distinguished habitat as suitable versus unsuitable based on the presence of certain forest types, using the habitat map from Keitt et al. (1995, 1997). The second landscape model estimated habitat suitability in 25-km^2 blocks, based on a combination of forest type and forest density. The authors found differences between landscape models in the effects of patch removal, and differences between patch-removal strategies within landscapes. Similar to their earlier analysis (Keitt et al. 1995, 1997), retention of certain patches that maintained connectivity buffered occupancy rates against habitat loss far more than removal of other, less spatially important patches. As long as connectivity among patches was maintained, occupancy rates remained high even in the face of loss of significant amounts of habitat. However, these conclusions rely largely on the assumption that maintaining a connected landscape will maintain dispersal processes regardless of population size. In reality, large losses in amount of habitat available to resident owls would result in fewer owls that could reproduce and fewer young to disperse. This ultimately could lead to the disconnection of subpopulations regardless of spatial aspects of connectivity.

In summary, Keitt et al. (1995, 1997) and Urban and Keitt (2001) evaluated landscape models that all highlight the importance of landscape connectivity (see also Barrowclough et al. 2006). Their findings further highlight the importance of both large patches of habitat, and of some small patches based on their location and consequent influence on landscape connectivity. Their results suggest that management plans should be concerned with those stepping-stone areas, and that conservation efforts focused in such areas may pay large dividends relative to land area involved in conservation measures. We view this general conclusion as robust to violations of model assumptions, although the specific patches involved obviously depend on those assumptions.

b. Landscape Composition.—Understanding landscape composition of sites occupied by Mexican spotted owls clearly would aid in developing conservation strategies for this species. To date, three studies have examined landscape composition around sites occupied by Mexican spotted owls at various spatial scales. These studies are discussed below.

Grubb et al. (1997) used air-photo interpretation to compare relative area of four canopy-cover classes between 47 owl nest and randomly located sites on the Coconino National Forest, north-central Arizona, at five different spatial scales. They analyzed landscape composition in both circles (radii = 0.1., 0.4, 0.8, 1.2, and 1.6 km [0.06, 0.25, 0.5, 0.75, 1.0 mi]) and concentric "rings," where outer rings did not include areas sampled in inner rings, and included owl nest sites in landscapes dominated by mixed-conifer forest, pine-oak forest, and rocky canyons with mixtures of forest types.

Landscape composition (based on concentric rings) differed between owl nest and random sites at all scales, but differences were greatest within 0.8 km (0.5 mi) of nest or roost sites and decreased at increasing spatial scales (Grubb et al. 1997: Fig. 2). Owl sites contained more area

in the >70% canopy-cover class and less area in the <10% canopy-cover class than random sites. The most abundant canopy-cover class on the landscape was 41-70%, except within 0.1 km (0.06 mi) of owl nests, where the >70% canopy-cover class was most abundant.

Peery et al. (1999) evaluated the use of specific cover types by Mexican spotted owls in the Tularosa Mountains, New Mexico, and the spatial configuration of those cover types. This study area was dominated by mixed-conifer forest (Peery et al. 1999: Table 1). They compared landscape characteristics between 40 owl nest or roost sites and an equal sample of randomly located sites, based on a vegetation map derived from Landsat Thematic Mapper imagery. They evaluated landscape composition at eight spatial scales, in circles with radii ranging from 500 m (1,640 ft) (area = 78.9 ha [195 ac]) to 4,000 m (13,123 ft) (area = 5,030 ha [12,429 ac]). These circles thus were not spatially independent, because much of the area included in larger circles also was included within smaller circles. For example, 76.5% of their outermost circle consisted of area sampled in the next smaller circle.

In Peery et al. (1999), areas around Mexican spotted owl nest and roost sites contained greater amounts of both mature mixed-conifer forest and mature ponderosa pine (*Pinus ponderosa*) forest than random sites. Differences between owl and random sites persisted across all spatial scales but were most pronounced within 500 m (1,640 ft) of the nest or roost and declined with increasing spatial scale (Peery et al. 1999: Figs. 1 and 2). Visual inspection of Figures 1 and 2 in Peery et al. (1999) suggests that much of the difference in vegetation composition at larger scales was driven by differences at smaller scales (i.e., to inclusion of area sampled by smaller circles in larger circles). After controlling for the area in various vegetation types, they found no differences between owl and random sites with respect to five indices of spatial configuration of cover types (mean patch size, edge distance, mean nearest-neighbor distance, mean patch shape index, and habitat heterogeneity).

May and Gutiérrez (2002) conducted a similar analysis for owls in a study area dominated by ponderosa pine - Gambel oak (*Quercus gambelii*) forest in the Coconino National Forest, Arizona (this area was included in the study area in Grubb et al. [1997]). They compared 51 owl nest or roost sites with an equal sample of random sites at three spatial scales: a circular plot of 800-m (2,625-ft) radius (area = 201 ha [497 ac]), and two 400-m (1,312-ft) wide "ring" plots between 800 m (2,625 ft) and 1600 m (5,249 ft) from each nest or roost tree. These scales thus were spatially independent in the sense that outer analysis areas did not include area sampled by inner analysis areas.

Landscape composition in May and Gutiérrez (2002) differed between owl and random sites only within the 201-ha analysis area. Areas around owl nest and roost sites contained more mature mixed-conifer forest and young mixed-conifer forest with canopy cover >55% than expected based on availability. Young forests were used only where residual large (≥45.7 cm [18 in] diameter at breast height [dbh]) trees were present. Again, no differences were noted between owl and random sites in three indices of landscape configuration (mean patch size, mean patch shape index, and contagion).

In summary, current studies of landscape composition suggest that owls locate home ranges non-randomly, placing them in areas such that the center of the home range contains greater than

average amounts of mature forest or in areas of younger forest with high canopy cover and containing residual large trees. Differences in landscape composition between owl and random sites generally were greatest near nest or roost sites and decreased with increasing area. This may indicate that owls are most selective for nesting or roosting core areas, or simply that larger circular analysis areas included more unused habitat or habitat used primarily for foraging. In general, the scale at which differences between owl and random sites were most pronounced (201 ha [497 ac]; Grubb et al. 1997, May and Gutiérrez 2002) correlated reasonably well with the size of Protected Activity Centers (PACs; 243 ha [600 ac]) recommended in USDI FWS (1995) and in this Recovery Plan.

B. Home Range Scale

a. Space Use.—Four concepts are relevant to understanding space and habitat use by resident Mexican spotted owls: territory, home range, activity center, and core area. A territory is defined as an exclusive area defended by the occupant (Welty 1975:224-225). A home range is defined as the area used (but not always defended) by an animal during its normal activities (Burt 1943). Unlike territories, home ranges of adjacent pairs may overlap spatially. Home ranges more appropriately define the area from which all resources required for a given time period are obtained by an organism. An activity center is an area within the home range receiving concentrated use. The activity center could be the same size as a territory when the former is small and consistently defended. A core area is a specific type of activity center that usually includes a minimum area for protecting special resources like trees and groves used for roosting, nesting, or rearing of young (Bingham and Noon 1992, Reynolds et al. 1992, Ward and Salas 2000). Activity centers and core-areas have been used to estimate the size of areas needed to protect habitat most commonly used by spotted owls (e.g., Bingham and Noon 1992, Gutiérrez et al. 1992, USDI FWS 1995).

Spotted owls are described as territorial in that mated pairs defend a breeding territory, at least during the nesting season. Fidelity to these territories is apparently high in Mexican spotted owls, with many owls remaining on the same territory year after year (Gutiérrez et al. 1995). No direct estimates of territory size are available for Mexican spotted owls. However, estimates of nearest-neighbor distances between adjacent pairs may provide some insight into the size of exclusive areas used by this owl. Such estimates are available for two study areas where there is reasonable certainty that all pairs of owls in a given area were located. One of these study areas was located in the Tularosa Mountains, New Mexico (Peery et al. 1999) and the other in north-central Arizona (May and Gutiérrez 2002). Mean distances between adjacent pairs in these areas were 2.1 km (1.3 mi) in New Mexico (n = 31 pairs) and 2.4 km (1.5 mi) in Arizona (n = 42 pairs), suggesting that exclusive use areas average approximately 346 to 452 ha (855 to 1,115 ac), respectively.

Investigators have studied home-range size of Mexican spotted owls directly by monitoring movements of radio-marked owls in a number of different geographic areas and/or habitats (Table B.2). Home-range size appears to vary considerably both among these studies (Table B.3) and between the breeding and non-breeding seasons. The factors underlying variation among studies are unclear, however. For example, various studies used different sampling

Table B.2. Characteristics of study areas where movements of radio-marked Mexican spotted owls were monitored (from Ganey and Block 2005a).

Study area	State	General landform	Primary cover types[1]	Source[2]
San Francisco Peaks	Arizona	Montane slopes	Mixed-conifer, ponderosa pine	1
Walnut Canyon	Arizona	Incised canyon	Mixed-conifer, ponderosa pine, riparian	1
Sacramento Mountains[3]	New Mexico	Montane slopes and canyons	Ponderosa pine/pinyon-juniper/oak, Mixed-conifer, ponderosa pine, pinyon-juniper	2, 3
Sacramento Mtns – mesic[3]	New Mexico	Montane slopes and canyons	Mixed-conifer, ponderosa pine, pinyon-juniper	4
Sacramento Mtns. – xeric[3]	New Mexico	Montane slopes and canyons	Mixed-conifer, ponderosa pine, pinyon-juniper	4
Bar-M Canyon	Arizona	Rolling hills, cinder Cones	Ponderosa pine – Gambel oak, ponderosa pine	5
Colorado	Colorado	Incised canyons	Mixed-conifer, pinyon-juniper, Ponderosa pine	6
Southern Utah	Utah	Incised canyons	Pinyon–juniper, mixed-conifer	7
Grand Canyon	AZ	Incised canyon	Pinyon-juniper	8

[1] Dominant species: Mixed-conifer = Douglas-fir (*Pseudotsuga menziesii*) and/or white fir (*Abies concolor*), with ponderosa pine (*Pinus ponderosa*) and southwestern white pine (*P. strobiformis*) common. Ponderosa pine = ponderosa pine. Riparian = boxelder (*Acer negundo*), narrowleaf cottonwood (*Populus angustifolia*), and quaking aspen (*P. tremuloides*). Ponderosa pine / pinyon – juniper / oak = ponderosa pine, pinyon pine (*P. edulis*), various juniper species (*Juniperus* spp.), and Gambel oaks (*Quercus gambelii*). Pinyon – juniper = pinyon pine, various species of junipers. Ponderosa pine – Gambel oak = ponderosa pine, Gambel oak.

[2] Sources: 1 = Ganey and Balda 1989b (UGM EMU); 2 = Zwank et al. 1994 (BRE EMU); 3 = Skaggs 1990 (BRE EMU); 4 = Ganey et al.2005 (BRE EMU).; 5 = Ganey et al. 1999 (UGM EMU); 6 = Johnson 1997 (Southern Rocky Mountains [SRM] EMU); 7 = Willey and van Riper 2000, 2007 (CP EMU); 8 = Bowden 2008 (Grand Canyon National Park, CP EMU).

[3] Ganey et al. (2005) recognized two distinct study areas in the Sacramento Mountains, whereas Zwank et al. (1994) and Skaggs (1990) did not. The mesic area was dominated by mixed-conifer forest, the xeric area by drier forest and woodland types.

Table B.3. Size (ha) of home ranges or activity centers (where available) of radio-marked Mexican spotted owls during the breeding and non-breeding seasons, as estimated in various studies. Seasons followed Ganey and Balda (1989b) in all studies (breeding season = 1 Mar – 30 Aug). *N* = number of owls included in estimates. Home range estimates based on the minimum convex polygon estimator (Zwank et al. 1994) or 95% adaptive kernel estimator (Ganey et al. 1999, 2005; Willey and van Riper 2007, Bowden 2008). Activity centers based on the 75% adaptive kernel estimator.

Parameter /	Breeding season			Non-breeding season			
Study area	*N*	Mean	SE	*N*	Mean	SE	Source
Home-range size /							
Sacramento Mountains[1]	9	278	75.3[2]	9	365	100.3[2]	Zwank et al. 1994
Sacramento Mtns. – mesic[1]	6	228.1	37.3	6	328.0	59.3	Ganey et al. 2005[3]
Sacramento Mtns. – xeric[1]	6	458.9	83.4	6	895.5	304.8	Ganey et al. 2005[3]
Bar-M Canyon	8	392.5	70.0	14[4]	948.9	146.8	Ganey et al. 1999
Southern Utah	12	545	518[5]	12	1032	657[5]	Willey and van Riper 2007
Grand Canyon	5	562	84				Bowden 2008
Activity-center size /							
Sacramento Mtns. – mesic[1]	6	69.9	9.5	6	89.3	14.4	Ganey et al. 2005[3]
Sacramento Mtns. – xeric[1]	6	156.2	22.0	6	352.1	131.1	Ganey et al. 2005[3]
Bar-M Canyon	8	121.7	21.8	14[4]	326.5	53.8	Ganey et al. 1999

[1] Zwank et al. (1994) pooled owls within the Sacramento Mountains when estimating size of seasonal home ranges, whereas Ganey et al. (2005) recognized two distinct study areas in the Sacramento Mountains. The mesic area was dominated by mixed-conifer forest, the xeric area by drier forest and woodland types.

[2] *SE* estimated from data in Zwank et al. (1994)

[3] Results presented here were recalculated using data from the sample of owls discussed in Ganey et al. (2005). Ganey et al. (2005) did not present data on activity-center size, and summarized data on home-range size in a figure.

[4] Fourteen range estimates computed for 13 individual owls. One radio-marked female dispersed to a new territory during the study. Separate range estimates were computed for this owl in different years.

[5] Standard deviation (Willey and van Riper 2007).

methods or home-range estimators, and studies were conducted in different years. All of these factors can influence estimates of home-range size (Kernohan et al. 2001), making direct comparisons among studies difficult. Consequently, observed differences among studies could be due to differences in methods, local habitat quality including abundance of prey, biogeographic effects (e.g., differences in climate pattern or biogeographic region), temporal variation (studies conducted in different years), or all of the above.

A study that used consistent methods simultaneously across two study areas in the Sacramento Mountains, New Mexico, suggested that differences in local habitat quantity and/or quality influenced home-range size (Ganey et al. 2005). Home-range size was greater during both the breeding and non-breeding seasons in a study area dominated by xeric forest types than in a study area dominated by mesic mixed-conifer forest (Tables B.2 and B.3). Further, range size was inversely related to the proportion of the home range consisting of mixed-conifer forest. This relationship held both within study areas and across both study areas considered together, and in both seasons (Ganey et al. 2005). Owls roosted primarily in mixed-conifer forest in both study areas, and observed fecundity and survival rates of radio-marked owls were lower in the area dominated by xeric forests than in the area dominated by mixed-conifer forest (Ganey et al. 2005). Collectively, these observed patterns suggested that differences in local habitat quality helped explain the variation in home-range size.

Some investigators also estimated size of seasonal activity centers (Table B.3). Again, considerable variability was observed across studies. In general, however, activity centers were considerably smaller than home ranges of radio-marked owls. Noting this concentration of activity in a portion of the home range, the recommended size of PACs in USDI FWS (1995) and in this Recovery Plan was based on activity centers rather than home ranges, in an attempt to focus management on the areas most used by the owls.

Thus, available information suggests that Mexican spotted owls use relatively large home ranges, with smaller areas of concentrated use embedded within those home ranges. Home-range size appears to vary among geographic areas and/or habitats. Some of that variation may be due to differences in methods among studies, but we assume that some of the observed variation is real. At this time, the relative influences of biogeographic regions versus local differences in habitat quality on home-range size of Mexican spotted owls remain unclear, although limited information suggests that such local differences may be important (Ganey et al. 2005, see also Carey et al. 1992, Zabel et al. 1995).

b. Habitat Use Within the Home Range.—Within their home range, Mexican spotted owls nest, roost, forage, and disperse in a diverse array of biotic communities. They can be found in heavily forested areas as well as in rocky canyons with sparse or no forest cover (Ligon 1926, Ganey and Dick 1995, Ward et al. 1995). Although these forest and canyon environments appear very different in terms of habitat conditions, they represent end points on a gradient of habitat conditions rather than discrete environments for use by Mexican spotted owls (Ganey and Balda 1989a). That is, these owls occur along a gradient ranging from areas that are extensively forested and largely lack significant rock outcrops or cliffs, to steep rocky canyons that lack significant forest cover. The Sacramento Mountains of south-central New Mexico provide a good example of forest-dwelling Mexican spotted owls. There, owls occur in heavily forested

mountains and typically are not closely associated with rock outcrops or cliffs (Ganey et al. 2000, Ward 2001, Lavier 2006). In contrast, Mexican spotted owls in the canyonlands of southern Utah and northern Arizona (e.g., Zion, Canyonlands, Capitol Reef, and Grand Canyon National Parks) occur in narrow slickrock canyons, are closely associated with cliff-forming rock formations, and are not reliant on extensive forest cover (Kertell 1977, Rinkevich and Gutiérrez 1996, Willey 1998b, Willey and van Riper 1998, 2007, Willey and Ward 2004, Bowden 2008).

Throughout their range, Mexican spotted owls are often, but not always, associated with steep topography (Ganey and Dick 1995). This association is particularly prominent in the canyonlands, where the topography likely contributes directly to habitat suitability. Owls in these areas frequently nest and roost on ledges on steep cliffs, or in caves, potholes, or alcoves formed in these cliffs (e.g., Rinkevich and Gutiérrez 1996, Willey and van Riper 1998, Willey and Ward 2004, Bowden 2008, Mullet 2008, see also Johnson 1997). These types of structures tend to occur most frequently in the same formations where deep, narrow, complex canyon systems with exposed cliffs are formed (see Box B.1 for a fuller discussion of Habitat of Canyon-dwelling Owls).

In more heavily forested areas, the reasons underlying the frequent association between owls and steep topography are less clear. Owls in these areas typically inhabit mature forests, and in many cases these forests are restricted to steep topography due to past harvest of forests elsewhere (Ganey and Balda 1989a, Ganey and Benoit 2002). In at least some areas, however, owls occur in gentle terrain where suitable forest structure is present (Ganey et al. 1999, 2000). This suggests that the association between owls and steep terrain in forested areas may be driven more by the influence of forest structure than by topography itself. However, diverse topography also contributes to diversity in vegetation types and structure in the southwest. This diversity in turn contributes to habitat complexity, a feature that seems to be common to areas occupied by Mexican spotted owls (Ganey and Balda 1989a, Willey and van Riper 1998, Willey and Ward 2004). Areas of diverse topography, especially where significant rock outcrops or cliffs are present, also may serve as fire refugia (Camp et al. 1997), reducing the frequency of widespread surface fires and allowing longer periods for development of forest structure. Regardless of the underlying mechanism, the association between owl occupancy and steep terrain is strong, even in forested terrain (see Bowden et al. 2003, Ganey et al. 2004). Indeed, this association is strong enough that several investigators have based predictive models of owl habitat primarily on topographic features (see Habitat Models).

In both forest and canyon environments, Mexican spotted owls tend to select roosting and nesting sites that provide thermal protection. In the case of forested sites, large trees, dense canopy cover, and first or second order tributaries all act to create a cooler microclimate during warm ambient temperatures of the breeding season (e.g., Ward and Salas 2000, Ganey 2004).

c. Cover Types.—Use of cover types by Mexican spotted owls varies according to geographic region. Much of this regional variation likely reflects regional variation in habitat composition, climate pattern, and prey availability.

BOX B.1
HABITAT OF CANYON-DWELLING MEXICAN SPOTTED OWLS

In parts of its range, the Mexican spotted owl occupies a variety of steep, rocky-canyon habitats (Kertell 1977, Ganey and Balda 1989a, Rinkevich and Gutiérrez 1996, Willey 1998b, Willey and Ward 2004, Willey and van Riper 2007, Bowden 2008, Mullet 2008). A complex of physical gradients (including water availability, amount of sunlight, slope, and elevation) can produce a "canyon effect" (Dick-Peddie 1993). The physical shape and dimension of canyons can affect local temperature, humidity, and vegetation, enhancing key welfare factors (e.g., nest and roost habitats) for the owl, particularly within arid portions of its range (Barrows 1981, Rinkevich and Gutiérrez 1996, Willey 1998b). Rocky cliffs and canyon rims can modify the amount of direct sunlight penetrating inner-canyon habitats, so that vegetation communities and microclimates may vary greatly among topographic zones (e.g., washes, benchlands, talus slopes, cliffs, and rim habitats). Canyon walls also can create complex habitat structure, a feature typically associated with habitats used by forest-dwelling spotted owls (Forsman et al. 1984, Ganey and Dick 1995).

Rocky canyon habitats used by Mexican spotted owls typically include dendritic watersheds with myriad tributary canyons, a variety of vegetation communities (ranging from arid to mesic), and prominent vertical-walled or overhanging cliffs (Rinkevich and Gutiérrez 1996, Willey 1998b, Swarthout and Steidl 2001). Within canyon habitats, Mexican spotted owls may nest and roost on cliff faces using protected caves or ledges (Rinkevich and Gutiérrez 1996, Willey 1998b, Bowden 2008) or roost in small patches of riparian tree species (Bowden 2008, Mullet 2008), and forage among caves, cliff faces, and rim or canyon-bottom vegetation for various small mammals, including mice (*Peromyscus* spp.), woodrats (*Neotoma* spp.), and bats (*Vespertilionidae*) (Ganey 1992, Ward and Block 1995, Rinkevich and Gutiérrez 1996, Willey 1998b, Johnson 1997, Sorrentino and Ward 2003).

We recognize several broad patterns of habitat use by Mexican spotted owls that occupy rocky-canyon habitats:

- Mexican spotted owl home ranges include a significant component of vertical walled rocky canyons with numerous cliffs, caves, ledges, and branching tributary canyons. Mexican spotted owls use nest, roost, and foraging habitats that are strongly associated with complex vertical and horizontal landscape structure, complex geomorphology, and canyon- and cliff-forming geologic substrates. Rocky architecture (e.g., slope, aspect, and ruggedness) may provide important habitat components (e.g., nest sites, roost sites, shade, foraging surfaces) normally associated with forest vegetation structure.
- Home ranges and activity centers used by Mexican spotted owls in canyon habitat can include a diversity of vegetation types, including desert-scrub, pinyon (*Pinus* spp.) –juniper (*Juniperus* spp.) woodland, riparian, ponderosa pine-oak, and mixed-conifer forest. Therefore it may be difficult to rely on vegetation alone to identify suitable habitat.
- Mexican spotted owls in canyon habitats primarily use rugged terrain located below canyon rims, and all known breeding sites and associated nesting cores areas have been located below the canyon rims (Willey and van Riper 2007, Bowden 2008). However, home-range data in some areas also indicate that the owls may use rims and mesa tops when hunting and vocalizing (Willey and van Riper 2007, Bowden 2008). Thus, adjacent highlands should not be ignored in management planning.

Canyon habitats occupied by Mexican spotted owls possess some common emergent properties. These primary elements include rocky cliffs, parallel-walled canyons, relatively long canyon complexes, cool north-facing aspects, complex branched tributary side-canyons, and a mosaic of vegetation communities ranging from cool riparian through montane forest to arid scrub desert. There are exceptions to these emergent properties, however, including occasional use of small side canyons and areas not on north-facing aspects.

In the northern portion of the Mexcian spotted owl's range, including Utah, Colorado, and parts of far northern Arizona and New Mexico (CP and SRM EMUs), owls occur primarily in steep-walled, rocky canyons (Kertell 1977, Rinkevich and Gutiérrez 1996, Johnson 1997, Willey and van Riper 1998, Willey and Ward 2004, Bowden 2008). These canyon systems vary in the amount of forest cover present, but in general they are less heavily forested than are canyons occupied farther south. Pinyon-juniper woodlands and mixed-conifer forest are prominent cover types used in these canyon systems (Ganey and Dick 1995, Willey 1998b), but in some cases these canyons are entirely or largely lacking forest or woodland cover.

Farther south, a wider range of cover types are used. For example, along the Mogollon Rim in Arizona and New Mexico (UGM EMU), spotted owls occur in mixed-conifer forests, ponderosa pine-Gambel oak forests, and associated riparian forests (Ganey and Balda 1989a, Ganey and Dick 1995, Seamans and Gutiérrez 1995, Peery et al. 1999, Stacey and Hodgson 1999, May and Gutiérrez 2002, Stacey 2010). They frequently occur in canyon systems and in association with steep terrain in this region as well. These canyons generally have greater forest cover than canyons in the northern portion of the range, however, and owls are not restricted to canyons and steep terrain in this region.

South of the Mogollon Rim, in southern New Mexico, and into Mexico (BRE, BRW, and Mexican EMUs) an even wider range of cover types are used, including mixed-conifer, Madrean pine-oak, and Arizona cypress (*Cupressus arizonica*) forests, encinal oak woodlands, and associated riparian forests (e.g., Ganey and Dick 1995, Tarango et al. 1997, 2001, Young et al. 1998, Márquez-Olivas et al. 2002, Mullet 2008, Mullet and Ward 2010). Some owls are found in association with canyon systems or steep montane terrain. But, as along the Mogollon Rim, many of these canyons contain extensive forest or woodland cover, and owls are not restricted to deep rocky canyons except for small populations of owls occurring in southern portions of the BRE EMU (e.g., Guadalupe and Davis Mountains, Mullet 2008). Thus, there appears to be a north-south gradient in diversity of habitats used, with a wider range of both cover types and terrain types used in the southern portion of the range than in the northern portion (Ganey and Dick 1995).

Despite the diversity of cover types where Mexican spotted owls have been found, these owls most commonly use mixed-conifer forests throughout their range within the U.S. (e.g., Ganey and Dick 1995, Seamans and Gutiérrez 1995, Willey 1998a, Stacey and Hodgson 1999, Ganey et al. 2000, Ward 2001, Stacey 2010). These forests are dominated by Douglas-fir (*Pseudotsuga menziesii*) and/or white fir (*Abies concolor*), with co-dominant species including southwestern white pine (*P. strobiformis*), limber pine (*P. flexilis*), and ponderosa pine (Brown et al. 1980). The understory often contains the above coniferous species as well as broadleaved species such as Gambel's oak, maples (*Acer* spp.), box elder (*A. negundo*), and New Mexico locust (*Robinia neomexicana*). These broadleaved species may be important (Ganey et al. 1992, 1999, 2003, Seamans and Gutiérrez 1995, Stacy and Hodgson 1999, May and Gutiérrez 2002, May et al. 2004), either in adding to structural complexity or by providing nest sites (SWCA 1992, Fletcher and Hollis 1994, May and Gutiérrez 2002, May et al. 2004) or additional food sources for prey species (Ward 2001).

Madrean pine-oak forests used by Mexican spotted owls are dominated by an overstory of various pine species in conjunction with species such as Douglas-fir and Arizona cypress. In

southern Arizona, pine species represented include primarily Apache (*P. engelmannii*), Chihuahuan (*P. leiophylla*), and Arizona (*P. arizonica*) pine. Farther south, a number of other pine species are present. For example, a study area in the state of Chihuahua, Mexico, included the pines discussed above as well as Durango (*P. durangensis*), Mexican white (*P. ayacahuite*), and weeping (*P. patula*) pine (Tarango et al. 1997). Still farther south, in Aguascalientes, Apache and Arizona pines dropped out, whereas ocote (*P. oocarpa*), nut (*P. cembroides*), and Michoacán (*P. michoacana*) pine were present (Tarango et al. 2001, Márquez-Olivas et al. 2002). Evergreen oaks were prominent in the understory in all of these pine-oak types (Brown et al. 1980, Tarango et al. 1997, 2001, Young et al. 1998, Márquez-Olivas et al. 2002).

In areas where Mexican spotted owls inhabit canyons, canyon structure and cover types can vary according to geographic region. The following sections provide separate canyon habitat descriptions for the CP, New Mexico portion of SRM, and BRE EMUs.

1. CP EMU.—In Utah, the type of incised canyon habitat occupied by Mexican spotted owls is present in Dinosaur National Monument, Desolation Canyon, the San Rafael Swell, Zion National Park, Grand Staircase-Escalante National Monument, Glen Canyon National Recreation Area, Capitol Reef National Park, and Canyonlands National Park. Canyon habitat also occurs in the Dixie, Manti LaSal, and Fishlake National Forests and on large tracts of land managed by the BLM. In Colorado, examples of rocky canyon habitat occur in and around Mesa Verde National Park and on Ute Tribal Lands. In Arizona, similar canyon habitat is present on the Navajo Nation, in Grand Canyon National Park, and on BLM – administered lands (e.g., Paria Canyon).

Willey (1998a, see also Willey and van Riper 2007) studied movements and habitat associations of radio-marked Mexican spotted owls in canyon habitat in southern Utah. Radio-marked owls inhabited areas featuring steep cliffs, rocky topography, and canyons with complex vertical and horizontal structure (Willey 1998b). They typically used roost sites characterized by cool daytime temperatures (relative to nearby randomly located sites) and relatively high overhead cover provided by canyon walls and vegetation (Willey 1998b: Table 4-2). Many roost sites had large conifers or deciduous trees nearby, but others were in areas dominated by pinyon-juniper woodland or desert-scrub vegetation (Rinkevich and Gutiérrez 1996, Johnson 1997, Willey 1998b). Tall cliffs and/or small stands of mixed-conifer forest provide the owls with cool microsites for roosts and nests. Although pinyon-juniper woodland was the most common vegetation type present in owl home ranges in Utah and in the Grand Canyon (Bowden 2008), mixed conifer forest, including Douglas-fir and white fir, was present within one-third of habitat plots randomly located within owl home ranges (Willey 1998b). Eighty-eight percent of telemetry locations occurred below the canyon rims (Willey and van Riper 2007). Thus, suitable canyon habitat can include canyon, rim, and adjacent mesa and plateau landscapes (see also Bowden 2008).

2. *SRM EMU.—* Within this EMU, Mexican spotted owls occur across a wide elevational gradient and occur in both forested mountains and canyons (Johnson and Johnson 1985, Johnson 1997, Hathcock and Haarmann 2008). Owls are more likely to be found in rocky canyons toward the lower end of their elevational range in this region, and more likely to inhabit forests at higher elevations (where forest cover tends to be more continuous on the landscape; T. Johnson, pers. comm.). For example, many owls occur in rocky canyons

incised into volcanic-tuff at lower elevations in the Jemez Mountain Range in northern New Mexico (Santa Fe National Forest and Bandelier National Monument; Johnson and Johnson 1985). These canyons provide many potholes, ledges, and small caves for owls to use for roosting and nesting (Johnson and Johnson 1985). Owls at higher elevations, both in the Jemez and Sangre de Cristo Mountains, are less restricted to rocky canyon situations but generally still occur in areas characterized by high topographic relief. Even at higher sites in the Jemez Mountains, however, many owls nest in cavities in small outcrops of tuff (T. Johnson, pers. comm.).

Vegetation in canyon bottoms and on canyon slopes includes species typical of mixed-conifer forest, such as Douglas-fir, white fir, and ponderosa pine. Deciduous species such as cottonwoods (*Populus* spp.), Gambel oak, boxelder, and alder (*Alnus* spp.) also are present in canyon bottoms (Johnson and Johnson 1985, Johnson 1997). Patches of pinyon-juniper and aspen (*P. tremuloides*) also occur within these canyons. At higher elevations, common species include Engelmann spruce (*Picea engelmannii*), subalpine fir (*A. lasiocarpa*), blue spruce (*P. pungens*), and limber pine (Hathcock and Haarmann 2008). As in many areas in the northern portion of the owls' range, high-elevation forests appear to contain greater amounts of spruce, true firs, and aspen than the mixed-conifer forests occupied by owls farther south.

3. BRE EMU.—Mexican spotted owls in this EMU occur in both forests and rocky canyons. For example, owls are abundant in mixed-conifer forests within the Sacramento Mountains, but they also have been found in the rocky-canyon networks of the Guadalupe and Davis Mountains in southern New Mexico and West Texas, as well as in Carlsbad Caverns National Park, New Mexico. These canyons contain riparian vegetation and encinal woodlands (Brown et al. 1980). In the latter cover type the dominant non-coniferous trees are evergreens, especially oaks and Texas madrone *(Arbutus xalapensis*). Coniferous trees such as pinyon pine (*P. edulis*), junipers, and ponderosa pine occur in low to moderate densities. Owls in these canyons roost in caves, cliff crevices, or in trees associated with springs or riparian corridors (Bryan and Karges 2001, Mullet 2008). In the Guadalupe Mountains, nest and roost sites occurred in steep, mesic canyons containing bigtooth maple (*A. grandidentatum*), western hop-hornbeam (*Ostrya knowltonii*), Chinkapin oak (*Q. muehlenbergii*), Douglas-fir, southwestern white pine, and Gambel oak (Mullet 2008, Mullet and Ward 2010).

d. Space Use of Resident Owls During the Non-breeding Season.—Resident Mexican spotted owls expanded their home range during the non-breeding season in all areas where seasonal home range estimates were available, although the magnitude of this seasonal expansion varied among areas (Table B.3). Clearly, owl home ranges were larger than PACs as defined in USDI FWS (1995:84-89). But PAC size was based on the size of owl activity centers, not home ranges. Size of owl activity centers was more comparable to PAC size in the three study areas where estimates were available (Table B.3). Spatial overlap between seasonal activity centers was considerable (Table B.4). In general, non-breeding-season activity centers contained most of the breeding-season activity center. The mean proportion of the non-breeding-season activity center contained in the breeding-season activity center was lower but still indicated considerable

Table B.4. Spatial overlap between seasonal activity centers (AC; estimated as the 75% adaptive kernel contour) of radio-marked Mexican spotted owls in three study areas[1]. *N* = number of owls included in estimate; only owls with valid range estimates during both the breeding and non-breeding seasons were included in estimates (from Ganey and Block [2005]).

	% of breeding-season activity center contained in non-breeding-season activity center			% of non-breeding-season activity center contained in breeding- season activity center			
				Observed		Maximum[2]	
Study area	*N*	Mean	SE	Mean	SE	Mean	SE
Sacramento Mtns. –mesic	6	85.7	4.6	66.9	5.6	82.6	8.4
Sacramento Mtns. – xeric	6	78.0	7.1	48.8	6.7	65.4	14.0
Bar-M Canyon	8	91.4	3.1	35.5	9.0	42.6	13.0

[1] Based on data from a sample of radio-marked owls included in Ganey et al. (1999, 2005). The parameters estimated here were not included in previous papers.

[2] Theoretical maximum proportion of the non-breeding-season activity center that could be contained in a breeding-season activity center given observed size of those breeding-season activity centers, assuming maximum spatial overlap.

spatial overlap. Further, the smaller size of breeding-season activity centers relative to non-breeding-season activity centers effectively limits the possible range for this measure of overlap (Table B.4). Thus, protection of nesting areas provides protection to areas used by resident owls throughout the year, not only during the breeding season.

e. Habitat Use by Resident Owls During the Non-breeding Season.—Little detailed information is available on habitat use by resident owls during the non-breeding season, but there is some evidence for use of more open habitats at this time. For example, Zwank et al. (1994) reported that owls in the Sacramento Mountains roosted in "shorter trees with less dense foliage" during the winter. Willey (1998a:73) reported that "during winter… Mexican spotted owls were observed roosting in more open habitats." In contrast to this trend, however, he also reported that some owls moved out of steep slickrock canyon terrain and into forested uplands during winter. Johnson (1997:49) noted that wintering owls used "…canyons with a north-south orientation dominated by pinyon-juniper woodlands with scattered patches of ponderosa pine." This latter description included owls classified as both residents and migrants by Ganey and Block (2005a; see also Seasonal Migration section).

In a study of radio-marked owls in pine-oak forests of north-central Arizona, relative areas of cover types did not differ between seasonal home ranges, but relative area in canopy-cover classes did (Ganey et al. 1999). Relative to non-breeding-season ranges, breeding-season ranges contained more area with canopy cover ≥60% and less area with canopy cover ranging from 20 to 39%. Structural features of forest stands used by foraging owls did not differ between seasons, but structure of stands used by roosting owls did. Stands used for roosting during the breeding season had greater live-tree basal area, oak basal area, and canopy cover than stands used during the non-breeding season (Ganey et al. 1999: Table 5). In an analysis focused on a finer spatial scale, canopy cover surrounding roost "microsites" also was greater during the breeding than the non-breeding season in this area (Ganey et al. 2000).

Ganey et al. (2000, 2003) also reported on aspects of habitat use by radio-marked owls in the Sacramento Mountains at these same spatial scales (stand and roost microsite). They found little evidence for differences in seasonal habitat use at either scale within the Sacramento Mountains, for either foraging or roosting use.

In summary, there is evidence for shifts in habitat use in some areas, but not in others. In general, evidence for seasonal differences in habitat use appears strongest where owls occupy rocky canyons in the northern portion of their range. In mixed-conifer forests farther south, seasonal differences in habitat use were less pronounced, and patterns were intermediate in an area where owls occupied pine-oak forest. Where resident owls do use different habitats during the winter, available evidence suggests that those habitats generally are more open in structure.

C. Microhabitat Features

a. Nests and Roosts.—Mexican spotted owls nest and roost primarily in closed-canopy forests or rocky canyons. In the northern portion of the range (southern Utah, Colorado, and parts of northern Arizona and northern New Mexico) and extreme southeastern portions of the range (Mullet 2008), most nests are in caves or on cliff ledges in steep-walled canyons (Johnson 1997,

Willey 1998b, T. Johnson, pers. comm.). Elsewhere, the majority of nests appear to be in trees (Fletcher and Hollis 1994, Seamans and Gutiérrez 1995, May and Gutiérrez 2002, May et al. 2004), but cliffs and caves can be locally important (e.g., Bryan and Karges 2001, Márquez-Olivas et al. 2002).

Where owls occupy rocky canyons, roost sites typically are located in deep, narrow canyons, often with vertical or near-vertical cliffs (Rinkevich and Gutiérrez 1996, Johnson 1997, Willey 1998b, Bowden 2008, Mullet 2008). Owls in these canyons roost on cliff ledges, cliffs, in caves or potholes, or in trees (Rinkevich and Gutiérrez 1996, Johnson 1997, Willey 1998b, Márquez-Olivas et al. 2002, Bowden 2008, Mullet 2008). Roost trees often are located in canyon bottoms near the base of cliffs. Roosting areas typically occur in narrow portions of canyons (Rinkevich and Gutiérrez 1996, Johnson 1997, Willey 1998b, Willey and Ward 2004, Mullet and Ward 2010) in areas featuring complex geomorphology with numerous caves, ledges, and potholes (Rinkevich and Gutiérrez 1996, Willey 1998b). In the canyonlands of Utah and northern Arizona, these canyons tend to be found in particular rock formations, apparently because these formations are suitable for the formation of canyon systems with the type of structural complexity described (Kertell 1977, Willey 1998b, Bowden 2008).

In forested environments, Mexican spotted owls tend to roost and nest in mature or old-growth forests with complex structure (e.g., Ganey and Dick 1995, Seamans and Gutiérrez 1995, Ganey et al. 1999, 2005, Peery et al. 1999, May and Gutiérrez 2002, May et al. 2004). These forests are typically uneven-aged, are multistoried, and have high canopy closure (e.g., Grubb et al. 1997). Where owls occur in younger forests, those forests typically contain large legacy trees (May and Gutiérrez 2002, May et al. 2004). Nest trees are typically large in size (SWCA 1992, Fletcher and Hollis 1994, Seamans and Gutiérrez 1995, May and Gutiérrez 2002, May et al. 2004), whereas owls roost in both large and small trees (Ganey 1988, Willey 1998b, Zwank et al. 1994, Ganey et al. 2000, May et al. 2004).

Tree species used for nesting vary somewhat among areas and habitat types. Douglas-fir is the most common species of nest tree in many areas, particularly areas dominated by mixed-conifer forest (SWCA 1992, Fletcher and Hollis 1994, Seamans and Gutiérrez 1995, Johnson 1997). In pine-oak forests where nesting has been studied in the U.S., nests were commonly found in cavities in large oak trees, followed by platforms in ponderosa pine trees (Ganey et al. 1992, SWCA 1992, Fletcher and Hollis 1994, May and Gutiérrez 2002, May et al. 2004). Only one nest has been reported from Mexican pine-oak forest. This nest was in a 30-cm (12-in) dbh Mexican white oak tree (*Q. polymorpha*, nest structure type not reported; Tarango et al. 1997).

A wider variety of trees are used for roosting, but patterns again vary among forest types and geographic regions. As for nesting, Douglas-fir is the most commonly used species in many areas dominated by mixed-conifer forest (Ganey 1988, Fletcher and Hollis 1994, Zwank et al. 1994, Johnson 1997, Stacey and Hodgson 1999, Ganey et al. 2000). In contrast, owls roost primarily in oaks and pines in areas dominated by pine-oak forests (Ganey et al. 1992, Young et al. 1997, Ganey et al. 2000, Tarango et al. 2001, May et al. 2004, Márquez-Olivas et al. 2002). The most frequently occurring tree species at roost sites in canyons in south-eastern New Mexico

and West Texas are bigtooth maple, western hop hornbeam, and chinkapin oak (Mullet and Ward 2010).

b. Foraging.—Most studies of foraging habitat are based on triangulated locations of radio-marked owls, because it is impossible to visually observe foraging behavior of wide-ranging owls at night. Triangulated locations are inherently inaccurate in the types of terrain and forests occupied by Mexican spotted owls (e.g., Ganey et al. 2003). As a result, our understanding of habitat use by foraging owls is limited. Available studies suggest considerable variability in use of foraging habitat, however, both among study areas and among individuals within study areas (Ganey and Balda 1994, Hodgson 1996, Willey 1998b, Ganey et al. 1999, 2003).

Owls in the canyonlands of southern Utah apparently forage primarily in rocky canyons, as 88% of locations of radio-marked owls fell within canyons (Willey and van Riper 2007, Bowden 2008). Specific features of foraging habitats were not reported in these studies. Owls in most forested study areas show some selectivity for foraging habitat relative to randomly available habitat, but the level of selectivity is reduced relative to habitat-use patterns for roosting and nesting. For example, owls typically forage in all forest stands used for roosting but do not roost in all stands in which they forage (Ganey et al. 1999, 2003). Areas used for foraging typically were in closed-canopy forests featuring high basal area of trees and high volume of logs (Ganey and Balda 1994, Ganey et al. 1999, 2003). Structural characteristics of areas used for foraging differed from those of proximal but random areas in some study areas (Ganey and Balda 1994, Hodgson 1996, Ganey et al. 1999) but were more variable than characteristics of stands used for roosting in all areas (Ganey and Balda 1994, Hodgson 1996, Ganey et al. 1999, 2003). Additional information on variability of the owl's foraging habitat also can be inferred from microhabitat descriptions for the owl's common prey (see Prey Ecology).

D. Summary of Habitat Use

Most studies of how Mexican spotted owls use their habitat have sampled habitat characteristics or otherwise quantified habitat use at relatively fine scales (<0.2 ha [0.5 ac], reviewed in Ganey and Dick 1995). As a result, we know relatively little about patterns of habitat use at coarser scales, including structure of forest stands and landscape composition (but see Grubb et al. 1997, Ganey et al. 1999, 2003, Peery et al. 1999, May and Gutiérrez 2002).

Patterns of habitat use vary with owl activity, seasonally, and regionally. For example, owls appear to be far more selective for habitats used for roosting and nesting than for habitats used for foraging (Ganey and Balda 1994, Ganey et al. 1999, 2003). Within areas that contain suitable roosting and nesting habitat, owls forage in a broader array of both cover types and structural conditions (Ganey and Balda 1994, Ganey et al. 1999, 2003). Similarly, selection for particular types of habitats appears to be relaxed during the non-breeding season, when owls wander more widely and use a wider array of habitats that also tend to have a more open structure. Based on these findings, USDI FWS (1995) explicitly assumed that the presence of suitable habitat for roosting and nesting limited distribution of Mexican spotted owls and primarily based management recommendations on retaining and enhancing such habitat.

a. Reasons Underlying Habitat-Use Patterns.—There are several possible mechanisms underlying habitat use and selection by Mexican spotted owls. For example, several hypotheses have bee
n proposed to explain why spotted owls nest and roost in late-seral, closed-canopy forests (reviewed by Carey 1985, Gutiérrez 1985). These include better thermal protection, greater access to prey, protection from predation, and availability of required nesting structures. Information documenting the relative importance of these factors is limited, with the exception of information relating to thermal protection and prey ecology.

Barrows (1981) suggested that spotted owls are relatively intolerant of high temperatures and roost and nest in shady forests because they provide favorable microclimatic conditions. This explanation seems particularly attractive with respect to Mexican spotted owls, because it provides a unifying explanation for the use of extremes along the habitat gradient that is occupied. Both closed-canopy forests and deep rocky canyons with caves, potholes, and alcoves provide well-shaded and cool microsites relative to surrounding areas, and owls typically use such areas for roosting and nesting (e.g., Ganey and Dick 1995, Seamans and Gutiérrez 1995, Grubb et al. 1997, Willey 1998b, Ganey et al. 1999, 2000, Willey and Ward 2004).

There is empirical evidence in support of this hypothesis in addition to observed patterns of habitat use. Ganey et al. (1993) observed that Mexican spotted owls produced more metabolic heat than great horned owls and were less able to dissipate that heat through evaporative cooling. Teng (1998) compared thermal environments of northern spotted owl roost and random sites in interior forests in northwestern California and estimated that roosting in randomly sampled areas would increase energy costs for thermoregulation by 5 to 34% per day and evaporative water loss by up to 5% per day relative to the sampled roost sites. Weathers et al. (2001) studied metabolic rate and water flux of California spotted owls in the field using doubly-labeled water. They determined that rates of water flux were high relative to metabolic rates and suggested that minimizing water loss might contribute to the owls' preference for cooler environments. Ganey (2004) sampled thermal environments throughout most of the breeding season (May – Aug) in 30 paired nest and random areas in northern Arizona. Owl nest areas were significantly cooler than random areas, and evaporative water loss modeled for Mexican spotted owls was significantly lower in nest than in random areas.

Potentially conflicting with this hypothesis is the presence of owls in canyons and riparian areas at relatively low elevations (e.g., Willey and Ward 2004, Bowden 2008). Although owls appear to select microsites in these canyons that are cooler than surrounding areas, summer daytime temperatures in some of these areas become quite warm. However, owls may be able to maintain favorable water and energy balance even in warm environments if water and prey resources are readily available in sufficient quantities. The ultimate quality of these sites is unknown, as both vital rates of owls using such sites and availability of prey resources in these sites remain unknown.

Taken together, the above research findings suggest that thermal environments may be important in shaping patterns of habitat selection by Mexican spotted owls (Weathers et al. 2001), but do not rule out other explanations. The same types of structural features that result in cooler microclimates may be correlated with factors such as prey abundance, protection from predators,

or availability of nest structures. For example, relatively dense forests with closed canopies and high basal area may provide improved hiding cover for owls in general, especially for inexperienced juvenile owls. Such forests also may provide more and better den structures for small mammals, as well as large, decadent trees that provide suitable nest structures for owls. Similarly, canyon bottoms may be more productive sites for the owl's prey in northern regions of the owl's range (Sureda and Morrison 1998). Individual owls that select roosting and nesting sites that are also closer to other required resources will presumably save energy in acquiring those resources, spend less time away from young, and potentially decrease risk of detection by predators. It seems unlikely that habitat selection is based solely on thermal constraints and more likely that such constraints interact with these other factors (see also Carey et al. 1992, Zabel et al. 1995, Ganey et al. 1997, Ward et al. 1998, Ward 2001, May et al. 2004).

E. Habitat Models

A number of efforts have been made to develop and test predictive models for Mexican spotted owl habitat. These efforts have been conducted independently and were not coordinated until recently. Although specific objectives and approaches differ among efforts, most have focused on nesting and roosting habitat, because of the apparent importance of this type of habitat in explaining owl distribution (USDI FWS 1995). Efforts and models can be loosely grouped by six sets of investigators as discussed briefly below.

a. Terrell H. Johnson.—From 1988 to 2003, T. H. Johnson developed a series of predictive models for Mexican spotted owl habitat. This series of models began with a timber-type model for the Jemez Mountains, New Mexico (Johnson and Johnson 1988, refined and expanded in Johnson 1990). The timber type model predicted availability of suitable habitat within these mountains based on USDA FS stage 1 timber inventory data. Johnson and Johnson (1988) reported that the model successfully discriminated owl from random sites and concluded that it could prove useful in other areas with available timber inventory data.

The timber-type model was superseded by a topographic model of potential owl habitat throughout New Mexico, with model predictions based on topographic characteristics derived from a 1-degree digital elevation model (DEM; Johnson 1993). This model again showed promise for predicting potential owl habitat, and it had the decided advantages that it was based on topographic data available for all land ownerships and might explain owl distribution better in canyon landscapes than did vegetation data. Johnson (2001) tested this model across the range of the owl in the southwestern U.S., using a database of owl locations compiled in 1993 in conjunction with recovery planning efforts (Ward et al. 1995). The model generally performed well in New Mexico and eastern Arizona, but accuracy declined along an east to west gradient. Johnson (2001) concluded that a longitudinal function should be included in future models and that such models should be based on higher-resolution topographic data.

Johnson (1996) reformulated the topographic model for higher-resolution 7.5-minute DEM data in northern New Mexico, then added Landsat imagery to a model covering the Los Alamos National Laboratory, New Mexico (Johnson 1998). Later, he developed a geophysical model of potential owl habitat for the southwestern U.S. (Johnson 2003). This model used the higher-resolution (7.5-min) topographic data and used variables related to winter and summer

precipitation to model the east-west gradient observed in tests of the earlier topographic model throughout the southwest (see Johnson 2001). This model performed reasonably well in tests using independent owl locations. The model assigned a potential habitat index to locations, rather than simply defining habitat as suitable or unsuitable, which may allow greater flexibility in using the model. Johnson (2003) noted that coordinates of some of the locations used in model development likely were recorded inaccurately or imprecisely and that this error hampered the model's ability to discriminate between owl and background sites. He suggested that future models could be improved simply by eliminating spatial error in owl locations and by incorporating additional data resulting from ongoing survey and research efforts on Mexican spotted owls.

b. David W. Willey and Colleagues.—D. W. Willey and colleagues also developed and tested a series of Geographical Information System (GIS)-based models based largely on topographic characteristics, with their efforts focused on the canyonlands of the CP. Their initial model identified predicted breeding habitat for owls throughout the state of Utah based on physical landscape features (Willey and Spotskey 1997). The model identified three habitat classes: predicted breeding habitat, predicted marginal habitat, and predicted non-habitat. The model incorporated data on slope, aspect, slope curvature (an index of ruggedness), and crude vegetation (e.g., forest, shrubland, or grassland). This model was designed to predict the general location of breeding habitat across large landscapes, and it was not intended for use at finer spatial scales (Willey 2002a).

Subsequent efforts expanded that modeling effort to cover northern Arizona as well and focused on producing a model that could be used at multiple spatial scales (Willey and Spotskey 2000, Willey 2002a). This model incorporated data on slope, aspect, slope curvature, vegetation at the species association level, surface geology, soil moisture, and an index of surface temperature (Willey 2002a). Tests of this model using different techniques and in different areas suggested that it was useful at identifying owl breeding habitat in canyon landscapes at relatively fine scales (<1:100,000; Willey and Spotskey 2000, Willey 2002b). However, Willey and Weber (2003) noted that predictions generated confusion among land managers, so they developed a third-generation model using finer-grained spatial data. Field tests of this model were conducted during 2004 with mixed results. In several cases, owls were not detected where probabilities of suitable roosting or nesting habitat were predicted to be high. This result could have been due to a year of low occupancy caused by factors independent of habitat suitability, however (e.g., Willey and Willey 2010). A more refined procedure was used in 2005 to generate and select among competing models developed with different geomorphological and vegetation-based variables. Models with the best performance based on two different selection criteria (Akaike's information criterion [AIC] versus a stepwise optimization procedure) produced similar results. In either case, maps based on confidence intervals (e.g., 95% or 99%) for prediction of occupancy could be produced**.** Percent slope was found to be the most useful variable in predicting owl roosting and nesting habitat regardless of model selection technique. The steepest slopes were identified as the most likely locations to find Mexican spotted owls in the study canyons of Utah.

Willey et al. (2007) further refined this model, again using model selection to rank competing GIS-based habitat models. Model parameters were generated using geomorphological and

vegetation-based habitat variables, and habitat associations were identified by comparing occupied and unoccupied sites located during extensive field surveys (Willey et al. 2007). The set of habitat covariates included: 1) landscape ruggedness, slope, and complexity (Rinkevich 1991, Willey 1998b); 2) relative surface temperature and presence of cool zones (Rinkevich 1991, Willey 1998b); and, 3) vegetation cover, which provides shelter as well as microenvironments for prey species (Ganey and Balda 1989b, Willey 1998b, Ganey et. al 2004). Willey et al. (2007) used model averaging across the three top habitat models to produce a predictive equation to identify potential Mexican spotted owl habitat in canyon terrain within the Utah study areas. The probability of owl occupancy was strongly and positively associated with percent slope and negatively associated with elevation range and selected vegetation covariates. Field testing included surveys in 487 1-km^2 (247 ac) test plots with 1,430 calling stations distributed across 22 U.S. Geological Survey quadrangle maps during the 2007 field season. Mexican spotted owls were detected in 14 quadrangles, including 57 owl detections within 22 individual test plots. The mean habitat suitability for the 22 test plots as estimated by the best approximating model was 60% (SD = 25%). In addition, 70% of the owl detections occurred within plots whose average suitability score was >50% and, for the 22 occupied study plots, only six showed habitat suitability less than 50%.

c. Tim Mullet.— In more recent work, Mullet (2008) examined the applicability of the two models described above (Johnson 2003, Willey et al. 2007) for predicting occupancy of Mexican spotted owls in the Guadalupe Mountains of southeastern New Mexico and West Texas. This work focused primarily on the zones of high-probability (>75%) of owl occurrence predicted by the two models. The two models produced slightly different maps of predicted habitat, with some (overlapping) areas predicted to contain suitable habitat by both models. Mullet (2008) used formal occupancy surveys (during a single breeding season, in a random set of 25, 2-km^2 (494 ac) survey cells, each with two to five stations) and modeled detection probabilities and the probability of site occupancy for each survey cell using various covariates. Covariates included the amounts of high-probability predicted habitat from a given model in each cell. Despite being smaller than the area predicted separately by either model, the overlapping area of habitat predicted by both models provided the same level of accuracy and precision as either model separately. This area of overlap between the two models primarily coincided with narrow, steep-walled canyons. Mullet (2008) therefore concluded that both models were useful for identifying habitat that had a high-probability of being occupied, but that the area of overlap of the two predicted habitat maps was much more efficient than either model alone in predicting habitat that would be occupied by Mexican spotted owls in the Guadalupe Mountains.

d. Joseph L. Ganey and Colleagues.—Efforts by this group focused on National Forest System (NFS) lands in northern Arizona. In an early effort, Ganey et al. (1990, see also Ganey 1991) used GIS, a DEM, and Landsat multispectral scanner imagery to develop a predictive model for Mexican spotted owl habitat on four National Forests in north-central Arizona. Model output was a spatially explicit map of predicted owl habitat. The model defined suitable owl habitat as occurring where slope was >15% and cover type was dense mixed-conifer, ponderosa pine, or deciduous forest.

Ganey (1991) tested this model at the landscape scale by evaluating agreement between model predictions and independent survey locations of Mexican spotted owls (i.e., locations not used in

model development). Prediction accuracy generally was high in mixed-conifer forests, intermediate in pine-oak forests, and lowest in rocky-canyon areas.

Ganey (1991) also tested the model using data from eight radio-marked owls representing five territories in three study areas. Owl locations occurred in predicted habitat significantly more than expected by chance at four of these sites. Agreement between model predictions and owl locations was low at the fifth site, where the owls occupied a rocky canyon. He concluded that the model could be used to prioritize general survey areas, and might be useful for identifying specific areas for habitat protection in mixed-conifer forest, but it was not useful at that scale in rocky-canyon landscapes. This relatively crude model was used by forest biologists to prioritize survey areas but was not developed further.

Ganey and Benoit (2002) evaluated the use of Terrestrial Ecosystem Survey (TES) data to identify potential Mexican spotted owl habitat on NFS lands. TES is a spatially explicit data set that uses information on soils, vegetation, and climatic conditions to define and map a set of ecological map units depicting potential vegetation. Using three separate owl data sets (locations from the 1993 survey database [USDI FWS 1995], locations of radio-marked owls, and results from complete surveys of selected quadrats [Ganey et al. 2004]), they identified subsets of map units that were strongly associated with owl use on three national forests in northern Arizona. These map units generally consisted of mixed-conifer or pine-oak forest, and those most strongly associated with owl use generally occurred on steep slopes containing rocky outcrops. Ganey and Benoit (2002) concluded that, with some caveats, TES data could be used to identify and map potential owl habitat.

e. William J. Krausmann and Colleagues.—William J. Krausmann and colleagues also focused on NFS lands, but their modeling efforts were specifically directed at assessing gross changes in amounts of Mexican spotted owl habitat over time (i.e., change detection, Krausmann et al. undated, Mellin et al. 2000). Thus, their efforts focused on products that could be used to monitor changes in amounts of owl habitat over time. They identified forest types "associated" with Mexican spotted owls on NFS lands in Arizona and New Mexico, using TES (see above) and Generalized Ecosystem Survey data (essentially a coarser-scale version of TES) and USDA FS timber stand data. They then assessed changes within those vegetation types using two Landsat images acquired approximately five years apart (1991/93 and 1997/98; Mellin et al. 2000).

Approximately 28.2% of NFS lands within Arizona and New Mexico were identified as belonging to vegetation units associated with Mexican spotted owls. Within those vegetation units, 4.2% underwent some form of vegetation removal or reduction over the five-year period, for an annual rate of change of <1%. Fire was the principal cause of habitat change identified and accounted for 60.5% of the change area. Timber harvest accounted for another 19.2%, with infestations of forest insects or pathogens accounting for 17.3% of the change area.

The conclusions regarding changes in amount of owl habitat depend heavily on the assumptions about which vegetation units were associated with Mexican spotted owls. The accuracy of these assumptions, and the resulting classification of "owl-associated" habitat, is unknown. To address this uncertainty, Mellin et al. (2000) also summarized change based on the area

contained within owl PACs. This analysis, which included nine national forests that had digitized GIS coverages of PAC boundaries, avoids the need to classify habitats as associated or not associated with owls. Vegetation removal or reduction occurred on 3% of the total PAC area, with 80, 14, and 5% of the change due to fire, mechanical treatments (timber harvest and/or thinning), and infestations of forest insects or pathogens, respectively.

The modeling effort by Krausmann and his colleagues demonstrated that Landsat imagery could be used to detect gross changes in owl habitats over time, as recommended in USDI FWS (1995). Thus, continued change-detection efforts could form part of a strategy to monitor trend in amounts and spatial distribution of owl habitat. However, no follow-up efforts have occurred, nor are there any plans to conduct follow-up analyses (W. J. Krausmann, pers. comm.). Further, the change-detection analysis focused mainly on obvious loss or reduction in vegetation. Identifying areas that may have matured toward suitable owl habitat during this time frame was beyond the scope of this effort, but would obviously be important in a comprehensive effort to monitor trend (including both gains and losses) in owl habitat.

f. Forest Ecosystem Restoration Analysis Project (ForestERA).—The Forest ERA program also developed a predictive model for Mexican spotted owl habitat covering a study area of approximately 8,100 km^2 (2 million ac) near Flagstaff, Arizona. ForestERA is a collaborative project headquartered within the Center for Environmental Science and Education at Northern Arizona University. It provides data, tools, and analytical frameworks for developing landscape-level strategies for ecosystem restoration, and assessing the impacts and implications of alternative management scenarios (Sisk et al. 2004). This program modeled Mexican spotted owl habitat as one data layer facilitating landscape-level assessments within their Western Mogollon Rim study area (Prather et al. 2005). The model defined Mexican spotted owl nesting and roosting habitat as areas where the dominant overstory vegetation consisted of pine-oak, mixed-conifer, or ponderosa pine cover types on steep slopes (>12 degrees), and where basal area exceeded 17 $m^2\ ha^{-1}$ (75 $ft^2\ acre^{-1}$). Predicted habitat was assessed using the Mahalanobis distance statistic and vegetation (tree density, canopy cover, basal area) and terrain (slope, aspect) characteristics around known owl nest sites. This statistic was used to determine how divergent a given location on the landscape was compared to the typical characteristics of the landscape at known nest sites, and it allowed them to assess the likelihood that owls would use a particular area. Preliminary assessments of model accuracy suggested that it successfully predicted the locations of most owl nest and roost sites, despite classifying only about 30% of the assessment area as nest/roost habitat (Forest ERA 2005).

ForestERA also produced a spatial coverage representing management definitions of Mexican spotted owl habitat across the assessment area. This data layer depicted habitat categories as defined in USDI FWS (1995). Categories modeled included protected habitat, restricted habitat, and areas with no specific owl-related guidelines (other forest and woodland types; USDI FWS 1995). This allowed for comparisons of overlap between predicted habitat and areas managed for owls under USDI FWS (1995). Although no quantitative analysis is available, a visual comparison of maps of predicted habitat and management guidelines suggests that 1) areas managed for Mexican spotted owls under USDI FWS (1995) cover less of the assessment area than is predicted to contain nesting and roosting habitat for owls, and 2) areas managed as protected or restricted habitat for owls generally are predicted to be owl habitat (Fig. B.5).

ForestERA recently updated this coverage based on definitions in this revised Recovery Plan. Results again indicated that plan recommendations target a relatively small proportion of the study area (approximately 20%; see Appendix C).

g. Other Recent Efforts.— Two other recent efforts focused on developing habitat models at more localized scales. Danzer (2005) used existing data on owl occupancy, fire history, and site characteristics to describe features of Mexican spotted owl territories in the Huachuca Mountains, Arizona. Owl territories were variable, but most occurred in canyons with riparian, mixed-conifer, and oak components, a finding consistent with previous analyses in this region (Ganey and Balda 1989a: Fig. 2, Duncan and Taiz 1992, Ganey et al. 1992, Ganey and Dick 1995: Table 4.1). Hathcock and Haarmann (2008) developed a vegetation-based predictive model for Mexican spotted owl habitat in the Jemez Mountains, New Mexico. Compared to random sites, sites used by owls had greater tree species diversity, tree density, tree height, canopy cover, and shrub density. Again, these features generally agree with other evaluations of owl habitat, both locally and in a broader sense. Model testing suggested that the model performed adequately, and Hathcock and Haarmann (2008) suggested that this model could be used to delineate habitat on a relatively fine scale.

h. Summary of Mexican Spotted Owl Habitat Models.—In summary, a number of predictive models have been developed for Mexican spotted owl habitat. Modeling efforts have occurred throughout much of the range and have incorporated many different approaches and objectives (e.g., prediction of breeding habitat versus change detection). These efforts have produced a number of useful products, including maps of predicted habitat for different areas and maps useful in detecting changes in habitat amount or condition. The ongoing efforts by T. H. Johnson and by D. W. Willey and colleagues appear to hold considerable promise for future efforts. Both also appear to hold the most promise for modeling owl habitat in areas such as rocky canyonlands, where topography and geology appear more important in determining owl distribution than vegetation type. Models incorporating topography have the advantage that they are based largely on topographic and/or climatic data that are available for all land ownerships across the range of the owl. The recent work by Mullet (2008) demonstrated the utility of these types of models in predicting occupancy of Mexican spotted owls in the Guadalupe Mountains and how structured validation surveys can lead to a more efficient model. In this case, the overlap between habitat predicted by two models provided the most efficient model (i.e., a model with less predicted habitat to search while conveying the same probabilities of occupancy).

In some areas, data on vegetation type and composition may improve models significantly. For example, the model produced by Forest ERA used data on vegetation structure and composition to model nesting and roosting habitat structure. These types of data are not as readily available as topographic data and typically require analysis of satellite imagery to derive useful data layers (Forest ERA 2004). Such data also can be used to detect changes in vegetation structure, however, and this ability would be critical in efforts to monitor amounts and distribution of Mexican spotted owl habitat. That is, topographic models can be used to model potential owl habitat, but they cannot effectively model current owl habitat except in areas where topography is more important than vegetation, such as in the canyonlands.

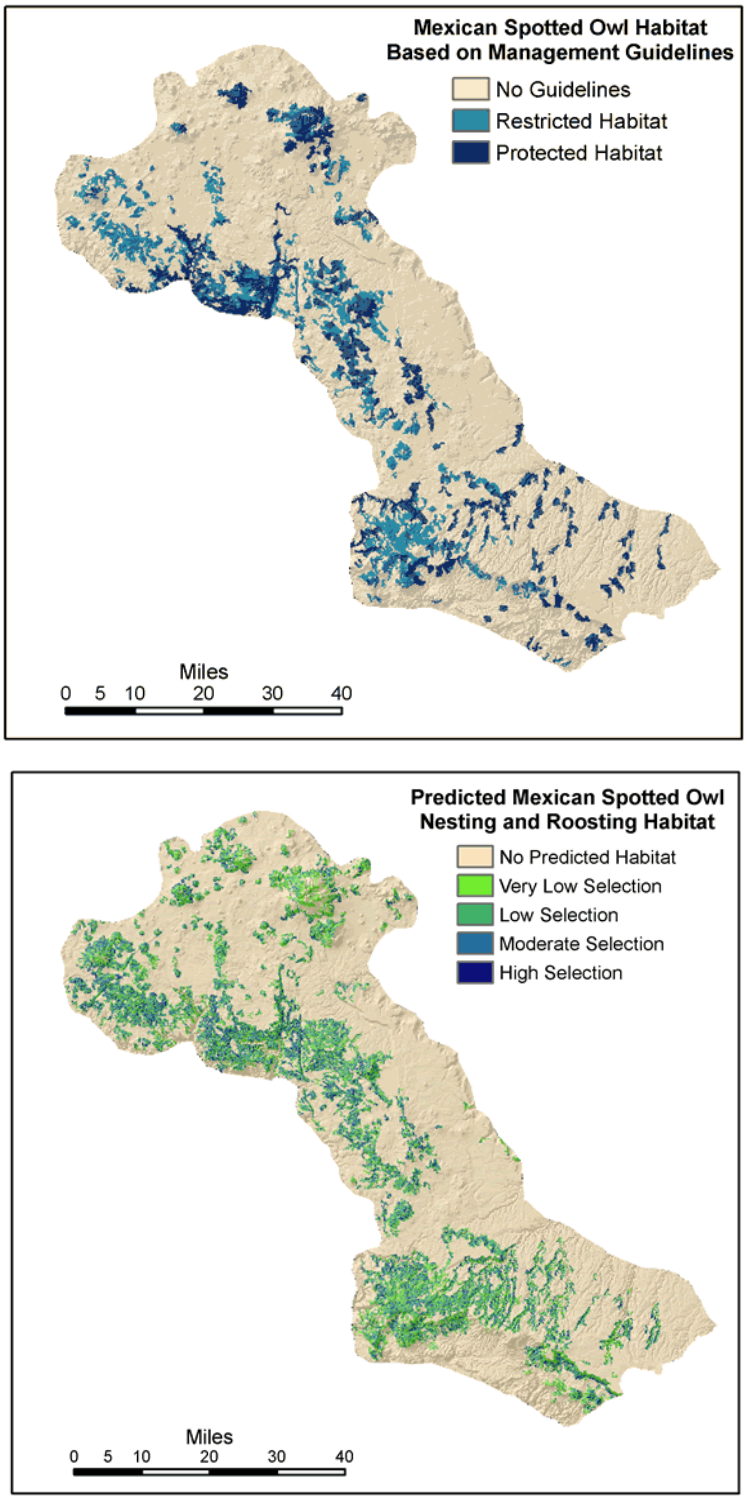


Figure B.5. Maps of predicted Mexican spotted owl nesting and roosting habitat (top) and management guidelines (bottom) for Mexican spotted owls under USDI FWS (1995). Source: Forest ERA 2005.

The habitat models developed also have produced some useful insights unrelated to their original intent. For example, Ganey and Benoit (2002) noted that TES data identified most of the map units strongly associated with owl use in their study area as not well suited for timber harvest, due to either steep slopes or soil-based considerations. Similarly, comparison of owl-related maps with other maps produced by Forest ERA suggests that there is high overlap between owl habitat, either as predicted by their habitat model or as defined based on protective categories in USDI FWS (1995), and predicted habitat for the northern goshawk (Fig. B.6, top), a species of special management concern (e.g., Reynolds et al. 1992). Another such comparison suggests that species diversity of breeding birds is generally greater in owl habitat than elsewhere (Fig. B.6, bottom). Together, these results suggest that 1) it might be feasible to protect owl habitat while simultaneously minimizing impacts to timber harvest programs, and 2) this protected habitat appears to be particularly important to other wildlife species of interest as well. Finally, the owl habitat coverages developed by ForestERA also allowed Prather et al. (2008) to evaluate potential conflicts between management to reduce fuels and risk of severe wildland fire and management to retain Mexican spotted owl habitat. This analysis demonstrated that although some conflicts exist between these objectives, their magnitude has been overstated (see also Appendix C). They concluded that the majority of the landscape could be managed to reduce fire hazard without eliminating owl habitat (see also James [2005] for a concurring view).

F. Disturbance Ecology and Owl Habitat

Several disturbance factors can influence Mexican spotted owls through their effects on the owl's habitat. For example, a change-detection analysis focused on Mexican spotted owl habitat (Krausmann et al. undated, Mellin et al. 2000) suggested that wildland fire, mechanical treatments, and forest insects and pathogens (in that order) were key disturbance agents affecting owl habitat. Other potential disturbance agents that may threaten the owl indirectly through habitat alteration include heavy grazing by domestic livestock and wild ungulates, concentrated housing development or urbanization, and shifts in the distribution of dominant plants and their associations driven by change in climate. All of these disturbance agents may alter habitat structure, reducing the quality or availability of habitat to individual owls. If habitat alteration is extensive, habitat loss can result in negative impacts on Mexican spotted owl populations by limiting the number of occupants and their reproduction. Indeed, presumed habitat loss due to timber harvest was one of the factors that precipitated listing the owl as threatened (USDI FWS 1993).

The majority of disturbance agents that can alter Mexican spotted owl habitat are discussed elsewhere in this Recovery Plan (Parts I and II). No studies are available on the specific effects of forest insects and pathogens on this owl's habitat, few studies have evaluated effects of mechanical treatments on spotted owls, and none of these studies focused specifically on Mexican spotted owls. As a result we know relatively little about the effects of these disturbance agents on the owl and its habitat. However, several studies or analyses have focused on wildland fire, which appears to have the greatest potential to greatly alter the owl's habitat over vast areas in a relatively short time period (e.g., Krausmann et al. undated, Mellin et al. 2000). Therefore, this disturbance agent and its potential influence on the ecology of Mexican spotted owls warrants specific discussion. There also is limited information about four other disturbances that may influence the owl's habitat: mechanical treatments, heavy grazing by domestic livestock and

wild ungulates, urban development, and shifts in biological communities caused by climate change. Below, we discuss the potential influences of these four disturbance agents.

a. Wildland fire and Prescribed Fire.— Fire is a natural disturbance agent in southwestern forests (Swetnam 1990), with which Mexican spotted owls co-evolved. Ponderosa pine and xeric-mixed conifer forests evolved with a fire regime characterized by frequent-surface fires. Early Euro-American-settlement, overgrazing, and other land-use practices that began around 1880, followed by organized fire suppression and logging, have resulted in severely altered surface fire regimes and forest structure in these southwestern forest types (Rummel 1951, Madany and West 1983, Savage and Swetnam 1990, Covington and Moore 1994, Fulé et al. 2004,). As a result, these forests have not experienced landscape-scale fire effects for over a century in many places and are now characterized by closed canopies with dense stands of small trees, and heavy forest litter and duff fuel loads. These widespread changes have resulted in substantially altered fire behavior and effects in these forests ecosystems. These forests are now very prone to stand-replacement, high-intensity and high-severity fires that are now very difficult to control. As a result, we have seen an increasing trend in the size and severity of wildland fires in the western U.S., including the Southwest (Westerling et al. 2006, Littell et al. 2009, Miller et al. 2009). This trend in the Southwest began around 1990 with the stand-replacing Dude fire in Arizona (> 2,400 acres), escalating in 2011 to the most intense and largest fires in Southwest history, as over 809,716 ha (2 million acres) burned in Arizona and New Mexico (USDA FS unpubl. data).

The real quandary is that fire is a double edged sword, potentially the savior and threat to the Mexican spotted owl. In essence low- to moderate-severity and even high severity fire patches on the fine scale (e.g., 1 to 100 acres) are likely desirable for more resilient forest landscapes and owl habitat. However, high severity patches over large areas (e.g., > 100 to 500 acres) may have cumulative effects on forest structure given recent trends that possible may not be beneficial to Mexican spotted owl recovery or sustainable forest management.

Recognizing these changing aspects of southwestern forest ecology and the potential for more and larger high-severity fires to occur in the near future, the Recovery Team recognizes stand-replacing wildland fire as one of the primary threats to the Mexican spotted owl and its habitat. The underlying assumptions are: 1) under some conditions stand-replacing wildland fire can severely alter forest stand structure and the attributes that Mexican spotted owls need for roosting and nesting; 2) replacement habitat could take centuries to regenerate given the age of forests and trees on these sites; and, 3) cumulative loss of large amounts of roosting and nesting habitat to wildland fire ultimately can be detrimental to spotted owls, even if they are able to persist in burned areas over the short term.

To better understand how much of the owl's habitat could be affected by stand-replacing fire in the future, the Recovery Team quantified recent trends in burn-severity over a 14-year period (1995 to 2008) within 90% of established PACs (Box B.2; we were not able to obtain spatial data for the other 10% of known PACs). The analysis showed variability among the five U.S. EMUs, but the overall analysis indicates that >40% of current PAC area could be altered by high-severity fire in the BRW, SRM, and UGM EMUs, whereas less than15% of habitat within PACs may be altered in the BRE and CP EMUs by 2110 (Box B.2, Fig. 1c). Projections that mega-fire

years like that observed in Arizona and New Mexico in 2011 will become increasingly more frequent could result in an exponential increase in rate of high-severity fire effects in PACs such that habitat within all currently designated PACs in the SRM and BRW EMUs could be burned by high-intensity fire within 40 to 90 years (Box B.2, Fig. 1d and e). In summary, high-severity fire effects will continue to impact PACs at an unknown, but likely, accelerated rate. Fuels reduction projects and previously burned areas distributed across the landscape may, over time, reduce the exponential trend of high-severity wildland fire effects in PACs. To slow or alter this increasing rate of high-severity fire effects, the potential for stand replacing fire needs to be significantly reduced on the landscape within 30 to 40 years. We reiterate, however, that the future trends of high-severity fire effects to Mexican spotted owls are largely unknown.

BOX B.2
MAGNITUDE AND SEVERITY OF WILDLAND FIRE IN MEXICAN SPOTTED OWL HABITAT

In this Recovery Plan, we presume that loss of habitat resulting from the effects of high-severity wildland fire is a threat to the Mexican spotted owl. High-severity fire effects include a high percent loss of site organic matter, canopy, and vegetation cover (i.e., stand replacement fire), and high tree mortality and exposure of soils (DeBano et al. 1998; Keeley 2009). Furthermore, the scale of high severity fire we have seen in recent decades in the ponderosa and more xeric mixed conifer forest ecosystems appears to be outside the historical range of variation (Fulé et al. 2004).

Understanding the magnitude of this threat requires knowledge of the following; 1) the rate and extent of high-severity fire affecting the owl's habitat; 2) the effects of high severity fire on owl habitats, forest ecology and succession; and, 3) how the owl and its populations respond to these habitat alterations caused by high-severity fire effects. To better understand the potential magnitude of high-severity fire effects on the owl's habitat, the Recovery Team examined recent trends in fire-severity within designated PACs. We quantified the number of PACs and amount of PAC area that were burned resulting in different severities of fire over a 14-year period (1995 to 2008) and then used the annual (estimated as a 14-year mean) rate of high-severity fire to project potential future losses of the owl's habitat in 10-year intervals through 2110. The results of this analysis are presented below. We currently have no long-term data from which to assess how the forest habitat or the owls will respond to these stand-replacing high-severity fire events (see Appendix B for further discussion regarding this topic).

To estimate the amount of owl habitat burned from 1995 to 2008, we used the geospatial boundaries of PACs to identify the most important, and limiting, habitat to Mexican spotted owls, and we used annual boundaries of fires ≥ 405 ha (1,000 ac) to estimate area burned and fire severity effects. Wildland fire boundaries were derived from the standardized USGS Monitoring Trends in Burn Severity database (MTBS; http://mtbs.gov/index.html), which only tracks fires ≥405 ha. From the overlap of these two data sets, we estimated the amount and percentage of area burned annually in PACs over the 14-year period. We examined PACs from 17 different public land management units, including 12 National Forests (six in Arizona, five in New Mexico, one in Utah), BLM lands in Utah, and four National Parks (one in Arizona, three in Utah). The time period was chosen because it followed the release (and hence recommendations) of the original Recovery Plan (USDI FWS 1995) and because burn-severity data were not available beyond 2008. Unfortunately comparable fire severity data from the record-breaking 2011 fire season were not available, nevertheless preliminary evaluations of the 2011 fire severities further support these findings.

The MTBS data included five general classes of burn-severity effects on vegetation: 1) unburned or undetected, 2) low, 3) moderate, 4) high, and, 5) burned, but with unknown severity (Eidenshink et al. 2007). To project future loss of owl habitat, we used the rates of high-severity fire effects estimated annually from the 14-year period to estimate the percent of PAC area that would be burned in future 10-year increments, assuming four scenarios. The first scenario assumed that the area burned by fire was fixed during each 10-year period and equal to the amount of area burned in each EMU during the initial 14-year period. In the second scenario, we assumed an exponential increase of 1% of additional PAC area burned each year than under the constant rate scenario. The third scenario assumed an exponential increase of 4 percent of additional PAC area burned each year. The final scenario assumed that the amount of PAC area impacted by high-severity fire effects would increase exponentially (4% annual increase), but would slow and eventually plateau after 40 years of increasing wildfire trends, fuels reduction and restoration treatments. We focused on high-severity fire effects because they result in the most significant alteration of owl habitat and hence, have the greatest potential for loss of habitat.

BOX B.2, Continued

Our analysis included 1,174 PACs 89% of the 1,324 known owl sites) and encompassed 329,054 ha (812,763 ac) (Table 1). During the 14-year period of 1995 to 2008, a total of 50,034 ha (123,632 ac) burned in 438 of the PACs. The percentage of habitat area burned by any type of fire was lowest in the CP EMU, where owl nest/roost habitat occurs more frequently in rocky canyons, which are less likely to burn than forested habitats (Figure 1a).

On average, low-severity fire effects were detected over the largest percentage of hectares and high-severity fire were detected in the lowest percentage of hectares within the burned PAC areas (Table 1). Large-fire years were observed in 2000, 2002, and 2004 and on average more PAC area burned with high-severity fire effects in these years (Figure 1b). The annual percentage of PAC area affected by high-severity fire varied among EMUs during the 14-year period (Table 2). The greatest percentage of PAC area affected by fire was in the BRW EMU (Figure 1a).

Projections about future extent of high-severity fire effects (constant rate of increase) under the first assumption indicated that modification of the owl's habitat during the next century in the five U.S. EMUs could range from 2 to 56 percent of current PAC area (Figure 1c). Projected losses, assuming the 1 percent-exponentially increasing rate of high-severity fire effects indicated that by 2110 all PACs in the SRM and BRW could be burned, that nearly 80% of the PAC area in the UGM could be burned, and that <30% of the PAC area could be burned in the CP and BRE EMUs (Figure 1d). Under the more extreme scenario of a 4 percent annual exponential increase, 100 percent of PAC area would be affected by high-severity fire in the SRM and BRW EMUs by 2065 and in the UGM EMU by 2075 (Figure 1e). Under this scenario much of the remaining PAC area not affected by high-severity fire would be in the CP EMU. The extreme scenario of 4% exponential increase could slow and begin to stabilize following the 40 years of increase if fuels reduction treatments are effective and/or high-severity fire effects are limited by the previous wildfire effects at an exponentially decreasing annual rate of about 2 percent (Figure 1f).

Although these projections are based on very simplistic assumptions and forecasts, the analysis is useful for showing: 1) past conditions and fire behavior varied by EMU, likely because of differences in fuel sheds and burning conditions related to elevation, weather, topography, and vegetation; and, 2) to date, high-severity fire effects in PACs have been relatively rare rangewide. Unfortunately, our analysis was not able to include fire data from 2011 because comparable data are not yet available. Although the extent of high-severity fire effects in PACs is not known for the 2011 fires, the number of PACs that experienced large (> ⅔ of PAC area) fires easily could double beyond the number recorded for our analysis period. Our results also indicated that under the conditions present from 1995 to 2008, owls dwelling in canyon habitats were least impacted by high-severity fire effects (i.e., the CP EMU), and the EMU's where the majority of owls are concentrated (e.g., UGM and BRE EMUs), experienced lower rates of high-severity fire than the BRW or SRM EMUs. However, the projected rates of habitat alteration for the future are rough estimates and the amount of habitat affected by high severity burns was not offset by restored or newly developed habitat over this analysis period. These data suggest that under climate-warming forecasts and less-conservative rates of high-severity fire effects, Mexican spotted owl habitat degradation could escalate in most portions of the range in the foreseeable future. Alternatively this undesirable habitat loss could potentially be mitigated if future wildfire effects are moderated under wetter decadal-climate regimes and more effective at reducing forest fuels and opening forest canopies rather than replacing them, and if strategically placed treatments across the landscape are more influential in slowing and reducing the size of future high-severity fire patches.

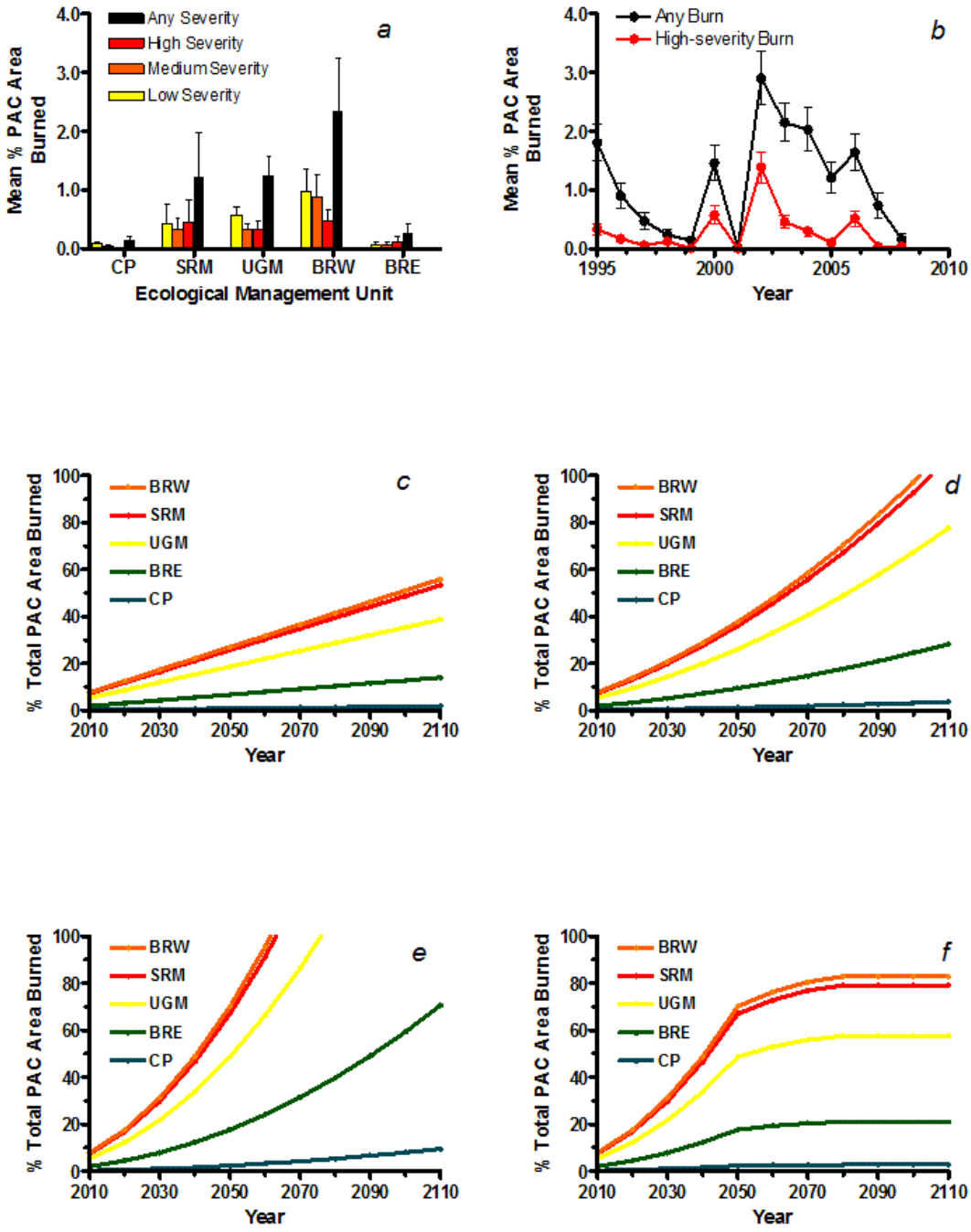
Box B.2, Table 1. Cumulative fire severities (ha) in Mexican spotted owl habitat (PAC area), 1995-2008.

EMU	No. PACs	PAC Area (ha)	Burn Severities within PAC Area (ha) Low	Moderate	High	Any
CP	132	52,642	562	327	109	998
SRM	50	13,668	909	726	999	2,634
UGM	684	181,730	14,743	8,535	8,264	31,540
BRW	155	43,193	5,746	5,129	2,653	13,527
BRE	153	37,821	344	340	650	1,335
Totals:	1,174	329,054	22,304	15,057	12,675	50,034
14-yr % of PAC Area[1]:			6.8%	4.6%	3.9%	15.2%
Annual % of PAC Area[2]:			0.48%	0.33%	0.28%	1.09%

[1] Calculated by dividing the total area burned over 14 years under each severity by the total amount of PAC area in an EMU.
[2] Calculated by dividing the 14-yr percentage of PAC area burned by 14.

Box B.2, Table 2. Percent of Mexican spotted owl PACs that burned with high severity fire effects, 1995-2008.

EMU	No. PACs	% of PACs with high-severity fire effects None	1–79 ha	81–162 ha	>162 ha	% PAC area with high-severity fire effects Mean	SE	*n*
CP	132	92.4	7.6	0	0	0.02	0.009	14 yr
SRM	50	78.0	10.0	8.0	4.0	0.46	0.371	14 yr
UGM	684	72.0	22.4	4.1	1.5	0.33	0.152	14 yr
BRW	155	50.3	41.3	8.4	0	0.48	0.190	14 yr
BRE	153	91.2	5.2	2.6	0	0.12	0.089	14 yr
Total PACs:	1,174	873	240	49	12			



Box B.2, Figure 1: *(a)* Mean percentage (± SE) of Mexican spotted owl PAC habitat burned in each of 5 EMUs from 1995 to 2008 and (*b*); annual trend in high-severity fire effects and fire in PACs from 1995 to 2008. Projected percent of PAC area burned resulting in high-severity fire effects through 100 years assuming: (*c*) a constant rate of increase equal to the EMU annual rate; (*d*) an exponential increase of 1% per year above the EMU annual rate; (*e*) an exponential increase of 4% annual increase per year above the EMU annual rate; and, (*f*) initial 4% exponential increase followed by asymptotic decrease under the assumption of forest treatment or disturbance effects after 40 years exponentially increased rates of high-severity burn effects. CP = Colorado Plateau, SRM = Southern Rocky Mountain, UGM = Upper Gila Mountain, BRW = Basin and Range-West, BRE = Basin and Range-East.

Understanding the impact of wildland fire on Mexican spotted owls also requires knowledge of the owl's response to fire. Since 1995, several studies have examined short-term effects of fire on Mexican spotted owls. Here, we summarize briefly the important results of those studies and re-evaluate the importance of fire as a threat to owl habitat based on these results. Additional recent studies have evaluated or speculated on fire effects and/or historical disturbance patterns affecting northern and California spotted owls (Elliott 1985, Buchanan et al. 1995, MacCracken et al. 1996, Bevis et al. 1997, Everett et al. 1997, Gaines et al. 1997, Verner 1997, Franklin and Gutiérrez 2002, Irwin and Thomas 2002, Irwin et al. 2004, Lee and Irwin 2005, Clark 2007, Bond et al. 2009). We restricted our evaluation here mainly to studies on the Mexican spotted owl, because of regional variation in fire regimes and the resulting apparent differences in this owl's environment compared to that of the other two subspecies. However, we include results from two recent studies on other subspecies of spotted owls (Clark 2007, Bond et al. 2009) because these studies evaluated fire effects more rigorously than previous studies, and their results have potentially important implications.

To date there have been at least seven studies or other evaluations on the effects of fire on Mexican spotted owls. These studies occurred in four EMUs, in a variety of geographic locations and forest types, and have included both wildland fire and prescribed fire. Studies are discussed below in chronological order.

Johnson (1995:5–6) did not study fire effects explicitly but discussed fire and Mexican spotted owls in the area impacted by the 1977 La Mesa Fire in the Jemez Mountains, New Mexico (SRM EMU). Two territories within the boundary of this fire were occupied more consistently than other territories in the Jemez Mountains in the decade from 1985–1995. Data on owl reproduction were not sufficient to compare reproduction at these territories to other territories within the region, and owls were not marked, so survival data were not available from these territories. Owls were sometimes observed roosting in burned areas and were heard at night in burned areas on the mesa. Thus, at least some territories were occupied following the fire, and owls appeared to forage and occasionally roost in burned areas.

Sheppard and Farnsworth (1997) discussed potential impacts of fire on owls. They estimated that at least 10 Mexican spotted owl territories were impacted by fire in Arizona and New Mexico during the 1994 fire season. They further estimated that >20,000 ha (>50,000 ac) of owl habitat experienced stand-replacing wildland fire from 1989 to 1994. They did not evaluate patterns of owl habitat use or territory occupancy relative to these fires, however.

Willey (1998a) tracked three pairs of radio-marked Mexican spotted owls before and after prescribed burns in Saguaro National Park, southern Arizona (BRW EMU). These burns increased canopy edge and structural diversity within stands (Willey 1998a:30–31). They created openings within the forest, but these openings were very small (<1 ha [2 ac]) relative to the size of owl home ranges (125 to 545 ha [310 to 1350 ac] pre-fire; Willey 1998b: Table 6), and no burning was done in the north-slope mixed-conifer forests where owls roosted and nested. Home range and activity centers decreased in size for two of three pairs following the burns, but increased for the third pair. Home range centroids shifted from 100 to 500 m (300 to 1500 ft) for all pairs. However, Willey (1998b) noted that both range shifts and changes in range size could be confounded by changes in nesting status pre- and post-fire, and he generally regarded these

results as inconclusive. Clearly, however, owls continued to use these areas following relatively low-intensity prescribed burns that occurred outside of nest/roost areas, at least in the short term.

Bond et al. (2002) documented minimum survival and site and mate fidelity for four pairs of color-marked Mexican spotted owls in Arizona and New Mexico (UGM EMU) after large wildland fires (>525 ha [1,300 ac]). Fire burned through the nest and primary roost sites in all four territories. Two territories experienced high-severity wildland fire over >50% of the territory, one experienced relatively high-severity fire over approximately 40% of the territory, and one experienced primarily low-severity wildland fire. Seven owls (87.5%) were known to have survived at least to the next breeding season. Three of the four pairs exhibited both mate and site fidelity, remaining paired and on the same territory. The male from the fourth territory was not re-sighted, and the female survived but did not return to that territory. This fourth territory underwent the greatest burn severity, experiencing high-severity wildland fire over 57% of the territory and low-severity wildland fire over the remaining 43%. Results were similar for northern and California spotted owls that experienced wildland fire on their territories (Bond et al. 2002). Thus, owls studied continued to occupy burned areas, even following relatively high-severity fires, except in the territory that experienced the highest burn severity. Results further suggested that survival rates and mate and site fidelity in these owls were relatively high in the year following fire.

Jenness et al. (2004; see also Jenness 2000) surveyed historical Mexican spotted owl territories (as delineated by USDA FS biologists) in 1997 that had experienced some form of fire during the previous four years, and compared owl occupancy and reproduction in these territories to unburned territories that were located nearby and were similar in cover type and topography. They surveyed 33 burned territories and 31 unburned territories in the UGM, BRW, and BRE EMUs. Extent and severity of fire within these territories varied widely, ranging from prescribed burns to intense wildland fires that burned across much of the territory.

In general, unburned territories surveyed had more pairs (55%) and reproductive pairs (16%) than burned territories (39 and 9%, respectively). Burned territories were more likely to contain single owls (21 vs. 16%) and almost twice as likely to be unoccupied as were unburned territories (30 vs. 16%). These differences were not statistically significant, but the significance test had low power due to small samples of sites (Jenness et al. 2004). Two of eight territories (25%) that burned one year prior to surveys were unoccupied, and eight of 25 territories (32%) that burned $\geq$2 years prior to surveys were unoccupied. Owls were present and reproducing in some severely burned sites, however. For example, three sites where >50% of the territory burned contained reproducing pairs, and a single owl was present at the most severely burned territory. No variables related to fire severity appeared correlated with patterns of occupancy or reproduction. These results again suggest that owls frequently continue to occupy burned areas, at least in the short term, and that some burned areas continue to be occupied even after severe, stand-replacing wildland fires. None of the burned territories had >55% stand-replacing burn within the territory boundary delineated by USDA FS, however, so pockets of habitat remained in all cases. Further, because owls were neither radio- nor color-marked in this study, it is not known if the birds present after fires were the same birds present before the fires.

Ward and Moors (2011) reported on occupancy and reproduction of Mexican spotted owls dwelling in burned and unburned landscapes in the Pinaleño Mountains of southeastern Arizona, based on a single season of survey in 2011. Their study area included the Nuttall-Gibson fire that occurred in 2004, 7 years prior to their survey. Seventeen PACs were included in their analysis and these ranged from 99% of the included area burned to 100% unburned, and high-severity burn ranged from 2.5 to 38.5% of area within the PACs. Pairs occurring in PACs with more burned habitat averaged 1.75 young/pair and included the only pair that had 3 young that year. Pairs in PACs with <4% of the habitat burned had an average of 1.33 young/pair. Owl density appeared greater in the portion of the landscape that burned, and anecdotal information indicated that numbers of *Peromyscus* spp. were high in 2011. Thus, owls continued to occupy and reproduce in burned areas. The authors noted that any potential benefits of burned habitat was of unknown duration, and encouraged monitoring of post-fire development of ground vegetation and small mammal communities in burned areas, to better understand the potential effects of fire in owl habitat.

Recently, Clark (2007; see also Clark et al. 2011) studied territory occupancy, survival, reproduction, and habitat use by northern spotted owls in both burned and unburned landscapes in southwestern Oregon. The study area included a mosaic of public and private lands, some of which had an extensive history of past timber harvest resulting in a high degree of fragmentation of older forest habitat. In addition, many burned areas in this landscape were subjected to clearcut salvage logging.

Territory occupancy rates declined rapidly following wildland fire. Annual survival rates were substantially lower for owls within the burn (0.69 ± 0.12) or displaced by the burn (0.66 ± 0.14), relative to owls that lived adjacent to the burn (0.85 ± 0.06; Clark et al. 2011). No differences were observed between productivity of owls in burned and unburned landscapes. Clark (2007) noted that he was unable to estimate the impacts of wildland fire and salvage logging separately on northern spotted owl survival or territory occupancy, "…because they were highly interrelated and I lacked sufficient data to model these effects separately."

Radio-marked owls used burned areas, but generally selected for either unburned forests or forests that burned with low severity and had little or no overstory canopy loss (Clark 2007:112). Radio-marked owls used areas that had been salvage logged less than expected based on their availability (Clark 2007:127). Clark et al. (2011:44) suggested that "…the combination of past timber harvest, severe fire, and salvage logging were responsible for the low survival rates during our study…". They noted that the landscape studied had a high degree of habitat fragmentation prior to the fires and salvage logging (Clark et al. (2011:45), and stated that "…we urge caution when applying our findings to forest management or recovery planning for spotted owls."

Bond et al. (2009) monitored movements and habitat use of radio-marked California spotted owls from four territories in the southern Sierra Nevada, California, four years following a large wildland fire. Study areas were not subjected to salvage logging (personal communication from J. P. Ward, Jr., 9 Sep 2011). Owls nested in all four territories, but only one pair was successful, fledging a single young. Two nests were located in moderate-severity burned mixed-conifer forest: one in low-severity burned mixed-conifer forest and one in unburned mixed-conifer-

hardwood forest. Owls roosted selectively in low-severity burned forest, avoided moderate-severity and high-severity burned forest, and used unburned forest in proportion to availability. Within 1 km (0.6 mi) of their nest, owls foraged selectively in all severities of burned forests and avoided unburned forests. These results collectively suggest that post-fire landscapes contained enough suitable habitat to support pair occupancy and at least attempted nesting. They further suggest that burned areas may provide benefits to foraging owls. Bond et al. (2009) concluded that assessments of fire impacts should not assume that all fires have negative impacts on spotted owls and recommended that burned forests within 1.5 km (0.9 mi) of spotted owl roosts or nests not be salvage-logged.

USDA FS (2010) reported on short-term results of surveys for California spotted owls (referred to in USDA FS [2010] as "CSOs") in two areas burned by wildland fires in 2007 in the Sierra Nevada. One area (MACFA) was largely burned by high-severity wildland fire, whereas the second area (COFCA) burned primarily at low-moderate severity. Surveys in 2008 and 2009 located only a single pair of owls in the 35,612-ha (88,000-ac) MACFA fire complex. Single males were detected at night within the fire perimeter on several occasions in 2008, but not in 2009. None of these males were ever located at nests or roosts in follow up surveys, and none of the nocturnal locations occurred within 0.8 km (0.5 mi) of each other. In contrast, surveys of a 1.6-km (1.0 mi) buffer area around the fire complex located 5 confirmed pairs in 2008 and 7 confirmed pairs in 2009, along with additional sites where pairs could not be confirmed but there was evidence of territorial birds. Thus, owls were present in the general area, but showed little use of the severely-burned area.

In the first year of surveys (2009) in the 8,500-ha (21,000-ac) COCFA fire complex, six territorial owl sites were documented within the fire perimeter (3 confirmed pairs, one unconfirmed pair, and two single males), along with three confirmed pairs and three single territorial owls in the buffer area around the fire. In 2010, survey extent in this area was limited by safety concerns related to illegal marijuana cultivation. Nevertheless, surveys still located two confirmed pairs and one unconfirmed pair within the fire perimeter, and two confirmed pairs and one unconfirmed pair within the buffer area. Thus, owls in this fire area occurred in much greater density than owls in the MACFA complex. They also occurred in roughly similar amounts in the fire area and the buffer, in contrast to the MACFA complex, where most owls occurred in the buffer area. USDA FS (2010) concluded that "…CSO are able to persist in landscapes that experience primarily low/moderate severity wildland fire, whereas landscapes that experience primarily high-severity do not support comparable numbers or distribution of CSOs."

In addition to the above studies, there are numerous anecdotal observations of Mexican spotted owls occupying territories following wildland fires and prescribed burns (P. Boucher, Gila National Forest retired, pers. comm.; S. Hedwall, FWS, pers. comm.), as well as evidence of radio-marked owls moving into and foraging in burned areas during winter (J. P. Ward, Jr. and J. L. Ganey, RMRS, unpubl. data). Most wildland fires burn in a patchy nature and leave pockets of useable habitat for owls, and owls appear able to locate and use these patches. Thus, Mexican spotted owls appear to be somewhat resilient to wildland fire, at least in the short term. However, we have no data on long-term effects of these fires on occupancy patterns or on components of Mexican spotted owl fitness such as survival and reproduction. The sparse data

available from other subspecies are not entirely consistent, and are complicated by differences among study areas in both pre-and post-fire management (i.e., whether or not areas were salvage logged; see Clark 2007, Bond et al. 2009). Further, the effect of fire likely varies greatly with fire severity and spatial pattern. That is, fires that burn large areas with high severity likely have a greater impact than fires that burn primarily at low to moderate severity (USDA FS 2010), fires that burn most of a territory likely have a greater effect than fires that burn only portions of a territory, and fires that burn in a patchy mosaic likely have less effect than fires that burn with high severity throughout a territory. Similarly, fires that burn favored roosting and nesting habitat likely have a greater effect than fires that burn only foraging habitat. In the latter case, Bond et al. (2009) suggest that effects on owls may be largely positive by increasing prey access in areas proximal to nests or roosts (see Prey Habitat below). Finally, spotted owls in general show high site fidelity (Gutiérrez et al. 1995). Because of this, owls might continue to occupy burned territories even if the habitat was degraded considerably. Thus, long-term data on owl demography, with information on the spatial pattern of fire severity and owl habitat use will be required to fully understand the effects of fire on spotted owls.

b. Thinning/Timber Harvest.−−Empirical data on the effects of thinning and other mechanical forest treatments on Mexican spotted owls are nonexistent. This is unfortunate, because thinning and other mechanical forest treatments are emphasized heavily in plans for landscape-restoration of southwestern forests (e.g., USDA FS 2011), and these activities could affect large areas of Mexican spotted owl habitat. Consequently, understanding how these treatments affect Mexican spotted owls is one of the major questions faced in integrating recovering this owl with plans for restoring southwestern forests. Although this has been clearly noted for years (e.g., USDI FWS 1995, Beier and Maschinski 2003, Ganey et al. 2011), no studies on this topic have been funded to date. Consequently, we can only extrapolate from the sparse data available on this topic resulting from studies of other subspecies of spotted owls, which we summarize below.

Meiman et al. (2003) conducted a case study of a single male northern spotted owl before, during, and after a commercial thinning operation conducted within the home range of this owl. Approximately 96 ha (237 ac) of forest lands were commercially thinned in this operation. Treatments occurred outside of a 28-ha (70-ac) designated core area, but within 70 m (230 ft) of nest trees used by the resident owls. Approximately 55 ha (136 ac) were thinned to a basal area of 39 m^2 ha^{-1} (170 ft^2 ac^{-1}), a 4.5-ha (11.1-ac) area was thinned to 20.7 m^2 ha^{-1} (90.2 ft^2 ac^{-1}) basal area, and a third area was thinned to 29.9 m^2 ha^{-1} (130.2 ft^2 ac^{-1}). Breeding-season home-range size of the radio-marked male declined slightly following thinning (from 895 ha [2,212 ac] to 753 ha [1,861 ac]), but shifted geographically to exclude part of the thinned area and include unthinned areas elsewhere. In contrast, the non-breeding season home range was 2.3 times larger after harvest (2,825 ha [6,978 ac]) than before harvest (1,204 ha [2,974 ac]). The radio-marked owl was located up to 7 km (4.4 mi) from the nest area during the non-breeding season after thinning, versus 3.4 km (2.1 mi) before thinning. Size of core use areas did not differ significantly between pre- and post-harvest periods, but as with home range, geographic shifts were observed away from the thinned area. Based on number of locations, use of the thinned stand was significantly reduced after harvest. Thus, results suggest some spatial shifts in areas used following harvest, as well as reduced use of the thinned stand following harvest. However, results are difficult to interpret because we generally lack information about temporal variation in space and stand use. Further, this study is unlikely to shed much light on how restoration

treatments might affect Mexican spotted owls, because the residual basal areas in treated stands (20. 7 to 39 m^2 ha^{-1} [90.2 to170 ft^2 ac^{-1}]) were far greater than residual basal areas typical of restoration projects in the southwestern U.S. (11.5 to 16.1 m^2 ha^{-1} [50 to 70 ft^2 ac^{-1};USDA FS 2011:43]).

Seamans and Gutiérrez (2007) examined the relationship between habitat selection of California spotted owls and variation in habitat in the Sierra Nevada. They modeled the probability of territory colonization, territory extirpation, and breeding dispersal in relation to the amount of mature forest within and among territories, and included a covariate to evaluate the effects of alteration of mature conifer forest habitat by timber harvest on these parameters. Estimates of habitat variables were based on 400-ha (988-ac) circles centered on the geometric center of all owl locations for a territory within a given year.

The probability of territory colonization was related to both area of mature conifer forest within a territory and alteration of that habitat. The top model for colonization indicated that territories in which ≥20 ha (49 ac) of mature conifer forest habitat was altered by timber harvest experienced a 2.5% decline in occupancy probability.

The top model for territory extirpation suggested that this parameter was negatively related to amount of mature forest within a territory. The structure of this top model did not allow them to separate the effects of habitat alteration within territories from variation in amount of mature forest among territories. Assuming that the variation in territory extirpation probability was due to variation in amount of mature conifer forest among territories, this model suggested that occupancy probability increased approximately 1.1% for every 20-ha difference in amount of mature conifer forest among territories.

The probability of breeding dispersal (i.e., leaving an established territory in year *t* to move to another territory in year *t*+1) was related to both amount of mature conifer forest and alteration of that habitat. The top-ranked model suggested that probability of breeding dispersal was negatively related to the amount of mature conifer forest within a territory and positively related to alteration of ≥20 ha (49 ac) of mature conifer forest. This model also included an interaction between amount of mature conifer forest and alteration of that habitat. This interaction term suggested that breeding dispersal was much more likely to occur in territories with <150 ha (371 ac) of mature conifer forest that experienced habitat alteration than in territories with greater amounts of mature conifer forest that did not experience habitat alteration.

Seamans and Gutiérrez (2007) did not provide details on what types of treatments were involved in habitat alteration in this study, nor on spatial extent of those treatments. That is, they modeled a covariate based on alteration of ≥20 ha (49 ac) of mature mixed-conifer forest, but provided no information on how frequently territories experienced alteration of that magnitude versus larger areas. These limitations complicate interpretation of their results. Nevertheless, those results generally indicate positive effects of amounts of mature conifer forest and negative effects of alteration of ≥20 ha (49 ac) of mature conifer forest on demographic parameters.

Gallagher (2010; see also USDA FS 2010b) monitored movements and habitat use of 10 radio-marked California spotted owls in the northern Sierra Nevada in a landscape recently modified

by fuels treatments. Fuels treatments included: Defensible Fuel Profile Zones (DFPZs), understory thin, understory thin followed by underburn, and group selection. DFPZs were areas approximately 0.4 – 0.8 km (0.2 – 0.5 mi) wide where surface, ladder, and crown fuels loadings were reduced (USDA FS 2009). They were typically constructed along roads and ridge tops to reduce fuel continuity across the landscape and provide a defensible zone for fire suppression activities, and were designed to function effectively under 90th percentile weather conditions. Understory thin treatments allowed removal of trees <25.4 cm (10 in) in dbh. Understory thin with underburn allowed for use of surface fire following thinning. Group selection treatments allowed removal of all trees <76.2 cm (30 in) in patches <0.8 ha (2 ac) in area.

Radio-marked owls avoided DFPZs, but use of all other treatments was variable, and results were confounded by spatial orientation of treatments relative to owl core areas. Noting these complicating factors, Gallagher (2010:2) noted that "Conclusions from this study are exploratory and are intended to provide a baseline for further research."

Dugger et al. (2011) evaluated relationships between northern spotted owls and barred owls in the southern Cascades of Oregon. They modeled the effects of barred owl presence on northern spotted owl territory occupancy, using amount of suitable spotted owl habitat as a covariate. Northern spotted owl territory colonization rates were strongly and negatively related to detections of barred owls, and territory extirpation rates were strongly and positively related to barred owl detections. Extirpation rates increased in response to decreased amounts of old forest habitat within territory cores, and colonization rates were greater where old forest habitat was less fragmented. Dugger et al. (2011) concluded that the combined barred owl and habitat effects observed suggested that interference competition was occurring between these owl species. They further concluded that these effects suggested that maintaining northern spotted owls on the landscape in the face of this competition would require conserving large amounts of contiguous old forest habitats.

As noted earlier, empirical data on effects of forest treatments on spotted owls are sparse and difficult to interpret. Although all of the studies discussed above individually present limits to interpretation, collectively they suggest that at least some kinds of mechanical forest treatments may negatively impact spotted owls. No clear guidance emerges from these studies relative to types, extents, or spatial arrangement of treatment that might minimize impacts to owls. Such information is badly needed if management is to proceed in owl habitat. Some treatments may have beneficial or neutral effects, but we do not know which types and intensities of treatments may be beneficial, neutral, or harmful. Lacking such information, managers should proceed cautiously in terms of treatment intensity and extent. That is, initial treatments should be limited in spatial extent and treatment intensity, and should be aimed at balancing reduced fire risk with maintaining the mature forest structure that seems to be favored by Mexican spotted owls. And all treatments in owl habitat should be linked to rigorous monitoring of owl response, to allow us to evaluate the effects of different types of treatments in an adaptive management context.

c. Grazing.—Heavy grazing intensity by domestic livestock and wild ungulates, repeated over successive seasons, can create a short to moderately long disturbance to vegetation that provides cover and food to the owl's prey, and it can influence both tree regeneration and dynamics and composition of understory vegetation in forests occupied by owls. Based on distribution of prey

species and regional variation in the owl's diet (e.g., Ward and Block 1995), portions of the owl's range that are most susceptible to disturbance from heavy grazing include regions where Mexican spotted owls commonly consume voles, hunt near the edges of montane meadows allocated as key grazing areas, or where domestic livestock and wild ungulates are found grazing on forested slopes or in riparian habitats within canyons used by Mexican spotted owls.

Only one study has specifically addressed effects of grazing by domestic livestock on Mexican spotted owls. This study examined small mammal abundance and diversity in adjacent grazed and ungrazed transects in two owl territories in the canyonlands of southern Utah. Both woodrat abundance and overall small mammal species diversity were greater in ungrazed than in grazed transects (Willey and Willey 2010). There also is circumstantial evidence that grazing may affect prey abundance and thus indirectly affect owls. The primary evidence here comes from 1) studies on impacts of livestock on plant communities and the features of those communities that influence prey populations (described below under Prey Habitat), and 2) the influence of abundance of various prey species or groups of species on the owl's feeding habits and reproduction (described below under Diet and Prey Selection, and Effects of Prey on Vital Rates). For example, species such as voles (and, to a lesser extent, woodrats) that are highly dependent on herbaceous plants for cover, food, and water are found in much lower abundance where drought combines with successive seasons of heavy grazing intensity, without opportunity for plant development and recovery from grazing events. These species can provide important contributions to owl diets in some regions and years (Ganey 1992, Ward and Block 1995, Seamans and Gutiérrez 1999, Ward 2001, Ganey et al. 2011). Current evidence suggests that small mammal biomass (including voles and mice) influences Mexican spotted owl reproductive output (Ward 2001). Hence, grazing can negatively influence owl abundance indirectly by decreasing populations of key prey species.

Grazing also can also affect forest structure, particularly by influencing patterns of tree regeneration. This has occurred in both upland (Rummel 1951) and riparian forests, but it likely is most important in riparian forests (Stacey and Hodgson 1999). Mexican spotted owls at one time nested in lowland cottonwood bosqués in parts of their range (Bendire 1892, Bailey 1928, Phillips et al. 1964). Most of these areas have been heavily impacted by grazing, and there are no recent records of Mexican spotted owls occupying such areas. Riparian forest along major rivers in the Southwest also may provide Mexican spotted owls with movement corridors in a landscape that otherwise might prove more resistant to effective movement or dispersal.

Montane riparian systems also have been impacted by grazing. Stacey and Hodgson (1999) noted that canyon-bottom riparian habitats in the San Mateo Mountains, New Mexico, differed between areas inside and outside of livestock exclosures. Within the exclosures, canyon bottoms supported dense stands of narrowleaf cottonwood, willows, and other riparian species. In contrast, areas outside of the exclosures contained some remnant riparian vegetation, but cottonwoods were not regenerating and most had died.

In another example, Martin (2007) documented significant declines in abundance of deciduous trees in snowmelt drainages along the Mogollon Rim, Arizona between 1987 and 2007. He attributed much of this decline to increased browsing pressure by elk (*Cervus elaph*us). That increase in turn was facilitated by warmer winters and reduced snowpack, which allowed elk to

remain in the area during winter months rather than migrating to lower elevations. Thus, this example documents an indirect effect on owl habitat involving grazing mediated by climate change. The observed changes in forest structure and composition were significant enough to cause the local extirpation of one formerly common bird species and severe population declines in several other species. Similar impacts may have occurred elsewhere in montane riparian systems.

d. Urbanization.— Urbanization and land development can affect Mexican spotted owls both directly and indirectly. Development and urbanization can affect owls directly where suitable habitat is lost, or indirectly through effects on either ecological integrity or management practices. No studies have directly examined the effects of land development on Mexican spotted owls, so the extent of potential impacts remains largely unknown. Impacts may be significant, however. For example, an analysis of the effects of interspersed urban land development on the amount and availability of habitat suitable for California spotted owls demonstrated that such development could reduce the amount of suitable habitat by more than 50% over a 40-year period (Manley et al. 2009).

Development impacts may vary by area. For example, in some areas spotted owls occur in landscapes with small amounts of private land, whereas other populations occur in landscapes with far greater amounts of private land. Presumably, development impacts will be greater in landscapes with larger amounts of private land, although some forms of development may have greater impacts than others. Development impacts also may depend on spatial location. For example, development in suitable nesting habitat may be more detrimental than development in foraging habitat at the periphery of a home range, and development in key stepping-stone (see Landscape Connectivity, above) or wintering areas (see Seasonal Migration, below) may be more detrimental than similar development in areas that are not as important spatially. Finally, development can exert indirect impacts by affecting management policies and decisions. For example, managers may more aggressively reduce forest fuels and canopies in areas adjacent to private lands than in more remote areas, and these activities may negatively impact habitat quality for Mexican spotted owls. For a broader discussion of types of development and potential impacts to Mexican spotted owls, see Part II.H.3.*x*.

e. Climate Change.— Climate change is the shift in previous long-term and wide-ranging patterns in meteorological parameters that are used to characterize weather. Climate and resulting weather patterns drive most ecological processes. Unfortunately, the science on ecological effects of climate change is just beginning to emerge. Thus, most assessments of effects of climate change on the spotted owl are speculative and based on circumstantial information (but see Peery et al. 2011). The emerging phenomenon of climate change has the potential to impact Mexican spotted owls in three general ways:

- Directly, through impacts on key physiological processes like thermoregulation and water balance,
- Indirectly, through similar impacts on desired prey species, and
- Indirectly, by causing shifts in physical limits that control distribution of other animal or plant species that create biological communities that influence the owl (e.g., Martin 2007).

Mawdsley et al. (2009) discussed these effects as: 1) shifts in the distribution of biological communities along elevational or latitudinal gradients; 2) direct loss of habitat due to increased fire frequency, bark beetle outbreaks, and direct warming of habitats; 3) effects on demographic rates, such as survival and reproduction; 4) reductions in population size; 5) changes in coevolved interactions, such as prey-predator relationships; and, 6) increased population or range expansion of species that are direct competitors. In this section, we discuss topics 1 and 2. Topics 3-6 are discussed below under Population Ecology.

1. Shifts in Distribution.—Shifts in Mexican spotted owl distribution could occur in response to predicted warming in the Southwest that may cause elevational and latitudinal shifts in tree species distribution. Predicted warming and drying in the Southwest may cause both latitudinal and elevational shifts in tree species distribution, as well as tree species extirpations at higher elevations (Dale et al. 2001, Mueller et al. 2005, DeGomez and Lenart 2006, Archer and Predick 2008). Over a long period of time the shift in plant communities could result in shifts in the distribution of both the owl and many of its important prey species. Exactly how these shifts will play out remains unknown, but some tree species and forest types currently present may be lost or greatly reduced in extent, especially where such species or communities occupy the upper elevations of island mountain ranges. For example, Mexican spotted owls occur in mixed-conifer and pine-oak forests at the tops of many of the Sky Island ranges in Arizona and New Mexico. Conifers within the Sky Islands of southern Arizona may be eliminated as temperatures increase and snowpack runoff decreases (Archer and Predick 2008). Loss of these forest types in these mountains presumably would eliminate or greatly reduce habitat for owls in these ranges. This in turn would greatly reduce landscape connectivity for Mexican spotted owls, likely reducing population viability as well (e.g., Keitt et al. 1995, 1997, Barrowclough et al. 2006, see also Ganey et al. 2008).

In contrast, however, these species also may migrate northward in response to changing climate, and/or Cordilleran (Rocky Mountain) species could be replaced by species with more Madrean affinities (such as Apache or Chihuahuan pines, or various species of evergreen oaks). We are aware of efforts to model and map shifting distributions of major southwestern conifers in relation to various climate-change scenarios, but results of these efforts have not yet been published. It seems likely, however, that loss of tree species or shrinkage in species' range extent will outpace colonization by new species in the face of rapid climate change. Further, Mexican spotted owls frequently inhabit late-successional forests, and it will take considerable time for such forests to develop even if appropriate tree species are able to colonize new areas. Thus, at least in the short term, Mexican spotted owls likely will face reductions in habitat extent and greater fragmentation of suitable habitat within their current range. Such possible shifts in distribution of owl habitat argue for preserving management options in areas not currently occupied by Mexican spotted owls, but where climate and tree species distribution models predict that owl habitat could develop in the future.

2. Direct Loss of Habitat.--Mexican spotted owls also may experience direct loss of or alteration of habitat due to other climate-induced disturbances such as heat stress to plants, increased fire frequency, and insect outbreaks (e.g., Ayres and Lombardero 2000, Dale et

al. 2001, Breshears et al. 2009, Floyd et al. 2009, van Mantgem et al. 2009, Allen et al. 2010). For example, over multi-century periods, increased and decreased activity of spruce budworms coincided with wetter and drier periods, respectively (Swetnam and Lynch 1993, Ryerson et al. 2003), and bark beetle outbreaks have caused considerable tree mortality during a recent drought (e.g., Raffa et al. 2008, Negron et al. 2009, USDA FS 2009). Increasing levels of drought, along with associated insect outbreaks and wildland fires, could rapidly and dramatically affect the distribution, amount, and composition of Mexican spotted owl habitat. Finally, increasing temperatures may increase the prevalence of wildland fire, both alone and in concert with other disturbance agents such as insects and disease (e.g., Dale et al. 2001, McKenzie et al. 2004). How resilient owls and their habitats will be to these types of disturbances remains unknown.

5. Prey Ecology

Understanding a predator's food choices along with the natural and life history of its common prey species can provide practical information for conserving and enhancing the predator's habitat. This section provides information on the owl's common prey species. Although the strong link between raptors and their food is well-documented (e.g., Newton 1979), few studies have quantified the relationships among spotted owls, their prey, and the environmental factors that influence the availability of favored prey to this owl (Noon and Franklin 2002).

A. Hunting Behavior

Forsman (1976) described spotted owls as "perch and pounce" predators. They typically locate prey from an elevated perch by sight or sound, then pounce on the prey and capture it with their talons. Spotted owls also have been observed capturing flying prey such as bats, birds, and insects (Verner et al. 1992, Duncan and Sidner 1990). They hunt primarily at night (Forsman et al. 1984, 2004; Ganey 1988), although infrequent diurnal foraging has been documented (Forsman et al. 1984, Laymon 1991, Sovern et al. 1994, Delaney et al. 1999a).

B. Diet and Prey Selection

Numerous studies have provided information on diets of Mexican spotted owls based on examination of prey remains from regurgitated pellets (see summary in Ward and Block 1995, also Wagner et al. 1982, Johnson 1997, Young et al. 1997, Willey 1998a, Seamans and Gutiérrez 1999, Ward 2001, Block et al. 2005, Bravo-Vinaja et al. 2005). Mexican spotted owls consume a variety of prey throughout their range, but they commonly eat small- and medium-sized rodents such as woodrats, mice, and microtine voles (Ward and Block 1995, Ganey et al. 2011). Mexican spotted owls also consume rabbits, bats, birds, reptiles, and insects.

The diet of Mexican spotted owls varies by geographic location (Ward and Block 1995: Fig. II.5.2). For example, woodrat consumption by Mexican spotted owls is far greater where owls occur in rocky canyons (e.g., southern Utah, Rinkevich 1991, Willey 1998a) than where owls occur in dense forests (e.g., the Sacramento Mountains, New Mexico; Ward 2001). In contrast, Mexican spotted owls occupying mountain ranges with forest-meadow interfaces take more voles than in other areas (Ganey 1992, Ward and Block 1995: Fig. II.5.2, Ward 2001). Regional

differences in the owl's diet likely reflect geographic variation in prey abundance and habitats of both the owl and its prey. Forsman et al. (2001) documented similar spatial variation in a regional analysis of diets of northern spotted owls.

Ward and Block (1995) retrospectively examined the link between abundance or consumption of specific prey and successful reproduction by Mexican spotted owls in the Sacramento Mountains, New Mexico (BRE EMU). They were not able to demonstrate strong relationships, but fecundity of Mexican spotted owls in this region appeared to be most associated with trends in abundance of Peromyscid mice during the time period studied (Ward and Block 1995). Seamans and Gutiérrez (1999) also did not observe strong relationships between number of young produced and the proportion of biomass of any particular prey species consumed by Mexican spotted owls in two populations, one in northern Arizona and another in west-central New Mexico. As in other studies of this owl's diet, small mammals comprised > 88% of dietary biomass, and, according to biomass consumed, woodrats were relatively important prey to owls in both populations (Seamans and Gutiérrez 1999).

The lack of demonstrated strong relationships in these studies does not mean that such relationships do not exist. More likely, it reflects difficulty in documenting the link between prey abundance and owl reproduction using opportunistic sampling of prey remains without knowledge of prey abundance or prey selection (i.e., the ratio between amounts in the owl's diet and availability, Ward 2001:Chapter 3).

Ward (2001) expanded on the work in the Sacramento Mountains summarized in Ward and Block (1995), incorporating data from additional years. In this study, five species of rodents (deer mouse [*P. maniculatis*], brush mouse [*P. boylii*], Mogollon vole [*M. mogollonensis*], long-tailed vole [*M. longicaudus*], and Mexican woodrat [*N. mexicana*]) provided from 53 to 77% of the diet by frequency and from 41 to 66% of the diet by biomass over a six-year period (1991 to 1996). Mean number of Mexican spotted owl young produced annually over this period was most strongly correlated with the combined available biomass of mice and voles. More intriguing was that consumption of woodrats was proportionally lower in the Sacramento Mountains owl population than in seven other populations of spotted owls that were studied, and temporal variability in owl reproduction was inversely related to the proportion of woodrats in the diet across these eight populations (Ward 2001: Fig. 4.7). Based on this finding, and the dominance of woodrats in the diet throughout much of the owl's range, Ward (2001) suggested that woodrats likely were an important prey type for spotted owls in many geographic areas.

In rocky-canyon habitats in southern Utah, Willey and Willey (2010) examined prey abundance and owl diet composition within three owl territories. Owl diets were dominated (>80% of biomass consumed) by woodrats in this area. The first years of this study (2000 to 2003) coincided with a period of severe drought, followed by significant increases in local precipitation from 2004 to 2006. Rodent populations on three trapping grids showed strong increases in species richness and abundance during increasingly wetter study years. Mexican spotted owl reproduction was low during the 2000 to 2003 dry period, and by 2003 only male spotted owls were detected at the sites. All three sites were re-colonized by female spotted owls during the period of increased precipitation from 2004 to 2006, and reproduction increased during this period. This study was observational and did not necessarily document cause-and-effect

relationships, and inference is limited by small sample size. Nonetheless, results suggested that precipitation influenced site occupancy and reproductive rates of Mexican spotted owls indirectly by increasing prey abundance (Willey and Willey 2010).

C. Prey Habitat

Understanding habitat relationships of important prey species can provide additional information relative to foraging behavior and ecology of a predator. Habitat correlates of the owl's common prey indicate that each prey species uses unique microhabitat features (Ward and Block 1995, Sureda and Morrison 1998, 1999, Ward 2001, Block et al. 2005) and that these features may vary among vegetation types (Sureda and Morrison 1999). In general, deer mice appear relatively ubiquitous in distribution, occupying areas with variable conditions, whereas brush mice are more restricted to communities with a strong oak component and dry, rocky substrates with sparse tree cover (Block et al. 2005). Mexican woodrats typically occur in areas with considerable shrub or understory tree cover, low grass cover, high volumes of large logs, and/or presence of rock outcrops (Sureda and Morrison 1998, 1999, Ward 2001, Block et al. 2005). In the canyonlands of southern Utah, Mexican woodrats were captured only in rocky canyons (Sureda and Morrison 1998, 1999), where radio-marked owls concentrated foraging activity (Willey and van Riper 2007). Mogollon voles occur in areas with high herbaceous cover, primarily grasses, and long-tailed voles are associated with high herbaceous cover, primarily forbs, many shrubs, and limited tree cover (Ward 2001). Thus, to provide a diverse prey base, managers can provide a diversity of habitats for prey species when designating PAC boundaries or manipulating vegetative conditions in recovery habitat. Managing habitat for a diversity of prey species may help buffer against population fluctuations of individual prey species and provide a more constant food supply for the owl (Sureda and Morrison 1998, Ward 2001, Block et al. 2005).

Ward (2001) suggested that longer-term (50-year) management aimed at increasing late-seral conditions of mixed conifer forest should favor increased abundance of woodrats, and that increasing woodrat abundance would be more successful for recovering Mexican spotted owl populations than management aimed at increasing abundance of mice. This conclusion was based on the demonstrated inverse association between consumption of woodrats and temporal variability in the owl's reproduction across eight populations of spotted owls (Ward 2001: Fig. 4.7). Given the relationships among key habitat variables and common prey abundance, shorter term management also should include fostering good to excellent conditions in key grazing areas (e.g., montane meadows) to ensure adequate vole populations near and within owl foraging areas. Of the common prey species examined, mice were considered less manageable because their abundances were correlated with habitat attributes that were much more difficult to manipulate (e.g., seed mast and rocky slopes; Ward 2001: Chapter 2). In contrast, vole numbers likely could be increased by managing for increased cover and height of grasses and forbs (Ward 2001), and woodrat numbers might be increased by promoting shrub diversity and increasing cover of large logs (Sureda and Morrison 1999, Ward 2001, Block et al. 2005). Because microhabitat features associated with small mammal species can vary among geographic regions and habitats within regions (Ward and Block 1995, Sureda and Morrison 1999, Block et al. 2005), management for small mammals may require site- or at least habitat-specific knowledge about relationships between mammal abundance and habitat features.

Habitat conditions for the owl's prey, access to those prey, and abundance of these prey species can also be changed by fire. Indeed, differences among areas in composition of prey communities may at least partially explain the apparent inconsistent response of spotted owls to fire (discussed above). To date, adequate long-term studies of small mammal populations have not been conducted to determine effects on of fire on many of the owl's prey species. Results of short-term studies suggest that individual small mammal species respond differently to fire, and that small mammal response is driven more by remnant understory composition and response than by fire severity itself (Kyle and Block 2000, Converse et al. 2006a, 2006b, 2006c), although severity can strongly influence understory composition.

6. Population Ecology

Knowing how and why populations change over time is a fundamental requisite for forecasting and developing strategies for species recovery. The change in size of any population during a specified time period can be represented with the simple equation,

$$N_{t+1} = N_t - D_t + B_t + I_t - E_t$$

where N_t is the population size at time t, D_t is the number of individuals dying, B_t is the number of new individuals produced in the population (births), I_t is the number of individuals immigrating into the population, and E_t is the number of individuals emigrating from the population. The combined effect of births, deaths, immigrations, and emigrations dictate the viability of the population, and hence its long-term persistence. Three of these parameters for Mexican spotted owl populations, abundance, survival, and reproduction, are discussed below in greater detail. Knowledge regarding immigration or emigration is provided under the topic of dispersal because of the importance of inter-population movements to metapopulation structure and persistence.

A. Abundance

a. Density.—The number of individuals in a population (or population size, N) divided by the area used by those individuals is known as density. The most reliable estimates of Mexican spotted owl density come from mark-resighting data analyzed with closed-population estimators (e.g., Pollock et al. 1990). These procedures provide for estimating the probability of detecting individual owls and ultimately for correcting the sample count of owls to more truly reflect population size. Unfortunately, only one study has been implemented for the primary purpose of estimating density of Mexican spotted owls, and that study, although geographically extensive, was limited to a single year. By surveying and marking owls in a stratified-random set of 25 quadrats across the UGM EMU (range in quadrat size = 43.7 to 76.4 km^2), Ganey et al. (2004) estimated that 2,941 (Coefficient of Variation = 36.6%) territorial adult or subadult owls occupied this EMU (excluding tribal lands, which were not included in the sampling frame). Density of adult and subadult owls within individual quadrats ranged from 0 to 0.44 territorial owls km^{-2}.

Using a different study design, Seamans et al. (1999) reported from 0.026 to 0.075 territorial females km^{-2} in a 585-km^2 area in northern Arizona and from 0.055 to 0.099 owls km^{-2} in a 323-km^2 area in west-central New Mexico from 1991 to 1997 (densities calculated from data in their Fig. 1). Density of territorial females was consistently greater in the New Mexico population

during this period. The study area in Arizona included large areas of ponderosa pine and ponderosa pine-Gambel oak forest interspersed among mixed-conifer forests, whereas the study area in New Mexico was dominated by mixed-conifer forest. Seamans et al. (1999) suggested that the greater density of Mexican spotted owls in the New Mexico study area was a function of the greater relative amount of mixed-conifer forest found in that study area.

Two other studies have used sample counts within fixed quadrat areas without estimating detection probabilities (Skaggs and Raitt 1988, 1995, Young et al. 1998). These probabilities are required for correcting raw counts of owls for individuals that were actually present but never detected. Ward et al. (1995) reanalyzed data from Skaggs and Raitt (1988) for the Sacramento Mountains, New Mexico. They reported mean densities of 0.275 owls km^{-2} in quadrats dominated by mixed-conifer forest, 0.080 owls km^{-2} in quadrats dominated by ponderosa pine forest, and 0.022 owls km^{-2} quadrats dominated by pinyon-juniper woodland. These results demonstrate variation in abundance among areas that differ in habitat composition without the confounding variation associated with time (all quadrats were surveyed in one year).

Young et al. (1998) reported densities for five randomly selected 70-km^2 quadrats surveyed in Chihuahua Mexico. The counts of territorial owls ranged from 0.055 to 0.111 owls km^{-2} in the five quadrats. Vegetation composition was not described for individual quadrats but 71% of the overall area surveyed consisted of pine-oak forest, with pure pine and mixed-conifer forest comprising 17% and 12% of total area, respectively.

Densities of Mexican spotted owls in canyonlands have yet to be reported. As a reference point for estimates reported above, density of northern spotted owls in a study area containing large core areas of late-seral mixed-evergreen forest (perceived to be relatively high-quality habit for these owls; Franklin et al. 2000) was 0.272 owls km^{-2} in 1993 (Franklin unpubl. data cited in Ward and Block 1995). Caution must be exercised in comparing densities among study types and different sized sampling areas, however. Size and shape of the bounded area can influence the calculation of density in small study areas (Franklin et al. 1990), and if simple counts are not corrected by detection probabilities, results are further confounded if those probabilities differ between/among areas. But collectively, the above studies suggest that mixed-conifer forests support higher densities of Mexican spotted owls than areas dominated by other vegetation communities.

To date, three factors have been associated with Mexican spotted owl density. These include vegetation composition (discussed above), the degree of topographic relief (greater relief corresponds to greater density; Ganey et al. 2004), and fecundity from two years prior to a given density estimate (higher fecundity results in greater density in subsequent years; Seamans et al. 1999). These factors may not act independently. Furthermore, although relative density among various forest-cover types or other categories is of interest, density alone can be a misleading indicator of habitat quality (Van Horne 1983). For example, Seamans et al. (1999) reported greater density in their New Mexico study area than in their Arizona study area, yet demographic rates were greater in the Arizona study area (see below). Consequently, it is important to assess demographic parameters such as survival, reproduction, or especially rate of population change, when attempting to define habitat quality (see Environmental Variation and Vital Rates).

b. Temporal Population Trends.—A fundamental parameter that describes population change is lambda (λ) or annual (finite) rate of population growth. Population trends can be shown as plots of density or population size over time and quantified as the average change in population size or mean λ during that period. Only a single study (Seamans et al. 1999, updated in Gutiérrez et al. 2003) has been conducted long and effectively enough to quantify trends in Mexican spotted owl abundance and population change.

Based on estimates of vital rates and a Leslie stage-projection matrix model, Seamans et al. (1999) reported declining populations for two study areas in Arizona and New Mexico. Although the years covered by these estimates were not stated explicitly, the declining trends were supported by estimates of annual abundance-based counts of owls from 1992 to 1997 (Seamans et al. 1999: Fig. 4). Gutiérrez et al. (2003) updated information on estimated trends in owl numbers (λ) for these study areas from 1993 to 2000. In the Arizona study area, mean λ (0.995, 95% confidence interval = 0.836–1.155) indicated a stable population (i.e., $\lambda \approx 1$) over this period. In contrast, the population of Mexican spotted owls from the New Mexico study area appeared to be declining (i.e., $\lambda < 1$) by approximately 6% per year during this period (mean $\lambda = 0.937$, 95% confidence interval = 0.895–0.979). However, analytical methods used in Gutiérrez et al. (2003) differed between study areas and differed from the methods used by Seamans et al. (1999)**.** These differences in methods complicate interpretation of the difference in observed trends between study areas and/or time periods.

Gutiérrez et al. (2003) also provided point estimates of "realized change." This measure uses consecutive annual estimates of λ to estimate the proportion of the initial population remaining in a given year, yielding a parameter that is more easily interpreted than λ (Franklin et al. 2004). They estimated that the owl populations remaining in their Arizona and New Mexico study areas in the year 2000 were 69.1 and 60.8% as large, respectively, as the 1993 populations. In other words, they estimated declines of >30% in both populations from 1993 (the first year in which they could estimate λ) to 2000.

Stacey and Peery (2002, see also Stacey 2010: Table 35.1) also reported declining trends in owl populations in the Black Range and Zuni, San Mateo, and Magdalena Mountains, New Mexico, based on data from 1991 to 1999. Declining trends were evident in all ranges studied, as well as when populations from these ranges were combined for an overall analysis (overall $\lambda = 0.803$, 95% confidence interval = 0.73 to 0.89). Populations in the Zuni and Magdalena Mountains apparently declined to zero during the study. Some re-colonization occurred in both ranges, but the populations were unstable, with territories typically occupied for only a year or two before becoming vacant again (Stacey 2010). Stacey (2010:615-616) also suggested that earlier (probably prior to 1994) local extirpations occurred in the Sandia and Manzano Mountains, and possibly in the Datil and LaDronnes Mountains, New Mexico. Seamans and Gutiérrez (2006; see also Seamans and Gutiérrez 2007 for effect of mates on breeding dispersal) suggested that spotted owls may use presence of conspecifics as cues in settling and therefore may be slow to re-colonize areas where they are locally extirpated (or even greatly reduced in number).

c. Temporal Trends in Occupied Sites.—Depending on the nature of the sampling design, time trends in the number or proportion of sites occupied in a study area can provide a surrogate index for trends in population numbers (MacKenzie et al. 2003). However, studies of site occupancy

through time that do not survey enough area to allow for detecting newly colonized or re-colonized sites will always show a decline.

There have been four studies that provided trends in number or proportion of sites occupied by Mexican spotted owls that may also be indicative of population trends. Johnson (2000) reported on occupancy of Mexican spotted owl territories in the Jemez Mountains, New Mexico from 1979 to 2000, with more formal monitoring conducted since 1989. Number of territories included in these annual estimates varied among years (maximum number in a year was 28 territories; average number monitored since 1989 was 20 territories), as did methods (e.g., early estimates were based on passive listening surveys rather than calling surveys). Results suggest that occupancy rates declined from 1985 to 1989 and have been fairly stable since 1989 (Johnson 2000: Fig. 1). Declines may have occurred earlier than 1985, but the change in methods makes it difficult to tell. By 2000, 14 of the 28 territories were known to be occupied by at least one Mexican spotted owl and eight of those territories were occupied by pairs.

Using a retrospective analysis of survey data gathered in the Sacramento Mountains of southern New Mexico, Lavier (2006) estimated the proportion of sites occupied by Mexican spotted owls following procedures recommended in the population monitoring section of this Recovery Plan. These procedures (see also MacKenzie et al. 2003) enhance estimation of site occupancy by also estimating and incorporating probabilities that owls are detected. Lavier's (2006) study showed a dynamic but generally stable or slightly declining pattern of site occupancy by territorial owl-pairs in the Sacramento Mountains from 1989 to 2004. Estimated site occupancy by pairs in this population ranged from a high of 85.4% (SE = 0.03%) in 1992 to a low of 54.4% (SE = 0.05%) in 2000. Site occupancy was estimated at 71.0% (SE = 0.05) in 2004, the last year of the study.

In rocky-canyon habitats in southern Utah, Willey (2010) and Hockenbary (2011) conducted occupancy based surveys for Mexican spotted owls at 47 historic territories in Zion and Capitol Reef National Parks, Grand Staircase-Escalante National Monument, and on Cedar Mesa (BLM) from 2007-2009, following methods in MacKenzie et al. (2003). Willey (2010) classified owl territories as occurring either in xeric (Grand-Staircase and Capitol Reef) or mesic (Zion and Cedar Mesa) canyon habitat. Mesic sites included patches of mixed-conifer and riparian forest, whereas xeric sites were dominated by desert scrub vegetation. Estimated year one site occupancy at territories was 92% (SE = 0.075%) at the mesic sites and 47% (SE = 0.10%) at xeric sites. AIC-based selection of models of occupancy rate supported a model with detection probability constant across years and a strong habitat effect indicating that occupancy rates differed between mesic and xeric territories. Re-colonization rates also differed between habitats, with re-colonization rates more than twice as great at mesic territories, compared to xeric territories. Thus, Zion and Cedar Mesa populations experienced high occupancy and re-colonization rates, whereas the xeric study sites showed low rates of occupancy and re-colonization. Numerous additional xeric sites located in Capitol Reef and the Paria River that were occupied during the 1990s (Willey 1998, 2007) were no longer occupied during surveys conducted during 2007 and 2008, suggesting that populations in xeric locations may have declined in southern Utah.

Investigating the same study areas and 47 territories studied by Willey (2010), Hockenbary (2011) continued occupancy-based research, and studied relationships among recreation use-

level by humans, habitat covariates, and owl site occupancy, colonization, extirpation, and detection probabilities. Detection probability, as by the best model evaluated, was 0.89 (95% CI = 0.82 – 0.94) across all three years of study. Two competing models of occupancy, colonization, and extinction rates both included a site-specific mesic/xeric habitat covariate. These models outranked models that included effects of recreation. From the best approximating model, occupancy was estimated as 0.75 (95% CI = 0.57 - 0.87) and 0.50 (95% CI = 0.27 – 0.73) for mesic and xeric sites, respectively. Recolonization rate was estimated at 0.10 (95% CI = 0.02 – 0.37) for xeric sites and 0.53 (95% CI = 0.28 – 0.76) for mesic sites, and extirpation rate was constant across years (0.25; 95% CI = 0.15 – 0.39). The results did not support recreation effects on site occupancy or colonization and extinction rates. High recreation sites were occupied by Mexican spotted owls during each year of the study, and fledglings were observed in these sites multiple years. Thus, results suggest that current management practices and imposed limits to recreational activity in the study areas have been adequate for protecting spotted owls.

Similar to Willey (2010), Hockenbary (2011) estimated higher occupancy and recolonization rates and lower extirpation rates for mesic than for xeric sites, suggesting that mesic sites were more stable (i.e., constant occupancy) than xeric sites. He concluded that mesic habitats may have more favorable microclimates and habitat structure, roost and nest sites, and diverse habitats for the owl's prey.

In summary, data on trends in populations or occupancy rates are sparse, and methods and sample sizes differ among studies, making comparisons difficult. In general, however, results suggest that most populations of Mexican spotted owls studied either have declined in the recent past or are still declining. Further, some evidence suggests that owls may be slow to re-colonize areas where such declines have occurred (Seamans and Gutiérrez 2006, Stacey 2010, Willey and Willey 2010).

B. Life History Strategy

In general, the life history of the Mexican spotted owl appears similar to those of the better-known northern and California subspecies. All three subspecies are characterized by high and reasonably constant adult survival rates, low juvenile survival rates, and relatively low and highly variable reproductive rates (e.g., Noon et al. 1992, Franklin et al. 2000, 2004, Blakesley et al. 2001, Gutiérrez et al. 2003, LaHaye et al. 2004, Anthony et al. 2006). These life history characteristics allow owls to reproduce when conditions are favorable and to survive unfavorable periods with little or no reproduction, a strategy that has been coined "bet-hedging" (e.g., Boyce 1988, Franklin et al. 2000).

Despite the above similarities, the Mexican spotted owl differs from the other two subspecies in important respects. In northern and California spotted owls, the population appears to contain numbers of non-territorial "floaters" (Franklin et al. 2000, 2004; Franklin. 2001). These floaters fill vacancies in the territorial population, so that the territorial population remains relatively stable even during periods with little or no reproduction. In contrast, available evidence suggests that few such floaters exist in Mexican spotted owl populations. Specifically, vacated territories may remain empty for years, and when territory vacancies are filled they are generally filled by subadult rather than older owls, suggesting that there is not a subset of the population that is

unable to find vacant territories. As a result, population trend tracks changes in reproduction with a short time lag (Seamans et al. 1999, Gutiérrez et al. 2003). Because reproduction in this owl is inherently variable (see Reproductive Biology and Rates, below), we can thus expect to see large variability in owl populations over time. Much of this temporal variability likely relates to large-scale climatic patterns, which also are inherently variable within the range of the Mexican spotted owl.

C. Reproductive Biology and Rates

Like many temperate-zone *Strix* owls, Mexican spotted owls form a monogamous pair-bond. The reproductive process is opportunistic, and success is dependent in part on the physiological condition of the female and availability of prey (Hirons 1985, Gutiérrez et al. 1995). The typical chronology for successful reproduction entails: 1) reformation of the pair bond, courtship and nest selection, copulation; 2) egg-laying, incubation, and brooding of young (all referred to as nesting); and, finally, 3) rearing of young outside of the nest.

Knowledge of the annual reproductive cycle of the Mexican spotted owl is important both in an ecological context and for placing seasonal restrictions on management or other activities that may occur within areas occupied by Mexican spotted owls to minimize disturbance to nesting owls. In Arizona, courtship begins in March with pairs roosting together during the day and calling to each other at dusk (Ganey 1988). Eggs typically are laid from late-March to mid-April. Incubation begins shortly after the first egg is laid and lasts approximately 30 days. Only the female incubates the eggs. During incubation and the first half of the brooding period, the female leaves the nest only to defecate, regurgitate pellets, or receive prey delivered by the male, who does most or all of the foraging (Forsman et al. 1984, Ganey 1988, Delaney et al. 1999a). This chronology may vary slightly throughout the range of the owl and from year to year, depending on weather conditions during winter and spring.

Mexican spotted owls nest on cliff ledges, stick nests built by other birds, debris platforms in trees, and in tree cavities (e.g., Ganey and Dick 1995, Gutiérrez et al. 1995, Seamans and Gutiérrez 1995, Johnson 1997, Willey 1998a, May et al. 2004). Spotted owls have one of the lowest clutch sizes among North American owls (Johnsgard 1988, Gutiérrez et al. 1995). Females normally lay one to three eggs, two being most common, and four being observed rarely (LaHaye 1997, Gutiérrez et al. 2003). Re-nesting following nest failure is unusual but has been observed in Mexican spotted owls (Kroel and Zwank 1992, Gutiérrez et al. 1995).

The eggs usually hatch in early- to mid-May (Ganey 1988). Female spotted owls brood their young almost constantly for the first couple of weeks after the eggs hatch but then begin to spend time hunting at night, leaving the owlets unattended for up to several hours (Eric Forsman, FS, pers. comm., Delaney et al. 1999a). Nestling owls generally fledge from early- to late-June, roughly four to five weeks after hatching (Ganey 1988). Owlets usually leave the nest before they can fly, jumping from the nest to surrounding tree branches or the ground (Forsman et al. 1984, Ganey 1988). Owlets that end up on the ground often will climb, using talons and bill, up an understory tree to a safe roost site. The mobility and foraging skills of owlets improve gradually during the summer. Within a week after leaving the nest, most owlets can make short, clumsy gliding flights between trees. Three weeks after leaving the nest, owlets can sustain

flapping flight and hold and tear up prey on their own (Forsman et al. 1984). Fledglings depend on their parents for food during the early portion of the fledgling period. Hungry owlets give a persistent, raspy "begging call," especially when adults appear with food or call nearby (Forsman et al. 1984, Ganey 1988). Begging behavior declines in late August, but may continue at low levels until dispersal occurs, usually from mid-September to early October (Arsenault et al. 1997, Ganey et al. 1998, Willey and van Riper 2000).

Mexican spotted owls breed sporadically and do not nest every year (Ganey 1988, Gutiérrez et al. 1995, 2003, White et al. 1995). In good years, much of the population will nest, whereas in some years only a small proportion of pairs will nest successfully (Fletcher and Hollis 1994, Gutiérrez et al. 1995, 2003). For example, during 12 years of study in Arizona and New Mexico (Gutiérrez et al. 2003), 63.6% of owl pairs nested in a given year, on average (SE = 8.91; range = 9.1 to 100%, n = 19 to 45 owl pairs monitored per year), and 74.6% of those pairs nesting fledged young (SE = 8.61, range = 0 - 100%). Reasons for this pattern of sporadic breeding are unknown, but temporal variation in food resources and weather are suspected to influence both the proportion of pairs nesting and the proportion fledging young (see Environmental Variation and Vital Rates, below).

Table B.5. Summary of estimates of reproductive output (young fledged per pair) of spotted owls.

Subspecies	Age-class[1]	Area	Populations studied[2]	Number of years[3]	Reproductive output		Source[4]
					Mean	SE	
Mexican	A, SA	Arizona	1	12	0.929	0.188	1
Mexican	A, SA	New Mexico	1	12	0.702	0.199	1
Mexican	A, SA	New Mexico	1	6	0.72	0.631	2
Mexican	A	New Mexico	4	NA	0.359	0.057	3
Mexican	SA	New Mexico	4	NA	0.150	0.107	3
Mexican	A, SA	New Mexico	1	18	0.97	No estimate	4
Northern	SA1	Rangewide	14	14	0.148	0.0584	5
Northern	SA2	Rangewide	14	14	0.416	0.064	5
Northern	A	Rangewide	14	14	0.744	0.058	5
California	A, SA	Rangewide	5	14	0.57-0.81[5]	0.16-0.82[5]	6
California	A	Southern	1	12	0.345	0.028	7
California	SA	Southern	1	12	0.139	0.050	7

[1] Age classes: A = adult, SA = subadult (first and second-year subadults combined), SA1 = first-year subadult, SA2 = second-year subadult. A, SA indicates that reproductive output was estimated for adult and subadult owls combined.
[2] Number of distinct study areas covered by estimate.
[3] Number of years included in the study. NA = number not available.
[4] Source: 1 = Gutiérrez et al. (2003); 2 = calculated from data in Ward (2001:Fig. 3.8); 3 = Stacey and Peery (unpubl. data); 4 = Johnson (2000); 5 = recalculated from fecundity in Anthony et al. (2006:Table 5); 6 = recalculated from fecundity in Franklin et al. (2004:Table 9); 7 = LaHaye et al. (2004).
[5] Range across populations.

Annual reproductive output of Mexican spotted owls, defined as the number of young fledged per pair, varies both spatially, temporally, and by age-class (Seamans et al. 1999, Johnson 2000, Ward 2001, Gutiérrez et al. 2003, Stacey 2010). Fecundity, the number of female offspring produced per female in a population, is half of the value for reproductive output when the sex ratio in the offspring is 50:50. Similar to other spotted owl subspecies, average reproductive rates are generally low in Mexican spotted owl populations (Table B.5) and rarely exceed 1 young per pair per year, although higher rates may occur in some years (Ward 2001). However, average annual reproductive output in Mexican spotted owl populations can be as great as 1.4 young per pair (Ward 2001). Although all three subspecies of spotted owls exhibit temporal fluctuations in reproductive success, the amplitude of those fluctuations is generally greatest for the Mexican spotted owl (Ward 2001: Fig. 4.7; see also reviews in White et al. 1995, Burnham et al. 1996, Franklin et al. 2004; Anthony et al. 2006). Adult individuals usually have higher reproductive rates than subadults (Table B.5).

D. Survival Rates

Annual survival is defined as the probability of an individual surviving from one year to the next, or as the proportion of individuals in a population that will survive from one year to the next. Survival rates of spotted owls typically are estimated either by marking individuals with leg-bands and documenting their presence through re-sighting in a spatially explicit population through multiple years (e.g., Forsman et al. 1996), or by intensively monitoring fates of radio-marked owls over shorter periods of time.

Gutiérrez et al. (2003) estimated apparent annual survival rates of Mexican spotted owls over a 10-year period on two study areas in Arizona and New Mexico, using mark-resighting methodology. Estimates of adult survival were comparable to estimates derived using similar methods for northern (Anthony et al. 2006) and California (Franklin et al. 2004) spotted owls, and to estimates from radio-marked owls (Table B.6). In contrast, estimates from four other populations in New Mexico were slightly lower (Table B.6, Stacey and Peery unpubl. data). Mark-resighting estimates of survival may be biased low if owls in these age classes emigrate from study areas (Zimmerman et al. 2007). Such emigration does not appear to be common, but Gutiérrez et al. (1996) reported one long-distance movement that may represent an example of adult dispersal, Arsenault et al. (1997) noted apparent subadult dispersal in Mexican spotted owls, and Duncan and Speich (2002) reported instances of "temporary and permanent emigration in response to fire altered habitat." Survival rates based on monitoring of radio-marked owls also could be underestimated if radios affect survival. Evidence on whether or not radios or their attachment affect survival of spotted owls is equivocal (e.g., Paton et al. 1991, Foster et al. 1992).

Estimates of juvenile survival rates are considerably lower and more variable than estimates for adult survival (Table B.6). Mark-recapture estimates of juvenile survival could be biased low if 1) substantial numbers of owls emigrate from the study area, or 2) a lag of several years occurs before marked juveniles reappear as territory holders, at which point they are first detected for recapture (White et al. 1995). As in all spotted owl subspecies, juvenile Mexican spotted owls have a high dispersal capability (Arsenault et al. 1997, Ganey et al. 1998, Willey and van Riper 2000). Consequently, a substantial portion of marked juveniles may emigrate from the study

Table B.6. Summary of estimates of annual survival for spotted owls.

Subspecies	Age-class[1]	Sex[2]	Area	Populations studied[3]	Methodology[4]	Survival estimate Mean	SE	Source[5]
Mexican	A, SA	B	Arizona	1	M-R	0.856	0.199	1
Mexican	A, SA	B	New Mexico	1	M-R	0.859	0.041	1
Mexican	A, SA	F	Rangewide	Several	RT	0.806	0.084	2
Mexican	A, SA	M	Rangewide	Several	RT	0.799	0.062	2
Mexican	A	B	New Mexico	4	M-R	0.769	0.037	3
Northern	A	B	Rangewide	14	M-R	0.750-0.886[6]	0.010-0.026[6]	4
Northern	SA1	B	Rangewide	14	M-R	0.415-0.860	0.010-0.111	4
Northern	SA2	B	Rangewide	14	M-R	0.626-0.886	0.009-0.079	4
California	A, SA	B	Rangewide	5	M-R	0.831	0.012	5
Mexican	J	B	Arizona	1	M-R	0.230	0.064	1
Mexican	J	B	New Mexico	1	M-R	0.080	0.028	1
Mexican	J	B	Arizona	1	RT	0.205-0.287[7]	0.028	6
Mexican	J	B	Utah	1	RT	0.096	No estimate	7
Northern	J	B	Rangewide	11	M-R	0.258	0.036	8
California	J	B	Southern	1	M-R	0.296	0.055	9

[1] Age classes: A = adult, SA = subadult, and J = juvenile. A, SA indicates that survival was estimated for adult and subadult owls combined.
[2] F = female, M = male, B= survival estimated for both sexes combined.
[3] Number of distinct study areas covered by estimate.
[4] Methodology underlying survival estimate. M-R = mark – recapture; RT = radio-telemetry.
[5] Source: 1 = Gutiérrez et al. (2003); 2 = White et al. (1995:Table 2.4); 3 = Stacey and Peery (unpubl. data); 4 = Anthony et al. (2006: Table 13); 5 = Franklin et al. (2004); 6 = Ganey et al. (1998); 7 = calculated from data in Willey and van Riper (2000); 8 = Burnham et al. (1996); 9 = LaHaye (pers. comm. in Noon et al. [1992:Table 4; San Bernardino Mountains]).
[6] Range across populations studied.
[7] Estimate differed depending on whether or not owls that were suspected to be dead were included as fatality events or censored.

areas. This may explain why the apparent survival of juveniles was lower for the smaller New Mexico study area than for the larger Arizona study. Concerning the second point, available data (see Dispersal, below**)** indicates that most Mexican spotted owls settle in the first three years of life, suggesting that a bias in survival estimates caused by time lag in detection may not be large.

Estimates from radio-telemetry studies also suggested low juvenile survival rates (Ganey et al. 1998, Willey and van Riper 2000). Biases in radio-telemetry estimates of juvenile survival can result if radios significantly affect their survival, or if these studies were conducted during time periods with lower than usual survival (e.g., a period of low prey availability). As noted above, evidence for effects of radios on survival of spotted owls is equivocal (Paton et al. 1991, Foster et al. 1992). However, at least one of the radio-telemetry studies (Ganey et al. 1998) may have occurred during a period generally unfavorable for owls. Seamans et al. (1999) estimated fecundity and survival rates of owls over a seven-year period in two study areas, one of which overlapped with the study area in Ganey et al. (1998). The two years in which radio-marked juveniles were studied (1994 and 1995; Ganey et al. 1998) also had the lowest fecundity estimates within that seven-year period in both study areas (Seamans et al. 1999: Fig. 2), and two of the three lowest estimates of adult survival (Seamans et al. 1999: Fig. 3). Similarly, the two years of the juvenile dispersal study conducted by Ganey et al. (1998) corresponded with the lowest recruitment rates estimated by Gutiérrez et al. (2003: Fig. 7a) in their Arizona study area. Collectively, these findings suggest a generally unfavorable period for owls. As a result, estimated survival rates may not be representative of survival rates during more favorable periods.

In summary, considerable uncertainty exists concerning survival rates of Mexican spotted owls, and especially concerning juvenile survival rates. Despite that uncertainty, the available estimates are useful as qualitative descriptors of the life-history characteristics of Mexican spotted owls. Accordingly, Mexican spotted owls exhibit high adult and relatively low juvenile survival. In this respect, point estimates of Mexican spotted owl survival probabilities appear similar to those of both northern (Burnham et al. 1996, Anthony et al. 2006) and California (Franklin et al. 2004, LaHaye et al. 2004) spotted owls. However, it is important to note that the temporal variability of survival rates of Mexican spotted owls appears greater than that of the other subspecies (Gutiérrez et al. 2003).

E. Environmental Variation and Vital Rates

Conservation and recovery of wildlife populations requires information about the factors that influence rates of population growth. This entails knowledge of environmental and human-induced agents that influence the owl's reproduction, survival, and ultimately abundance over time. Several studies on northern and California spotted owl populations have examined sources of variation in associated vital rates (i.e., survival and reproduction; Franklin et al. 2000, 2004, Olson et al. 2004, Blakesley et al. 2005, Dugger et al. 2005, Anthony et al. 2006, Glenn et al. 2011). However, only one study of two Mexican spotted owl populations has been conducted long enough (11 years) to examine rigorously sources of variation in both survival and reproduction (see Seamans et al. 2002, Gutiérrez et al. 2003). Another study (Ward 2001) was only able to examine influences of environmental variation on reproductive rates, and this study

also was of shorter duration (six years). Here we briefly summarize some pertinent patterns in variation of vital rates, then discuss some specific environmental factors that may cause change in survival and reproduction of Mexican spotted owls.

a. Types of Variation in Vital Rates.—Spotted owls show considerable temporal and spatial variation in vital rates (Franklin et al. 2000, 2004, Ward 2001, Gutiérrez et al. 2003, Anthony et al. 2006, Glenn et al. 2011). Franklin et al. (2000) found that climate explained all of the temporal process variation (variation due to ecological processes rather than variation due to sampling) in vital rates of a northern spotted owl population, and habitat conditions explained most of the spatial process variation. This is intuitively logical: forest habitat conditions vary considerably over space but little over short time intervals such as annual breeding cycles of owls. Thus, we would expect habitat conditions to be linked to spatial variability in survival and fecundity, but not to short-term fluctuations in these vital rates. We also should expect that the magnitude of effects from various sources on spotted owl vital rates will differ among regions because environmental factors that can influence those rates also will vary (for example, see Ward and Block 1995, LaHaye et al. 2004).

Temporal and spatial variation in vital rates of two Mexican spotted owl populations studied by Gutiérrez et al. (2003) was roughly 2 to 5 times greater than in the population studied by Franklin et al. (2000). In addition, Gutiérrez et al. (2003) found that temporal variability in fecundity was far greater than temporal variability in survival for these populations.

b. Effects of Weather on Vital Rates.— Both survival and reproduction of Mexican spotted owls can be influenced by weather. However, with the exception of the direct influence of overheating or chilling of young, most effects will be manifested through the interaction between energetic demands and food supply. Both thermoregulation and prey availability can be influenced by physical environmental variables determined by regional climate, such as temperature and precipitation.

Seamans et al. (2002) modeled the influence of climate-related factors on temporal variation in vital rates, and Gutiérrez et al. (2003) expanded this effort to include models of spatial variation. Both vital rates appeared to be influenced by precipitation, but the nature of the relationship varied between study areas. In Arizona, a moisture index (the Palmer Z index) explained much of the temporal variation in both owl survival and fecundity. In New Mexico, the best approximating model included rainfall from the previous monsoon season (Jul – Sep) but explained little of the temporal process variation in fecundity and none of the variation in survival. Survival varied more spatially than temporally in these populations (Gutiérrez et al. 2003). The examined habitat covariates explained little of the spatial variation in owl vital rates for either study area.

Ward (2001) examined factors that might influence reproductive potential (number of young produced in a territory relative to the maximum number of young that could be produced) of Mexican spotted owls in southern New Mexico. Several *a priori* models were developed and compared. These models included different combinations of covariates describing climate, cover type, and available prey biomass over a six-year period. He found that: 1) models including factors describing climate or prey availability were better predictors of owl reproductive

potential than models that included only habitat variables; 2) models that included factors related to both weather and prey availability were better predictors than models that included only weather or prey availability; and, 3) models that included availability of prey aggregated among species were better predictors than models that included availability of single prey species. However, these models explained relatively little of the observed variation in owl reproductive potential and the strongest correlation observed was between a different measure of reproduction (reproductive output) and available biomass of mice and voles ($r = 0.77$, $P = 0.07$, $n = 6$ yrs).

Lavier (2006) studied the influence of temporal variation on aspects of site occupancy by Mexican spotted owls in the Sacramento Mountains, New Mexico. Winter precipitation was negatively correlated with site extirpation, whereas spring precipitation was positively correlated. Both monsoon and winter precipitation were positively correlated with site colonization, while spring precipitation was negatively correlated with colonization. Lavier (2006) suggested that spring, winter, and monsoon precipitation may influence probabilities of site extirpation or colonization through their effects on Mexican spotted owl survival and reproduction, respectively, and concluded that variability in weather had a greater influence on site occupancy than spatially related habitat effects (see next section). As noted earlier (see Diet and Prey Selection, above), weather also appeared to influence owl territory occupancy and productivity in the canyonlands of southern Utah indirectly by influencing prey abundance and diversity (Willey and Willey 2010).

c. Effects of Habitat on Vital Rates.— Expanding on their study of temporal variation and Mexican spotted owl vital rates, Gutiérrez et al. (2003) included models of spatial variation in habitat. They found that survival varied more spatially than temporally in two populations studied (one in northern Arizona and the other in west-central New Mexico), but the habitat covariates examined explained little of the spatial variation in owl vital rates for either study area.

Lavier (2006) evaluated amounts and spatial patterns of forested patches in areas occupied by Mexican spotted owls in the Sacramento Mountains, New Mexico. Few spatially explicit habitat variables were significantly correlated with rates of site extirpation or colonization or the probability of site occupancy. Amounts and spatial arrangement of landscape habitat features showed no apparent influence on site extirpation probabilities, but amount of interior forest and the density of interior forest patches within a site had a positive effect on site colonization, and amount of meadow habitat had a negative effect. In general, habitat variables appeared to influence site occupancy less than weather variables (see preceding section).

d. Effects of Prey on Vital Rates.— Several studies have shown that successfully breeding northern and California spotted owls consume more large prey (e.g., woodrats) than pairs that do not breed successfully (Barrows 1987, Laymon 1988, Thrailkill and Bias 1989, White 1996, Smith et al. 1999). However, this relationship did not hold in all studies of northern spotted owls, even in areas where this owl is known to select for larger prey like dusky-footed woodrats (Ward et al. 1998, Forsman et al. 2001). Similarly, successfully breeding Mexican spotted owls in northern Arizona and west-central New Mexico did not consume larger prey than non-breeding pairs (Seamans and Gutiérrez 1999). These inconsistent results may reflect the fact that diets are quantified from pellets gathered opportunistically, which may not adequately represent

the diet of individual pairs of owls, or they may represent true regional and temporal variation in the owl's food habits and associations with reproduction.

Reproduction and survival of Mexican spotted owls are more likely a function of total prey biomass consumed by these owls than of the biomass of any single prey species (Ward and Block 1995, Ward 2001). Most predators are opportunistic and will shift to taking alternative prey when preferred prey species are not as available. In Ward's (2001) study in the Sacramento Mountains of southern New Mexico, Mexican spotted owls appeared to prefer Mexican woodrats, but the amount of woodrats consumed was not correlated with owl reproduction. Rather, owl reproductive output across six years of study was correlated with the combined biomass of two species of Peromyscid mice and two species of voles in approximated home ranges of the owl. Ward (2001) suggested that woodrats may be selected for by Mexican spotted owls because they provide a consistent staple for survival, and individual owls must survive before they can reproduce. Reproduction in this population, however, occurred when mice and voles were more abundant. Thus, in this landscape, overall prey biomass exerted more influence on the owls' reproduction than did the abundance of any single prey species. Seamans and Gutiérrez (1999) reached a similar conclusion for Mexican spotted owls, and Rosenberg et al. (2003) cautioned that simple prey-relationship models were unlikely to account for the highly synchronous temporal patterns observed in reproduction by northern spotted owls.

When comparing multiple spotted owl populations across the species range, Ward (2001) also demonstrated that the proportion of woodrat biomass in the diet was inversely related to temporal variation in reproductive output by spotted owls. Mexican spotted owls in the Sacramento Mountains, New Mexico, consumed the lowest proportion of woodrat biomass and showed the highest variation in young produced over time (Ward 2001: Fig. 4.7). Two other populations of Mexican spotted owls, one in northern Arizona and one in west-central New Mexico (Seamans et al. 1999), consumed moderate amounts of woodrat biomass. These populations showed less variation in reproductive output than the population in the Sacramento Mountains, but higher variation than recorded for northern spotted owls dwelling in northwestern California (Franklin et al. 2000). Based on these results, Ward (2001) suggested that management aimed at increasing woodrat abundance might reduce temporal variation in owl reproduction.

As noted earlier (see Diet and Prey Selection), prey abundance and diversity, as mediated by precipitation, also appeared to influence owl territory occupancy and productivity in the canyonlands of southern Utah indirectly, presumably by influencing food availability (Willey and Willey 2010).

Despite concerted efforts to understand the influence of environmental variation on owl vital rates, considerable uncertainty remains. Limited or inconsistent evidence indicates that temporal variation in owl vital rates is influenced directly by climate, especially precipitation, and by prey availability. Because estimated vital rates appeared responsive to precipitation several months prior to the estimation period, Gutiérrez et al. (2003) speculated that precipitation influences vital rates through an indirect mechanism that might involve precipitation influencing primary productivity, prey population dynamics, and ultimately owl vital rates, and work in southern Utah appeared to support this hypothesis (Willey and Willey 2010). However, when examined over the short-term and in a different study area and owl population (Ward 2001), these

pathways were not supported by empirical data. That is, each of several common prey species showed different associations with precipitation, temperature, and abundance of different plant species, and they demonstrated asynchronous population dynamics. Key interactions among climate, microhabitat condition, and food will influence energy and water balance of individual members of spotted owl populations but these more complex interactions have not been quantified due to lack of long-term or experimental study. We still have much to learn about how these more complex interactions are related to vital rates of Mexican spotted owls.

F. Fatality Factors

Several fatality factors (discussed below) have been identified as potentially important with respect to the Mexican spotted owl. Remains of a number of radio-marked owls have been found following death and examined by both field biologists and laboratory personnel, but most owls simply disappear. Further, cause of death often is difficult to impossible to determine even for owls that are found. Consequently, we know little about the extent or relative importance of factors that cause fatality.

Most known fatalities of territorial adult and subadult owls occurred from November through February (Ganey and Block 2005a), suggesting that most fatality occurs during the winter months for territorial owls. In contrast, fatality was observed in juvenile owls even before they left their natal areas (late September through October). Mortality rates were high during the early dispersal period (October and November), and fatalities were observed throughout the year (Ganey et al. 1998, Willey and van Riper 2000).

Some of the factors discussed below can influence owl populations by impacting reproduction in Mexican spotted owls as well as by causing fatality directly. To reproduce, individuals must not only survive to a breeding period, but also have sufficient energy resources to produce and rear offspring. Thus, owl abundance can be influenced not only by factors determining the number of owls surviving to breed, but also by factors determining how many of those owls obtain sufficient energetic resources to allow for reproduction.

a. Predation.—Predation may be a common fatality factor of Mexican spotted owls, accounting for at least five of 11 deaths documented among radio-marked adult and subadult Mexican spotted owls (Table B.7), and 14 of 29 documented fatalities of radio-marked juveniles (Ganey et al. 1998: Table 1 and Willey and van Riper 2000: Table 1). Predation may account for more deaths than recorded, because cause of death is often unknown. The specific predator is typically unknown. Procyonid mammals were observed attempting to raid cliff nests occupied by Mexican spotted owls in southern Arizona (Russell Duncan, Southwestern Field Biologists, pers. comm.), suggesting that they may prey on Mexican spotted owls. However, avian predation is suspected to be the main form of predation. Potential avian predators of Mexican spotted owls include great horned owls, northern goshawks (*Accipiter gentilis*), red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), and barred owls (where they are sympatric; Leskiw and Gutiérrez 1998). Some of these predators occupy the same general habitats as the Mexican spotted owl, but there is little direct evidence that they prey on Mexican spotted owls (Gutiérrez et al. 1995). Ganey (1988) reported one instance of apparent great horned owl predation on an adult Mexican spotted owl, and Richard Reynolds (RMRS, pers.

comm.) observed a golden eagle preying on a Mexican spotted owl. Results from radio-marked Mexican spotted owls indicate that all age classes are preyed upon (Ganey 1988, Ganey et al. 1998, 2005, Willey 1998a, Willey and van Riper 2000).

b. Starvation.—Starvation has not been observed in many deaths of adult and subadult owls (Table B.7), and generally occurred in mid-winter (J. L. Ganey, RMRS, unpubl. data). In contrast, starvation apparently accounted for 15 of 29 documented deaths of radio-marked juveniles, and occurred throughout the dispersal period (Ganey et al. 1998:Table 1; Willey and van Riper 2000:Table 1). Juvenile spotted owls may be more vulnerable to starvation than adults because of their poor hunting skills (Gutiérrez et al. 1985, Miller 1989, Ganey et al. 1998, Willey and van Riper 2000). Starvation also could result from low abundance or availability of prey, which could affect both adults and juveniles, and which is most likely to occur from late fall through winter when prey resources generally are reduced in abundance (Ward 2001, Block et al. 2005: Fig. 1). In addition, starvation may predispose young or even adults to predation (see Ganey et al. 2005). When starvation occurs in resident adults due to low prey populations that are regionally synchronous, this form of fatality can influence a number of owls at one time. When low survival is combined with lack of reproduction, population decrease can be rapid. There is evidence that this occurs in some Mexican spotted owl populations (Seamans et al. 1999, Ward 2001).

Table B.7. Kaplan-Meier estimates of annual survival of adult or subadult radio-marked Mexican spotted owls in different study areas.

		Owl-	Annual survival		Fatality factors[1]		
Study area(s)[2]	Owls	years[3]	Mean	SE	P	S	U
SFP, WM, WC	8	12	0.88	0.12	1	0	0
Bar-M	13	26	0.79	0.10	0	2	2
SM-mesic	6	20	0.87	0.09	2	0	0
SM-xeric	7	13	0.62	0.14	2	1	0

[1] P = suspected predation, S = starvation, U = unknown cause of death.
[2] Study areas: SFP = San Francisco Peaks; WM = White Mountains; WC = Walnut Canyon (all in Arizona, UGM EMU, see Ganey [1988]); Bar-M = Bar-M Canyon, Arizona (UGM EMU, see Ganey et al. 1999); SM-mesic and SM-xeric refers to mesic and xeric study areas within the Sacramento Mountains, New Mexico, respectively (BRE EMU, see Ganey et al. [2005]). Bar-M Canyon area was dominated by ponderosa pine-Gambel oak forest. The Sacramento Mountains – xeric study area also was dominated by dry forest types, whereas all other study areas (SFP, WM, SM-mesic, WC) either were dominated by or contained significant amounts of mixed-conifer forest.
[3] Number of owl years = (number of owls radio-marked x number of years marked owls were monitored). This figure is approximate.

c. Accidents.—Accidents may be another fatality factor. For example, in some portions of their range, Mexican spotted owls have been viewed perched on the ground or on fence posts adjacent to roads (J. P. Ward, FWS, pers. comm.) and there are documented cases of Mexican spotted owls being hit by cars (Roger Skaggs, Glenwood, New Mexico, pers. comm.; Russell Duncan, Southwestern Field Biologists, pers. comm.; J. L Ganey, RMRS, unpubl. data; S. Hedwall, FWS, upubl. data). The type of roads at which fatalities of spotted owls occurred ranged from unpaved forest roads to paved highways. Owls flying at night also might collide with power lines, tree branches, or other obstacles. This might be particularly true for birds migrating or dispersing through unfamiliar terrain (Martin 1986). Little information is available either on how frequently this might occur, or when it occurs. Again, starvation or at least hunger could predispose owls to accidents if it drives them to hunt along roadsides, in unfamiliar areas, or in weakened condition.

d. Disease and Parasites.—Little is known about how disease and parasites affect spotted owls. A northern spotted owl found dead was diagnosed with an infection by a relapsing fever-like *Borrelia* species (Thomas et al. 2002). The mechanism of exposure was unknown. The principal vectors known to transmit similar diseases are soft-bodied ticks, making transmission by nest-dwelling parasites a possibility. However, direct transmission from prey may be more likely, as small rodents, which constitute the primary food of spotted owls, serve as reservoirs for relapsing fevers (Thomas et al. 2002). Until more is known about the means of transmission, the potential importance of this disease with respect to spotted owls is unknown.

One disease of particular concern to birds in general is West Nile virus (WNV). This virus was first isolated in Africa and first appeared in the U.S. in 1999, in New York (see reviews in Blakesley et al. 2004, McLean 2006). It spread rapidly across the country and has now reached the range of the Mexican spotted owl. The virus is commonly spread by transmission between mosquito vectors and bird reservoir hosts. However, birds can also become infected by means other than arthropod transmission (Marra et al. 2004). Komar et al. (2003) reported that ingestion of WNV in aqueous solution resulted in infection in several bird species, including great horned owls. It is not known whether ingestion of infected prey by raptors has resulted in bird fatality, but the risk exists (Marra et al. 2004). Finally, contact transmission has been documented in the laboratory in caged birds (McLean et al. 2001; Komar et al. 2003), perhaps from such behaviors as mutual preening and beak-to-beak contact.

Avian fatality from WNV has been extensive in North America (Komar et al. 2003). Natural fatal infections were detected between 1999 and 2002 in over 28,000 bird carcasses representing 198 species, including a captive spotted owl (subspecies not identified; Center for Disease Control unpubl. data). However, we are unaware of any records of wild spotted owls being infected with WNV. Hull et al. (2010) tested 209 California spotted owls in the Sierra Nevada of California between 2004 and 2007 and detected no antibodies in those specimens, despite numerous recorded infection incidences in other avian species in the region during that time. Hull et al. (2010) concluded that WNV infection likely was absent in the area's spotted owls, but they also noted that an absence of detections could indicate that spotted owls exposed to WNV do not survive long enough to develop a detectable immune response.

We are unaware of any incidence of WNV in Mexican spotted owls, or of any program (systematic or otherwise) of surveillance for this disease in the subspecies. Nonetheless, the potential impact of the disease on threatened species and those of ecological importance is of great concern (Joyner et al. 2004). The scientific panel that reviewed the status of and threats to the northern spotted owl was unanimous in regarding WNV as a potential future threat (Blakesley et al. 2004).

Thus, the impact of WNV on Mexican spotted owls is difficult to predict. In general, we know little about the abundance and behavior of the relevant vectors in areas occupied by Mexican spotted owls, making it difficult to predict infection rates. We also do not know how many of the owls infected by WNV will die or suffer reduced viability, or whether or not owls will develop some level of immunity to the disease following initial exposure. Thus, all we can say with certainty at this time is that WNV has arrived and has the potential to significantly impact population viability of Mexican spotted owls.

Relative to parasites, Young et al. (1993) found Hippoboscid flies on 17% of 382 live northern spotted owls examined for parasites, and Hunter et al. (1994) found Hippoboscid fly larvae in the ears of six of 18 live Mexican spotted owls examined. Hunter et al. (1994) also found a larval mite and lice on two of 28 museum specimens of Mexican spotted owls examined, and some of the live owls examined also had lice. Neither study reached firm conclusions concerning fatality and ectoparasites in spotted owls, but Hunter et al. (1994) suggested that larval infestations in their ears could affect the owls' hearing. Because hearing is important for foraging at night, such infestations could eventually affect the birds' ability to hunt effectively. Further, Young et al. (1993) noted that hippoboscid flies are vectors for several hematazoan (blood-borne) parasites in birds.

Infection rates of such blood-borne parasites appear to be high in spotted owls. For example, Gutiérrez (1989) found an infection rate of 100 percent in a survey of blood parasites in all three subspecies of spotted owls. More recently, a survey in northern and California spotted owls found infection rates of 52 and 79% respectively (Ishak et al. 2008). Infection rates of spotted owls were far greater than rates in sympatric barred owls (15%), and spotted owls were far more likely than barred owls to harbor multi-species infections (Ishak et al. 2008). These high infection rates and the numbers of spotted owls with multiple infections support the hypothesis that spotted owls have weaker immune systems than sympatric barred owls, and this may provide barred owls with a competitive advantage (Ishak et al. 2008).

The effects of both parasites and disease likely vary depending on the condition of individual owls. Thus, infections that are normally nonpathogenic can assume greater importance in owls that are stressed or malnourished (Young et al. 1993). Therefore, both disease and parasites can interact with other factors such as climate and prey availability, and these interactions likely determine the ultimate effect of disease and parasite infections. Similarly, as noted above, disease and parasite infections could influence the outcome of, for example, interactions with competitors.

G. Other Ecological Interactions

a. Interspecific Competition.—Several other species of raptors and owls occur within the range of the Mexican spotted owl. Raptors may compete with Mexican spotted owls for resources such as nest sites, but tend to prey primarily on diurnally active prey species. In contrast, most owls focus on the kinds of nocturnally active prey that dominate the diets of Mexican spotted owls. Thus, competition between owl species is suspected to be more important than competition between owls and raptors.

In general, we know little about potential competitive relationships among sympatric owl species within the range of the Mexican spotted owl. Logically, the two species most likely to compete directly with Mexican spotted owls are the great horned owl and the barred owl, based on their relative size, natural history, and, in the case of the barred owl, genetic similarity. Throughout much of the range of the Mexican spotted owl, the most likely competitor is the great horned owl (USDI FWS 1995). This owl is larger than the Mexican spotted owl, is sympatric with Mexican spotted owls throughout their range, and both owls are active at night, suggesting that they could compete for nocturnally active prey (Gutiérrez et al. 1995, Houston et al. 1998). The great horned owl and the barred owl may prey on spotted owls (Forsman et al. 1984, Ganey 1988:185, Gutiérrez et al. 1995), and spotted owls in turn may prey on other smaller owls (e.g., Ganey 1988: Table 20).

Despite this potential for competition and possible predation by great horned owls on Mexican spotted owls, little is known about interspecific interactions between the two. Some evidence suggests that Mexican spotted owls may avoid areas occupied by great horned owls (e.g., interference competition). For example, Phillips et al. (1964) reported that great horned owls colonized an area previously occupied by Mexican spotted owls following a fire that opened up the forest canopy. Spotted owls were not heard in this area in subsequent years. Similarly, Johnson and Johnson (1985) reported that once great horned owls moved into areas previously occupied by Mexican spotted owls, they seldom heard Mexican spotted owls in those areas.

In contrast, Ganey et al. (1997) reported considerable spatial overlap among home ranges of sympatric, radio-marked spotted and great horned owls in Arizona. On average, Mexican spotted owls shared 51.0 ± 24.3% (*SE*) of their breeding-season home range and 74.1 ± 4.8% of their non-breeding-season home range with great horned owls (n = 6 Mexican spotted owl and 3 great horned owl home ranges). The figures for proportions of great horned owl home ranges shared with Mexican spotted owls were similar (57.4 ± 12.2 and 70.5 ± 12.3% for breeding- and non-breeding-season home ranges, respectively; Ganey et al. 1997: Table 2). Both species of owls sometimes foraged in the same forest stands. These stands were not necessarily used at the same time, however, and Mexican spotted owls also foraged in many stands that great horned owls did not appear to forage in (Ganey et al. 1997: Table 3). Home-range composition, in terms of cover types and canopy-cover classes, did not differ between species in either the breeding or non-breeding season (Ganey et al. 1997: Table 4). In contrast, use of cover types and canopy-cover classes within the home range differed between species in at least some combinations of season and activity considered (Ganey et al. 1997: Table 4). Differences were typically greatest with respect to roosting habitat used during the breeding season. For example, >90% of roosting locations for Mexican spotted owls during the breeding-season were in forests with canopy cover

>40%, whereas >64% of great horned owl roosting locations were in forests with canopy cover <40% (Ganey et al. 1997: Table 5). Great horned owls also foraged primarily in forests with <40% canopy cover (78 and 71% of foraging locations during the breeding and non-breeding seasons, respectively). In contrast, >50% of Mexican spotted owl foraging locations occurred in forests with canopy cover >40% during both seasons. Spotted owls roosted primarily in pine-oak forest during both seasons, sometimes roosted in ponderosa pine forest, and did not roost in meadow cover types (Ganey et al. 1997: Table 6). In contrast, great horned owls frequently roosted in both pine-oak and ponderosa pine forest, and sometimes roosted in isolated clumps of trees within meadow cover types. Stands used by foraging Mexican spotted owls contained greater volumes of logs and greater shrub cover than stands used by great horned owls during both seasons. During the non-breeding season, stands used by foraging Mexican spotted owls also had greater canopy cover, whereas stands used by great horned owls had greater forb cover (Ganey et al. 1997). These observations are consistent with the hypothesis that Mexican spotted owls may be avoiding competition with great horned owls (and potentially predation) by partitioning use of habitat resources over space and through time. Similar patterns have been observed for northern spotted owls living in sympatry with barred owls in conifer forests of Washington (Buchanan et al. 2004, Hamer et al. 2007).

Avoidance of competition by partitioning food was less apparent. Diet overlap was considerable between Mexican spotted and great horned owls in the same study area where habitat partitioning was observed (Ganey and Block 2005b). Both species preyed primarily on nocturnally active small mammals, although both also ate birds and insects, and great horned owls occasionally preyed on lizards. Mammals comprised 63 and 62% of the diets of spotted and great horned owls, respectively, based on total numbers of identified prey items in regurgitated pellets (n = 1125 and 94 prey items for Mexican spotted owls and great horned owls, respectively). In terms of prey biomass, mammals comprised 94 and 95% of the diets of spotted and great horned owls, respectively. Mean prey mass averaged 40.1 ± 1.8 g for Mexican spotted owls and 47. 0 ± 7.4 g for great horned owls when all prey were included. For all non-insect prey (n = 746 and 63 items for spotted and great horned owls, respectively), mean prey mass was 60.0 ± 2.4 g for Mexican spotted owls and 69.7 ± 9.8 g for great horned owls. Dietary overlap, calculated using Pianka's (1973) index, was 0.95. This index ranges from zero (no overlap) to 1 (complete overlap). Observed overlap in diet composition between species was greater than expected based on null models of diet overlap (null models generated using program ECOSIM; Gotelli and Entsminger 2001).

Thus, in this study area, home ranges of these species overlapped considerably. There also was overlap in areas used for foraging, as well as in the size and type of prey taken. These results suggest a potential for both exploitation and interference competition for food resources, which are assumed to be limiting in some years (Verner et al. 1992, Ward 2001). There also were strong differences in habitat-use patterns between species, however. These differences suggest that these species may be able to partition habitats in areas of sympatry, with Mexican spotted owls primarily using forests with canopy cover >40%, and great horned owls primarily using forests with canopy cover <40%. Whether or not these patterns of habitat use are influenced by the presence of the other owl species is unknown. The observed habitat-use patterns for both species were generally consistent with known patterns from other studies (reviewed in Ganey and Dick 1995, Gutiérrez et al. 1995, Houston et al. 1998), as well as with morphological and

behavioral characteristics of both species (Ganey et al. 1997). This seems to suggest that habitat use was not strongly influenced by the presence of the potential competitor. We observed numerous instances of apparently agonistic calling encounters between radio-marked owls, however (J. L. Ganey, RMRS, pers. obs.; see also Ganey 1990). This suggests the possibility that interference competition, where individuals physically interfere with each other, may occur, and may partially explain some of the apparent habitat partitioning observed. Regardless of the underlying mechanisms, at present these owls appear able to partition available forest habitats and likely take similar prey in different areas, minimizing direct competition for resources. This interaction could be altered if extensive forest management occurs and reduces the area of forests with canopy cover >40%. This change could benefit the great horned owl and reduce habitat quality for the Mexican spotted owl (Ganey et al. 1997).

We also know little about possible competitive interactions between barred owls and Mexican spotted owls. The barred owl is considered a significant threat to northern spotted owls, however (Kelly et al. 2003, Gutiérrez et al. 2004, 2007, Kelly and Forsman 2004, Levy 2004, Olson et al. 2005, Buchanan et al. 2007, Kroll et al. 2010). Overlap between northern spotted owls and barred owls appears to be high in both habitat use (Herter and Hicks 2000, Kelly et al. 2003, Pearson and Livezey 2003, Buchanan et al. 2004, Olson et al. 2005, Hamer et al. 2007, Bailey et al. 2009, Singleton et al. 2010) and diet (Hamer et al. 2001). In addition, these owls are known to hybridize (Hamer et al. 1994, Haig et al. 2004b, Kelly and Forsman 2004, Seamans et al. 2004), suggesting that competition for mates also occurs. In many areas, numbers of barred owls are increasing, whereas numbers of spotted owls are decreasing, suggesting that the larger and more aggressive barred owls are competitively dominant and are displacing spotted owls (Kelly et al. 2003, Gutiérrez et al. 2004, 2007, Kroll et al. 2010; but see also Crozier et al. 2006, Livezey and Fleming 2007, Van Lanen et al. 2011). A recent study also suggested that barred owls may gain a competitive advantage over sympatric spotted owls due to lower infection rates with blood-borne parasites (Ishak et al. 2008; see Diseases and Parasites, above). Records of possible predation of spotted owls by barred owls also exist (Leskiw and Gutiérrez 1998).

The barred owl may be sympatric with Mexican spotted owls in Mexico (Williams and Skaggs 1993, Howell and Webb 1995, Holt et al. 1999), but little is known about patterns of either distribution or habitat use of either owl in the apparent zone of sympatry (Williams and Skaggs 1993, Enriquez-Rocha et al. 1993). Thus, there may be potential for interspecific competition to occur in Mexico, but the extent of such competition (if any) is unknown.

Barred owls historically have not co-occurred with Mexican spotted owls within the U.S., with the possible exception of southern Texas. Both species have been reported occasionally from the vicinity of Big Bend National Park (Wauer 1996). We do not know if either or both species are regular residents in that area, however. There also are recent confirmed records of barred owls in northern and eastern New Mexico (Williams 2005, cited in Cartron 2010, H. Walker, NMGFD, pers. comm.). Whether such records indicate a range expansion by barred owls or simply vagrant individuals is unknown. Thus, there does not appear to be much opportunity for competition between barred and Mexican spotted owls in the U.S. at present, but that could change if the barred owl expands into the range of the Mexican spotted owl.

In summary, we know relatively little about competitive relationships between Mexican spotted owls and other owls. Competition for food resources also may extend to medium-sized and small carnivores that consume large amounts of nocturnal rodents and that hunt in habitats similar to Mexican spotted owls. This would include species like bobcat (*Lynx rufus*), gray-fox (*Urocyon cinereoargenteus*), ring-tailed cat (*Bassariscus astutus*), and coyote (*Canis latrans*). Better information clearly is needed to assess the potential occurrence and importance of such competition, as well as to understand the potential influence that forest management might have on competitive interactions.

b. Human Disturbance.—Although a variety of human-caused disturbances can affect birds of prey and other wildlife (Knight and Gutzwiller 1995), we know relatively little about the effects of human disturbance on Mexican spotted owls. Delaney et al. (1999b) and Johnson and Reynolds (2002) studied the response of Mexican spotted owls to overflights by helicopters and fixed-wing aircraft, respectively. Both studies suggested that owls were fairly resilient to short-duration disturbance caused by overflights. Delaney et al. (1999b) also developed an owl-weighted frequency curve to simulate hearing sensitivity of owls in various parts of the sound-frequency spectrum and used this curve to evaluate relative disturbance levels caused by chainsaws. Mexican spotted owls were more sensitive to disturbance by chainsaws than by helicopter overflights at comparable distances, and chainsaw operation caused most owls to flush from their perches when chainsaws were operated <60 m (197 ft) from roosting Mexican spotted owls. Owl response decreased with increasing distance to noise source for both chainsaw operation and helicopter overflights, and Delaney et al. (1999b) suggested that a buffer zone of 105 m (344 ft) would minimize impacts of helicopter overflights on Mexican spotted owls.

In a later study, Delaney and Grubb (2004) quantified relative, owl-weighted noise levels caused by road-maintenance equipment (rock crusher, loader, bulldozer/roller, and grader) in Mexican spotted owl habitat. They found consistent differences in noise levels among types of equipment, microphone positions (in trees versus on the ground), distance from noise source, and habitat (forest versus meadow). Rock crushers were louder than other equipment, sound levels were greater in trees than on the ground at all distances, sound levels decreased with distance, and sound levels were greater in meadows than in forests at comparable distances. Delaney and Grubb (2004) concluded that owls were capable of hearing all sound sources tested at distances of at least 400 m. Owl response to these noise sources was not evaluated in this study. In a study on northern spotted owls, however, Hayward et al. (2011) found that owls close to noisy roads fledged significantly fewer young than owls close to roads. They concluded that routine traffic exposure may decrease reproductive success of northern spotted owls over time.

Swarthout and Steidl (2001, 2003) experimentally evaluated the effects of hikers on Mexican spotted owls in canyonlands terrain. They quantified both flush responses and activity budgets of owls exposed to hikers. Owls exposed to hikers sometimes flushed and spent more time vocalizing and less time handling prey and performing maintenance activities than owls not exposed to hikers. In general, owl response level was related to both perch height and distance to the hiker. Swarthout and Steidl (2003) concluded that cumulative disturbance caused by recreational hiking near nests potentially could be detrimental to owls, but likely would be detrimental only where owls occupied canyons receiving use by ≥50 hikers per day. Swarthout and Steidl (2001) concluded that placing a 55-m (180-ft) buffer zone around known owl roosting

sites would eliminate most flush responses. However, a buffer of this size also would restrict hiker access to 80% of the narrow canyons occupied by Mexican spotted owls. They concluded that a less conservative 12-m (39-ft) buffer zone likely would minimize flush response while excluding access to only 25% of canyons occupied by owls.

In summary, the limited information available suggests that: owls may be disturbed by a variety of human-caused activities; ground-based activities generally are more disturbing than overflights; and decibel levels within the owl's hearing range and distance to the source of disturbance are significant factors in determining owl response. Further, at least one study of northern spotted owls documented a significant effect of increased road noise on reproductive success, suggesting that human disturbance may impact fitness parameters of spotted owls.

H. Climate Change

In addition to changes in distribution and amounts of the owl's habitat, climate change may result in direct and indirect influences on the owl's population demography and interactions with other species. Much of the evidence for these potential influences was presented in the preceding sections that detailed the owl's population ecology, but we summarize some additional examples here.

a. Changes in Demographic Rates.—Shifts in key weather variables may influence owl demography by influencing the physiology of individual owls. For example, if climate change results in more or longer periods where microclimatic temperatures exceed lower or upper critical limits, owls will require additional energy and/or water to maintain homeostasis (Ganey et al. 1993, Weathers et al. 2001). If owls are not able to adopt new behaviors to counter these additional energetic demands, such as finding roost sites with greater thermal protection, they will have less energy to allocate to reproduction and/or survival. Should temperatures increase enough that all available microclimates exceed the owl's lethal limits, the owls must disperse elsewhere to inhabitable environments. Because climate change will likely create shifts in weather over large areas and because long-distance dispersal (>150 km [93 mi]) is not very plausible for most Mexican spotted owls, shifts in temperatures that regularly exceed critical or lethal limits will result in greater fatality and declining populations. Changes in water balance may be as important as changes in energy balance (see Weathers et al. 2001), particularly if climates become both warmer and more arid.

Annual weather patterns are associated with survival and reproduction of spotted owls (Franklin et al. 2000, 2004, North et al. 2000, LaHaye et al. 2004, Olson et al. 2004, Dugger et al. 2005, Anthony et al. 2006, Seamans and Gutiérrez 2007). Precipitation may influence the owl's reproductive output either directly or indirectly. Direct negative effects of increased precipitation during the nesting period on survival and especially reproduction have been shown in other subspecies of spotted owls (e.g., Franklin et al. 2000, North et al. 2000, LaHaye et al. 2004). This direct negative effect has not been documented in Mexican spotted owls, however.

In a study on two populations of Mexican spotted owls, Seamans et al. (2002) documented positive relationships between precipitation (i.e., precipitation during the previous year, during the previous winter, or during the previous monsoon season) and survival and reproductive

output. Seamans et al. (2002) speculated that precipitation was probably important in providing indirect benefits to Mexican spotted owls. Specifically, they hypothesized that germination and sprouting of annual plants during the monsoon season may extend the breeding season of small mammals in the Southwest and may increase overwinter survival and therefore abundance of prey. Many prey species eaten by Mexican spotted owls exhibit high temporal variability in abundance (Ward and Block 1995, Ward 2001, Block et al. 2005), and owl reproduction appears linked to changes in prey biomass (e.g., Ward and Block 1995, Ward 2001). Thus, changes in climate that affect prey abundance likely also will affect owl reproduction. Interactions among temperature and moisture regimes may differ across elevational gradients in the Southwest, thus affecting small mammal populations differently in different areas (Seamans et al. 2002:331). Climate changes that decrease prey availability may also negatively influence the owl's water balance, especially when non-metabolic water is not available.

In the only direct study on the effects of climate change on demographic rates of Mexican spotted owls , Peery et al. (2011) used the demographic data from the study areas discussed in Seamans et al. (2002, see above) to evaluate how climate change might influence population dynamics and extirpation risk of Mexican spotted owls. They used stochastic, stage-based matrix models, parameterized with vital rates linked to annual climatic variation, to project owl populations forward in time under both current climatic conditions and three IPCC emissions scenarios (B1, A1B, and A2; IPCC 2007). Resulting models showed that populations in both the Arizona and New Mexico study areas declined rapidly over the next century under all three emissions scenarios, and extirpation risk for both populations was much higher under all three scenarios than under current climatic conditions. Results were driven largely by negative effects of warm, dry conditions on Mexican spotted owl fecundity and survival, with those effects far greater for fecundity than for survival. Changes in population growth rates were more sensitive to predicted increases in temperature than to predicted declines in precipitation. Peery et al. (2011) concluded that Mexican spotted owls were highly vulnerable to climate change even in core portions of their range.

Peery et al. (2011) also evaluated the effects of climate change on a population of California spotted owls from the San Bernardino Mountains, California. Again, they used existing demographic data (LaHaye et al. 1994, 2004) and the same three IPCC scenarios, and projected the California spotted owl population forward in time. Unlike the Mexican spotted owl populations analyzed, the California spotted owl population was relatively insensitive to predicted changes in climate, and extirpation risk for this population was low under all climate scenarios modeled. This difference was due primarily to a negative relationship between fecundity of California spotted owls and cold, wet springs, and the fact that such springs were less common under predicted climate scenarios. This suggests that responses of populations of spotted owls to climate change may differ among geographic regions. Whether such variation will occur within the range of the Mexican spotted owl remains unknown, however.

The study by Peery et al. (2011) necessarily relied on models rather than observed population responses to climate change. Nevertheless, they used a rigorous modeling framework, the best available demographic data, and relationships between that demographic data and annual variation in climate derived from sound empirical studies to parameterize models. Consequently,

we view their results as robust and sobering, especially because the models evaluated by Peery et al. did not include potential changes in disturbance regimes caused by climate changes.

b. Reduction in Population Size.— At this time, no empirical evidence exists documenting changes in Mexican spotted owl distribution or population size due to climate change. As mentioned above, however, both survival and reproduction were positively correlated with precipitation in two populations studied (Seamans et al. 2002), and a simulation study conducted by Peery et al. (2011), suggested that increasingly warmer and drier climates would greatly increase extirpation risk for Mexican spotted owls in study areas in Arizona and New Mexico.

c. Changes in Co-evolved Interactions.— Changing climates also could influence distribution patterns and abundance of major prey species, as well as potential competitors with and predators on Mexican spotted owls. Each species has different physical tolerances and resource requirements, including the small mammal species eaten by Mexican spotted owls (Ward 2001). This makes it hard to generalize about the effects of changing climates on prey distribution and availability. In examining the influence of habitat and weather-related covariates on the biomass (g ha^{-1}) of five common prey species of Mexican spotted owls in the Sacramento Mountains, New Mexico, Ward (2001) identified a spectrum of effects for each species. Deer mice were influenced by weather related effects that changed with time, whereas Mexican woodrats were more influenced by habitat related effects. Untested predictions about the order of species decline or loss of the five studied prey species in the Sacramento Mountains given their current distributions and natural histories (reviewed by Ward [2001: Chapter 2]) would suggest that drier warmer microclimates would result in loss of vole species first, followed by loss or a reduction in numbers of woodrats, and finally a reduction in numbers of peromyscid mice. The magnitude of such potential changes in the distribution and abundance remain untested at this time, however.

In rocky-canyon habitat in southern Utah, Willey and Willey (2010) documented increases in abundance and species diversity of rodents during a period of increased precipitation. Territory occupancy and territory re-colonization rates of Mexican spotted owls also increased during the period of increased precipitation, presumably in response to increases in prey abundance (Willey and Willey 2010). The strong apparent response of small mammals to precipitation in this study may have been a function of the semi-arid climate of the region. For example, a review of variation in responses by deer mice to increased precipitation in varying environments demonstrated that the greatest response occurred in arid regions and the lowest response occurred in the wet coastal forests of the Pacific Northwest (Ward 2001: Chapter 2).

d. Interactions With Competitors and Predators.— Changes in forest composition also could influence abundance and distribution of owl competitors and predators, but the magnitude and direction of such potential changes again are unknown at this time. Northern spotted owls are being affected by a direct competitor, the barred owl, which recently expanded its range into the Pacific Northwest and California (Gutiérrez et al. 2007). This species occurs in the eastern U.S. and portions of Mexico (Mazur and James 2000). Whether climate change will ultimately result in a sympatric distribution of Mexican spotted and barred owls is unknown. It is possible that warmer, drier conditions might favor such potential predators as great-horned owls (see

Predation, above), which occur in habitats ranging from high-elevation and high-latitude forests to hot deserts (Johnsgard 1988).

7. Movements and Migration

The ability of Mexican spotted owls to move within and among habitats or across a landscape is a key factor for assessing function and viability of populations over time. For example, small populations often require recruitment from larger (core) populations to persist for long periods. Understanding how frequently and under what conditions owls are successful in completing movements can allow better predictions about long-term or local viability. Knowledge for mobile organisms like Mexican spotted owls is often difficult to obtain, however, and details about conditions that allow for successful dispersal or explanations for periodic migrations are limited. Nonetheless, a few studies have documented movements of this owl. This section summarizes existing knowledge about movement patterns of the owl and the processes that influence its movements.

A. Seasonal Migration

Ganey and Block (2005a) summarized available information on seasonal movements and range use of radio-marked Mexican spotted owls, supplemented by anecdotal observations of owls during the non-breeding season, and evaluated the adequacy of management guidelines in protecting habitats used by owls during the non-breeding season. They operationally defined all radio-marked owls that moved $\geq$2 km (1.2 mi) from their breeding-season home-range center as "migrants" and treated all other radio-marked owls as "residents," with this distance criterion based on mean nearest-neighbor distances reported in studies of Mexican spotted owls in Arizona and New Mexico (see Space Use above).

Seasonal movements or migration occurred in most areas where movements of radio-marked owls were monitored (Table B.8). Seasonal migration generally involved a subset of the population, with the size of that subset varying both among study areas and years (Table B.8). Migrating owls typically left study areas in November or December, and returned from January to April (Table B.9). Distance moved ranged from 5 to 50 km (3 to 31 mi) for owls whose wintering areas were located. Wintering areas of two owls from the San Francisco Peaks could not be located despite an aerial search covering thousands of square kilometers, suggesting that some owls may move long distances (see also Gutiérrez et al. 1996).

Duncan and Speich (1995) provided additional evidence for down-slope migration in Mexican spotted owls. They documented a subadult owl overwintering in Sonoran riparian deciduous woodland (Brown et al. 1980) at 838 m in the foothills of the Santa Catalina Mountains, Arizona. They relocated this owl five years later as a member of a territorial pair near the summit of this range, at an elevation of 2,560 m (8,399 ft). We also are aware of numerous anecdotal observations of Mexican spotted owls in woodland, semi-desert, and desert cover types during the winter months. In most cases, however, it is impossible to determine whether these represented migrating territorial owls or dispersing juveniles, which use similar habitats (Arsenault et al. 1997, Ganey et al. 1998, Willey and van Riper 2000, Duncan and Speich 2002). Thus, available information suggests that seasonal migration of some individuals occurs in many

or most populations of Mexican spotted owls, and that such migration occurs in both sexes (Table B.9). Partial migration also occurs in California spotted owls (Laymon 1989, Verner et al. 1992). In contrast, migration appears to be rare in northern spotted owls (Gutiérrez et al. 1995).

Reasons why only some owls migrate are unknown. In addition, some individual Mexican spotted owls migrate in some years, but not others (Table B.8). Migration generally entails a change in elevation for both Mexican (Table B.9) and California spotted owls (Laymon 1989, Verner et al. 1992), with most owls moving down slope (but see Willey 1998a). Migration to lower elevations allows owls to winter in areas that are warmer than their breeding areas during the winter and that lack persistent snow. This may facilitate an energetic savings in maintaining homeostasis and hunting for small mammals, which comprise the bulk of the diet (Ward and Block 1995). It also may allow the owls to move to areas with more concentrated prey resources, as populations of small mammals reach their nadir in owl breeding areas during the winter months (Ward and Block 1995, Ward 2001, Block et al. 2005). For example, Block et al. (2005:625) used live trapping to estimate available winter prey biomass in both the traditional breeding area and a wintering area used by a pair of radio-marked Mexican spotted owls. They estimated that winter prey biomass was almost eight times greater within the wintering area than within the breeding area (1,200 g ha^{-1} vs. 155 g ha^{-1}). Although circumstantial, the evidence suggests that migration was driven by food availability.

Also presently unknown is how and why migrating owls select particular wintering areas, as we have little information on specific habitat features that migrating Mexican spotted owls use in wintering areas (but see Peterson 2003). Further, owls use these areas at a time of year when they are unlikely to vocalize (Ganey 1990), making it difficult to locate such areas through calling surveys.

From a conservation perspective, some migrating owls occupy cover types that have no protected status under the original recovery plan for the Mexican spotted owl (USDI FWS 1995) or this revised Recovery Plan. These cover types also are used by dispersing juvenile owls during the fall and winter (Arsenault et al. 1997, Ganey et al. 1998, Willey and van Riper 2000). The types of lowland areas in which wintering owls have been observed cover vast areas, however, and we have no evidence that suitable wintering areas are limiting. Thus, there is little evidence that specific protective measures for wintering areas or habitats used by migrating Mexican spotted owls are necessary at this time, with the possible exception of portions of the foothills of the Front Range in Colorado. This region has experienced rapid growth and development since 1990.

Table B.8. Numbers of radio-marked Mexican spotted owls observed to migrate during the winter in various studies (from Ganey and Block [2005a]).

Study area	Years	Number of owls radio-marked	Number of owls migrating[1]	Source
San Francisco Peaks	1986-1987 (1989b)	4	2	Ganey and Balda
Walnut Canyon	1986-1987 (1989b)	2	2	Ganey and Balda
Sacramento Mtns.	1989-1990	8	4	Skaggs (1990)
	1990-1991	9	0	Zwank et al. (1994)
	1992-1995	15	0	Ganey et al. (2005)
Colorado	1992-1996	5	3	Johnson (1997)
Southern Utah	1991-1995	15	2	Willey (1998a)
Bar-M Canyon	1990-1993	13	3	Ganey et al. (1999)

[1] Migration was defined as movement >2 km (1.2 mi) from the center of the breeding-season home range.

Table B.9. Distance moved, movement duration, elevation change, and habitats used by migrating adult or subadult Mexican spotted owls (from Ganey and Block [2005a]).

Study area	Years	Sex	Distance moved (km)	Duration	Elevation change (m)[1]	Cover type[2]	Source[3]
San Francisco Peaks	1986-87	F	Unknown[4]	Nov-Apr	Unknown	Unknown	1
San Francisco Peaks	1986-87	M	Unknown[4]	Nov-Apr	Unknown	Unknown	1
Walnut Canyon	1986-87	F	10	Dec-Jan	100	MC, PP, P/O/J, R	1
Walnut Canyon	1986-87	M	10	Dec-Jan	100	MC, PP, P/O/J, R	1
Sacramento Mtns.	1989-90	F	10-24	Unknown	Unknown	PJW, SDS	2
Sacramento Mtns.	1989-90	M	10-24	Unknown	Unknown	PJW, SDS	2
Sacramento Mtns.	1989-90	M	~5	Unknown	Unknown	MC	2
Sacramento Mtns.	1989-90	M	~11	Unknown	Unknown	MC	2
Bar-M Canyon	1990-91	M	10	Dec-Jan	0	PO	3
Bar-M Canyon	1990-91	M	50	Dec-Apr	920	PJW	3
Bar-M Canyon[5]	1991-92	F	50	Dec-Apr	920	PJW	3
Bar-M Canyon[5]	1992-93	F	50	Dec-Apr	920	PJW	3
Colorado	1992	M	6.7	Nov-Apr	407	PJW, PP	4
Colorado	1995	F	16.5	Nov-Feb	335	PJW, PP	4
Colorado	1995	M	6.7	Dec-Jan	182	PJW, PP	4
Utah	Unknown	F	25	Unknown	+913	SF	5
Utah	Unknown	M	20	Unknown	685	MS	5

[1] Elevation changes are negative unless otherwise indicated.

[2] Cover types: MC = mixed-conifer forest, MS = mountain shrub, PJW = pinyon-juniper woodland, PO = ponderosa pine-Gambel oak forest, PP = ponderosa pine forest, P/O/J = ponderosa pine/oak/juniper, R = riparian, SDS = semi-desert scrub, SF = Spruce-fir forest.

[3] Sources: 1 = Ganey and Balda (1989b); 2 = Skaggs 1990; 3 = J. L. Ganey and W. M. Block (unpubl. data); 4 = Johnson (1997: Table 5); 5 = Willey (1998a:54-55).

[4] Wintering areas not located despite an aerial search covering thousands of square kilometers.

[5] These two records represent one female owl that migrated to the same area in two consecutive winters. This owl did not migrate in the winter of 1990-1991 (but her mate did).

B. Dispersal

Two forms of dispersal occur in spotted owls. Natal dispersal, or dispersal by young of the year from their birth sites, is the most common form and begins each fall following the production of young (Gutiérrez et al. 1985). Breeding dispersal, or movement by subadult or adult individuals from a previously occupied territory to another, occurs less frequently (Gutiérrez et al. 1995, Forsman et al. 2002, Blakesley et al. 2006).

a. Natal Dispersal.— Dispersal by juvenile Mexican spotted owls has been studied directly by monitoring movements of radio-marked individuals in New Mexico (Arsenault et al. 1997), Arizona (Ganey et al. 1998), and Utah (Willey and van Riper 2000), and indirectly in Arizona and New Mexico by monitoring movements of color-banded juvenile owls (Duncan and Speich 2002, Gutiérrez et al. 2003).

Radio-marked juvenile Mexican spotted owls began dispersing in September and October in all study areas, with most dispersing in September. Initial dispersal movements were rapid, abrupt, and random with respect to direction. In an effort to understand triggers of natal dispersal, Willey and Van Riper (2000) recorded observations of parent-offspring interactions and departure dates of juvenile Mexican that were supplemented with food and a control group without additional food. Juvenile owls that were provided with supplemental food all left their natal sites significantly sooner than juveniles that did not receive supplemental food. Aggressive behaviors among offspring and parents that might induce dispersal were not noticeably different between the two treatment groups, however. Thus, this study did not support the hypothesis that food shortage triggers natal dispersal in Mexican spotted owls. Rather, it suggested that body condition might positively influence departure. That is, acquiring sufficient energy reserves prior to embarking may be a key physiological factor in the timing of natal dispersal in spotted owls (Willey and van Riper 2000).

Two types of behavior during natal dispersal followed initial movements: rapid dispersal across the landscape and extensive local exploration. Many dispersing juveniles exhibited periods of both types of movements. Distance from the natal site to the last observed location for radio-marked juveniles ranged from <1 to >92 km (<0.6 to >57.2 mi). These distances likely represent minimum estimates of dispersal capability, as only one of 62 radio-marked juveniles was tracked until it settled on a territory and paired with a mate. Directions from natal sites to final observed locations did not differ from random, indicating that dispersing owls did not follow a singular path or corridor. In addition, dispersing juveniles from all studies used a wide variety of habitats, including some that were very different in structure and composition from typical breeding habitat. Because juvenile survival is typically low (<30% of these individuals apparently live to the next year), documenting final dispersal distances using radio-marked birds requires that a large number of young are radio-marked (>100) and followed for a longer (>3 years) period than most radio-transmitter batteries or funding for aerial monitoring will last (Forsman et al. 2002). However, the patterns observed for the smaller samples of Mexican spotted owls differed little from a more comprehensive study of natal dispersal of northern spotted owls in Oregon and Washington (Forsman et al. 2002). For example, natal distances observed in this long-term, large-sample study (n = 324 radio-marked and 711 banded juveniles followed from 1985—1996) ranged from 1.8 to 103.5 km (1.1 to 64.3 mi) for radio-marked

juveniles and from 0.6 to 111.2 km (0.4 to 69.1 mi) for re-sighted individuals originally color banded at natal sites. The distribution of these dispersal distances was skewed toward shorter distances with only 8.7% of the final distances between the natal territory and location of settlement being >50 km (31 mi). On average, male and female juveniles in this study eventually settled within an average of 4.2 and 7.0 territory widths from their natal sites after two to five years (Forsman et al. 2002).

Estimates of natal dispersal distances from mark-recapture studies also suggest that most California and northern spotted owls settle on territories within a few territory widths of their natal site (LaHaye et al. 2001, Forsman et al. 2002). These estimates may provide a better estimate of final distances traveled by successful dispersers than did the radio-telemetry studies discussed above, although the finite size of the mark-recapture study areas could underestimate this distance. For example, LaHaye et al. (2001) examined settling patterns of dispersing California spotted owls in the San Bernardino Mountains, California, within a 535-km^2 (132,201 ac) study area. They evaluated possible effects of study-area size on dispersal distances by nesting several successively smaller areas within their complete study area. They found that dispersal distances were underestimated when using band-resighting data for establishing settling patterns in the smaller nested study areas (see also Zimmerman et al. 2007). In contrast, Forsman et al. (2002) compared distance estimates based on radio-marked northern spotted owl juveniles with estimates derived from settling patterns and found no evidence that the small study areas used to study settling patterns biased distance estimates. Thus, it is unclear whether or not the finite size of demography study areas consistently results in underestimates of natal dispersal distances.

Unfortunately, few estimates of natal dispersal distance are available for the Mexican spotted owl. Duncan and Speich (2002) were able to document four instances of inter-mountain movement by dispersing Mexican spotted owl juveniles that had been marked with color bands at their birth sites. These movements required these owls to cross desert valleys between Sky Island mountain ranges in southeastern Arizona. Distances between natal sites and territories established by these four individuals ranged from 28 to 54 km (17 to 34 mi).

It is not clear when natal dispersal typically ceases in spotted owls. Gutiérrez et al. (2003) reported that 90 to 100% of fledged young that occupied territories in two demography study areas did so within three years. Patterns differed between their Arizona and New Mexico study areas, however. In Arizona, over 60% of fledged young that settled did so in their first year, with declining proportions of young settling through year five (Gutiérrez et al. 2003: Fig. 13a). In New Mexico, young settled in equal proportions in the first three years following fledging, with no recruitment observed in subsequent years (Gutiérrez et al. 2003: Fig. 13b). LaHaye et al. (2001) noted that >50% of successful natal dispersers in their California study area occupied territories within one year and that virtually all successful dispersers occupied territories within three years. Forsman et al. (2002) noted variable patterns in northern spotted owls, with some owls settling permanently in their second summer while others did not settle permanently until they were two to five years old. Thus, available evidence suggests that most young occupy territories in the first three years following fledging, but that dispersal movements may continue for up to five years for some owls.

b. Breeding Dispersal.— Reasons for and distances traveled during dispersal by previously settled subadult and adult Mexican spotted owls are poorly understood. Breeding dispersal is thought to occur when a mate is lost, or in some cases when a better reproductive opportunity is found elsewhere. Examples of both have been documented for all three subspecies (LaHaye et al. 2001, Forsman et al. 2002, Gutiérrez et al. 2003, J. L. Ganey and J. P. Ward, unpubl. data).

Arsenault et al. (1997) noted apparent cases of dispersal in subadult Mexican spotted owls, and Gutiérrez et al. (1996) suggested that dispersal also may occur in adult Mexican spotted owls. In their more comprehensive study of northern spotted owls, Forsman et al. (2002) noted that breeding dispersal of northern spotted owls in Oregon and Washington occurred relatively infrequently. Based on settlement patterns of banded birds, distance dispersed ranged from 0.01 to 85.2 km between previously and newly occupied breeding sites for all age classes. However, first-year subadults (n = 71) moved farther than second-year subadults (n = 75) and adults (individuals ≥3 years; n = 294; median distances 5.1, 4.1, and 3.5 km [3.2, 2.5, 2.2 mi], respectively). Most (83%) adults that did disperse only moved once. Of those that moved twice or more, 41% moved backed to an original territory (Forsman et al. 2002). There were no significant differences in breeding dispersal distances among the sexes. The probability that an individual would move was generally greater for females, however, and was greatly magnified for either sex if the pair bond was disrupted by disappearance (movement or death) of a mate.

In summary, juvenile dispersal appears to be obligate in Mexican spotted owls, and settled subadult or adult birds may disperse to another site on a much rarer and irregular basis. Juvenile owls leave the natal territory in September or October and wander the landscape. Many perish in the process. They are capable of moving long distances, but many successful dispersers occupy territories near their birthplace. Natal dispersers move through a wide variety of habitats during the dispersal period, many of which differ greatly from typical breeding habitat and have no formal protective measures under USDI FWS (1995; see also Ganey and Block 2005a) or this revised Recovery Plan. There is little evidence from study of movements that would allow us to identify common dispersal directions, movement corridors, or important areas or habitats. Many Mexican spotted owls appear to occupy territories at one to two years of age, while others may settle when older. Some of this variation may be driven by trends in owl density and fecundity, manifested through trends in numbers of territory vacancies. In general, however, we know little about dispersal behavior, and especially about dispersal movements of Mexican spotted owls during and following their second summer of life.

8. Metapopulation Ecology

Many authors have noted that the structure and spatial distribution of spotted owls at a rangewide scale suggests that groupings of individuals may occur as subpopulations and that these subdivided populations may function as a metapopulation (e.g., Levins 1970, Hanski 1998) or a series of subdivided populations where population interactions are much higher within than between populations (Gutiérrez and Harrison 1996; see also Shaffer 1985, Noon et al. 1992, LaHaye et al. 1994, Noon and McKelvey 1996,). Indeed, Gutiérrez and Harrison (1996) argued that spotted owl population dynamics and viability could be understood *only* in the context of a metapopulation. Of the three subspecies, the distribution of Mexican spotted owls appears to most naturally resemble the metapopulation construct, with perceived subpopulations existing in

useable habitat created by elevation gradients and disconnected mountain or canyon systems, separated by a matrix of low-quality to unsuitable habitat.

Despite the important contributions made by metapopulation theory and models to management of northern and California spotted owls (Shaffer 1985, Noon et al. 1992, LaHaye et al. 1994, Gutiérrez and Harrison 1996, Noon and McKelvey 1996), few studies have examined metapopulation structure of Mexican spotted owls. Keitt et al. (1995, 1997) examined the spatial pattern of forest habitat patches across the range of the Mexican spotted owl. Their objective was to gauge the extent to which the owl might behave as a metapopulation in the classical sense of a set of local populations linked by infrequent dispersal. Such a finding, if verified, would suggest that population dynamics of owls in one local population might be influenced by factors, including management activities, which affected nearby populations. Conversely, if local populations are functionally discrete, then those populations could be treated separately with some confidence that actions in one part of the owl's range would not greatly affect other populations.

Keitt et al. (1995; and refined by Keitt et al. 1997) reported that patches of forest habitat in the range of the Mexican spotted owl showed a connectivity threshold of approximately 45 km (28 mi). They concluded that an organism capable of dispersing a distance of ≥45 km (28 mi) through inhospitable terrain, and with an average exponential dispersal distance of ≥15 km (9.3 mi), would perceive the landscape as a series of connected patches. They further concluded that Mexican spotted owls met these criteria (see Dispersal, above), and that the distribution and temporal dynamics of this subspecies' populations probably behaves as a classical metapopulation over much of its range. That is, the level of habitat connectivity is such that many habitats are "nearly connected" at distances corresponding to the best empirical estimates of the owl's dispersal capability. At this scale, the landscape consists of a set of large, more-or-less discrete habitat clusters. For example, most of the Mogollon Rim functions as a single cluster, the SRM as another single cluster, and so on. This suggests that owls could successfully disperse within habitat clusters with very high probability and disperse between clusters with much lower probability. Thus, we would expect owls to disperse within clusters most of the time and between clusters rarely, which is consistent with the definition of a metapopulation. This finding suggests that habitat connectivity should be maintained (or increased) across the owl's range. Habitat connectivity buffers a population from stochastic variability through time by providing the opportunity for local population failures to be "rescued" by immigration from other populations, and it also facilitates gene flow among populations (Barrowclough et al. 2006).

Gutiérrez and Harrison (1996) noted two other concepts related to metapopulation dynamics that are relevant to spotted owls. The first is spatially structured population dynamics. The spatial structuring described by this concept arises from territorial behavior and is relevant in continuous or relatively continuous habitat. Individuals in such habitat will tend to interact mainly with neighboring owls, rather than mixing freely throughout the larger population. The dynamics of this situation can be modeled using individual territory models (Lande 1987, 1988, Noon and McKelvey 1996). Resulting models are similar to metapopulation models, except that extirpation and colonization is modeled for territories rather than for larger populations (Gutiérrez and Harrison 1996, Noon and McKelvey 1996). No individual territory models have

been developed for the Mexican spotted owl. The approach may be relevant to particular areas where clusters of owls occur in relatively continuous habitat, however (e.g., Mogollon Rim, Sacramento Mountains).

The second concept relates to source-sink dynamics (Pulliam 1988). As typically defined, source populations occur in high-quality habitat and produce surplus individuals. In contrast, low quality habitats may act as population sinks, where reproduction is insufficient to balance fatality. Sinks may be occupied only when high quality habitat is fully occupied, in which case sinks can serve a valuable function by serving as a reservoir for surplus individuals (Pulliam 1988, see also Howe et al. 1991). Conversely, if dispersing individuals settle in sinks rather than continuing to search for higher quality habitat, sinks may be detrimental to long-term population viability (Lamberson et al. 1992, Zimmerman et al. 2003).

Little is known about potential source-sink dynamics in Mexican spotted owls. Ganey et al. (2005) reported an example of possible source-sink dynamics in two populations occupying different habitats in the Sacramento Mountains, New Mexico. However, this was based on a study of short-duration involving relatively few owls. Consequently, we cannot be certain that the apparent sink functions as a sink over longer time frames. And, if it is indeed a sink, we do not know whether it serves as a reservoir for surplus owls when population levels are high, or as an ecological trap for individuals that might find better vacant habitat if they continued looking.

Another important concept relevant to metapopulation dynamics deals with correlation (or lack thereof) among population growth rates of different subpopulations. LaHaye et al. (1994) demonstrated that high correlation in vital rates among subpopulations increased the risk that such populations would decline simultaneously. In contrast, lack of correlation among subpopulations resulted in situations where some populations were able to contribute surplus individuals to declining populations. The metapopulation dynamics evaluated were very different for these situations, with increased correlation among subpopulations resulting in an increased risk of rangewide population declines and ultimately extinction.

The extent of correlation in vital rates among subpopulations of Mexican spotted owls is only partly understood. Spotted owl vital rates appear to be partly influenced by large-scale climatic patterns (Seamans et al. 2002, Gutiérrez et al. 2003). Such patterns are likely to be at least somewhat correlated across much of the range of the owl, suggesting that correlation among subpopulations could be high. However, available evidence suggests that one vital rate, reproductive output, was only moderately correlated among three populations (Sacramento Mountians, Coconino, and Gila) of Mexican spotted owls during a period of simultaneous study (1991-2000). Reproductive output was relatively high for all populations in 1991. Reproduction in the Sacramento Mountains declined steadily to low levels and remained there through 1995, rebounding in 1996 (Ward 2001: Fig. 3.8). Reproduction was more variable in the other two populations, but declined abruptly in both from 1993 to 1994 (Seamans et al. 1999: Fig. 2). Reproduction in the Coconino population then increased gradually from 1994 to 1996, whereas reproduction in the Gila population continued to decline through 1995 before rebounding in 1996. Thus, reproduction appeared to be somewhat, but not completely, correlated in these populations, with a period of low reproduction occurring in all populations during the mid-1990s. This decline occurred earlier in the Sacramento Mountains (BRE EMU) than in the other

two populations. However, the Coconino and Gila populations both were located in the UGM EMU, and climatic patterns (and therefore population dynamics) may be more similar within than among EMUs. Survival estimates also are available for two of these populations during the same time period (Seamans et al. 1999: Fig. 3). Survival trajectories were similar between areas for owls <1 year old, but not for older owls. Again, this suggests some level of correlation in vital rates among populations but that such rates are not completely correlated among populations.

In summary, the distribution of Mexican spotted owls throughout their range suggests a spatial distribution congruent with a group of subpopulations that may function as a metapopulation. The UGM EMU includes the largest contiguous area of habitat for Mexican spotted owls, which is reflected in the large number of documented owls in that EMU (e.g., Ganey et al. 2004, see also Table B.1). Because of its size and central location to other areas inhabited by Mexican spotted owls, the larger subpopulation in this EMU likely serves as a core, source population for supplying new recruits to proximal outlying locations. Other subpopulations, particularly those occurring in the BRE, appear isolated enough that recruitment must come primarily from reproduction within the local subpopulation. Limited evidence from simulation models and genetic analysis supports these aspects of metapopulation function and spatially structured population dynamics. Although temporarily asynchronous reproduction and survival may occur among some subpopulations, interstitial distances and dispersal ability may limit the beneficial traits of metapopulation function such as the numerical rescue effect. This may be the case for the concentrated population of Mexican spotted owls in the Sacramento Mountains of New Mexico (Barrowclough et al. 2006). Consequently, subpopulations that are large enough to produce surplus individuals (i.e., acting as a source population) in some years, but isolated enough that external recruitment is rare, will require more conservation attention to maintaining internal recruitment and viability; whereas conservation for smaller subpopulations near larger core populations may require a greater focus on identifying and enhancing dispersal corridors. More information is needed to identify the magnitude of numerical exchange of individuals among subpopulations and the relative influence on local, EMU-wide, and rangewide population viability.

9. Conclusions

In many ways, the Mexican spotted owl appears to be quite similar to both the northern and California spotted owls with respect to general behavioral patterns and ecology. For example, all three subspecies are most common in forests of complex structure, prey mainly on nocturnally active small mammals, and share similar vocalizations, reproductive chronologies, and population characteristics. However, important differences exist between the Mexican spotted owl and the other subspecies. The distributional pattern of the Mexican spotted owl is more disjunct and ranges over a much larger area than that of the other subspecies, with the possible exception of some California spotted owl populations that occur in disjunct mountain ranges of southern California (Noon and McKelvey 1992). The Mexican subspecies also appears to use a wider range of habitat types than the other subspecies and to date only the Mexican subspecies has been found to dwell and reproduce in rocky canyons in any significant numbers (although cliff nesting has been documented in both northern [Hane et al. 2007] and California [Peyton 1910, Dickey 1914] spotted owls). These unique aspects of the ecology of the Mexican spotted

owl require unique approaches to its management. For example, threats to owl habitat and management proposed to address those threats may well differ among the diverse habitats occupied by Mexican spotted owls. In addition, because of its disjunct distributional pattern, dispersal among subpopulations of Mexican spotted owls is an important consideration. Thus, habitat management plans may need to consider not only areas occupied by owls but also intervening areas, even where such areas are very different in habitat structure from those typically occupied by Mexican spotted owls.

We have learned a great deal about the Mexican spotted owl in the last three decades, but significant information gaps still remain. Most studies of the owl to date have been descriptive rather than experimental. Although we have identified patterns with respect to some aspects of this owl's ecology (e.g. habitat use), cause and effect relationships have not been documented. Much more information is needed on how specific factors alone and in combination affect change in Mexican spotted owl abundance. These considerations suggest that much additional research is needed, and that management recommendations in the near term must deal with extremely high levels of uncertainty.

APPENDIX C - MANAGEMENT RECOMMENDATIONS

1. Assumptions and Guiding Principles

The recommendations proposed in this revised Recovery Plan are based on several key assumptions about habitat requirements of the Mexican spotted owl and a number of guiding principles. These assumptions and guiding principles are:

- Spotted owl distribution in forested and rocky-canyon environments (see definitions below) is limited primarily by the availability of habitat used for nesting and/or roosting. Owl distribution may also be limited by prey availability and competition for nest habitat among raptors.
- Landscape analyses must be conducted prior to initiating any management actions. These analyses should identify known owl sites, areas to be managed as replacement nest/roost habitat, potential foraging habitat, and prospective habitat corridors.
- Habitat used for nesting/roosting also provides adequate conditions for foraging and dispersal activities. Thus, sustaining nesting/roosting habitat meets other survival requirements. Some habitats not used for nesting/roosting may provide conditions for other activities such as foraging and dispersal. In forests, these habitats include forest types that do not typically support nesting/roosting and forest stands in seral stages younger than typical nesting/roosting habitat. In rocky canyons, these habitats canyon rims and/or adjacent plateau highlands.
- Nesting/roosting habitat typically occurs either in well-structured forests or in steep and narrow rocky canyons. Nesting/roosting habitat in forest environments is typified by certain structural features, including high canopy cover, large trees, and other late seral characteristics that are common in, but not restricted to, late-successional forests. Nesting/roosting habitat within rocky canyons is dominated by relatively narrow vertical-walled canyons formed by parallel cliffs with numerous caves and/or ledges within specific geologic formations. Large trees and late-seral features that are common in, but not restricted to, riparian and mixed-conifer forests are present in some rocky canyon habitats; however, steep cliffs with ledges and caves may provide adequate nest and roost structures in the absence of late-seral forest.
- Forested nesting/roosting habitat is typically found in mixed-conifer, pine-oak, and riparian forests, with some other types locally important (e.g., encinal oak woodlands). Other habitats are used primarily for foraging, dispersal, or wintering. Because of ecological conditions (e.g., mesic north facing slopes) and processes (e.g., fire) that tend to limit denser forest stands to particular locations on the landscape, the distribution of nesting/roosting habitat is naturally discontinuous and limited in some areas.
- Disturbance events leading to forest canopy gaps are important for maintaining a diversity of tree and understory species, particularly in mixed-conifer spotted owl nest/roost stands. Both shade-tolerant and shade-intolerant species contribute important diversity to both dry and wet mixed-conifer forests.
- Existing forested habitat used by Mexican spotted owls for nesting/roosting generally has not been developed through planned silvicultural treatments. That is, although owls may be found in managed stands, these stands were not treated specifically to enhance spotted owl habitat.

- Forest restoration and fuels-reduction treatments must be evaluated over time using appropriate modeling, rigorous monitoring, management experiments, and/or research to assess their effectiveness in maintaining or creating owl habitat and/or their effectiveness in reducing the threat of high severity or stand-replacing wildland fire.
- Recruitment of large trees in both forested and rocky-canyon habitats is a function of both time and ecological site-specific factors affecting productivity. Similarly, many late-seral characteristics typical of owl habitat, such as large snags and broken-topped trees, high canopy cover, large downed logs, and the sharing of growing space among multiple shade-tolerant and -intolerant species, are attained primarily through time and the operation of ecological processes such as fire and forest pathogens.
- This revised Recovery Plan represents a short-term (10 year) strategy, but management actions recommended herein will have long-term consequences. Therefore, care should be taken to preserve future options while designing management prescriptions.
- Ongoing climate change will result in unpredictable changes in habitat distribution and quality, and this creates considerable uncertainty in developing strategies to recover the owl. Again, this argues for preserving options where possible, as well as for attempting to account for potential changes in habitat distribution and quality.
- In general, management should strive to sustain and develop desired conditions for the owl (Tables C.2, C.3) where appropriate.
- We recognize that situation will arise when land managers may need to deviate from the recommendations. These deviations from the Recovery Plan should be addressed with the FWS through the ESA Section 7 consultation process.

2. Definitions of Forest Types and Canyon Habitat

In this Recovery Plan we propose specific guidelines for several forest cover types based on: 1) considerable evidence that these cover types provide habitat for nesting, roosting, and foraging activities by Mexican spotted owls; and, 2) our desire to target guidelines for the most appropriate habitats. In addition to a discussion on forest cover types, we revised this section from the 1995 Recovery Plan to include a discussion on canyon habitat. The following sections of this Appendix rely upon these definitions for implenting the Management Recommendations.

a. Forest Types

Numerous treatments deal with the concepts of classifying vegetation cover or habitat types (e.g., Daubenmire 1952, 1968; Pfister 1989). We do not review these concepts here. In general, we accept the view that the basic unit of classification of climax vegetation is the plant association (Küchler 1964, Daubenmire 1968, Pfister 1989). These associations are defined using information on species composition and successional pathways. However, under natural disturbance regimes, many southwestern forests may not attain climax conditions. For example, in an analysis of Mexican spotted owl habitat on the Alpine Ranger District, Apache-Sitgreaves National Forests, we determined that habitat classifications based on current and climax vegetation gave very different results. Based on current vegetation, important nesting and roosting habitat was classified as mixed-conifer forest. The same forests would be classified as spruce-fir based on potential natural vegetation type. This example demonstrates the need for

clear operational definitions of forest types to be used when applying guidelines under this Recovery Plan.

In this section, we provide operational definitions for forest types referred to in the plan, and a simple key to these types. This key will allow land managers to classify lands in a manner compatible with the recommendations we provide in this plan. A review of literature on classification of forest types in southwestern forests was provided in the 1995 Recovery Plan and is not repeated here.

b. Recovery Plan Definitions for Forest Types

This forest type classification scheme is primarily concerned with a subset of the available forest types in the southwestern U.S. We are interested in both potential and existing vegetation. Consequently, this forest typing scheme is a hybrid of classification schemes based on potential vegetation (series, association, and habitat type) and forest cover types based on existing vegetation.

Three terms we use in the forest typing scheme below require definition: pure, majority, and plurality. Various definitions have been used to describe a pure stand. Daniels et al. (1979) described pure stands as those where ≥90% of the dominant or co-dominant trees are of a single species. Dominant trees are those whose crown extends above the general level of the main canopy (Helms 1998). The crowns of co-dominant trees help to form the main canopy in even-aged stands. In uneven-aged stands, crowns of co-dominant trees are above the crowns of the tree's immediate neighbors and receive full light from above and partial light from the sides (Helms 1998). Under this definition, a stand may have an understory of other species without changing the pure designation. The key to this concept is the distinction between the dominant and co-dominant species and the understory component.

In contrast, Eyre (1980) defined a pure stand as one where ≥80% of the stocking is by one species. For purposes of this plan, we use the term pure to refer to any stand where a single species contributes ≥80% of the basal area (BA) of dominant and co-dominant trees.

We use the term majority to refer to the situation where a single species contributes ≥50% of the BA (Eyre 1980). We use the term plurality to refer to the situation where a species (or group of species of interest) comprises the largest proportion, but not a majority, of a mixed-species stand (Eyre 1980). With these definitions and concepts in mind, we provide definitions for specific forest types below.

i. Ponderosa Pine (Pinus ponderosa) Forest Type

The ponderosa pine forest type occurs in what Moir (1993) described as the Lower Montane Coniferous Forest. Forests in this zone are dominated by pines, sometimes co-occurring with junipers and oaks. The climate is sometimes not conducive for forests, with moisture becoming limiting in the upper portions of the soil profile during part of the long growing season. We define the ponderosa pine forest type as:

1) Any forested stand of the *Pinus ponderosa* series not included in the Pine-oak Forest Type (see below); or

2) Any stands that qualify as pure (Eyre 1980) ponderosa pine, regardless of the series or habitat type.

ii. Pine-oak Forest Type

A number of habitat types exist in the southwestern U.S. that could be described as pine-oak forests. Most of the stands relevant to the recovery of the Mexican spotted owl fall within two series, the Ponderosa pine series and the Chihuahuan pine series. Present evidence, however, suggests that the former series includes many areas that could never attain the type of forest structure sought by Mexican spotted owls for roosting and nesting. Therefore, we use the following operational definition for pine-oak forest under this plan:

1) Any stand within the Chihuahuan pine series.

2) Any stand within the Ponderosa pine series that meets the following criteria simultaneously:
   a. The stand is located in the UGM EMU, the BRW EMU, or the Zuni Mountains or Mount Taylor regions of the CP EMU.
   b. Habitat types that reflect Gambel oak or a Gambel oak phase of the habitat type.
   c. $\geq$10% of the stand BA or 4.6 m^2/ha (20 ft^2/ac) of BA consists of Gambel oak $\geq$13 cm (5 in) in diameter at root collar.

3) Any stand within the BRW EMU of any other series that meets the following criteria simultaneously:
   a. A plurality (Eyre 1980) of the BA exists in yellow pines: ponderosa pine, Arizona pine, Apache pine, or Chihuahuan pine.
   b. $\geq$10% of the stand BA or 4.6 m^2/ha (20 ft^2/ac) of BA consists of any oaks $\geq$13 cm (5 in) in diameter at root collar.

iii. Mixed-conifer Forest Type

Natural variability is high within this forest type. This variability is the result of mixed-conifer forest occupying a continuum of sites situated between drier and warmer ponderosa pine forests and wetter and cooler spruce-fir forests. Despite this variability, an extant classification scheme based on series and habitat types (Layser and Schubert 1979; Hanks et al. 1983; Alexander et al. 1984a, b; Youngblood and Mauk 1985; DeVelice et al. 1986; Alexander and Ronco 1987; Fitzhugh et al. 1987) is available. This classification system is in widespread use and has interagency support. Given that background, we propose using that system as a starting point in defining mixed-conifer forest, with some added refinements. Specifically, we propose that the definition of mixed-conifer forest generally be confined to the following series (Layser and Schubert 1979) and associated habitat types: white fir, Douglas-fir, limber pine, or blue spruce. Within this framework, we provide the following exceptions to the general guideline stated above:

1) Any stand within the bristlecone pine, Engelmann spruce, or corkbark fir series not having a majority (Eyre 1980) of BA in bristlecone pine, Engelmann spruce, corkbark fir, or ponderosa pine, singly or in combination should be classified as mixed-conifer.

2) Stands that can be described as pure (Eyre 1980) for coniferous species other than Douglas-fir, white fir, southwestern white pine, limber pine, or blue spruce should be excluded from the broad category of mixed conifer for the purposes of plan implementation regardless of the series or habitat type.

3) Stands of mixed species with >50% of the BA consisting of quaking aspen should be defined as quaking aspen for the purposes of Recovery Plan implementation regardless of the series or habitat type.

iv. High-elevation Forest Type

We define high-elevation forest as any stand of the bristlecone pine, Englemann spruce, or corkbark fir series that meets the following criteria:

1) The majority (Eyre 1980) of stand BA consists of any of the three species listed above, either singly or in combination, or

2) Any stands that qualify as a pure stand (Eyre 1980) of any of these species, regardless of the series or habitat type.

v. Quaking Aspen Forest Type

1) We define as quaking aspen forest type any stands with >50% of the total BA consisting of quaking aspen. In situations following stand replacing fire, where aspen is returning and may not yet have measurable BA, it should still be classified as aspen if it comprises >50% of the tree stems.

vi. Riparian Forest Type

We take our definition of riparian directly from FWS (2009) but restrict it to areas distinguished by the presence of trees. Riparian forests are plant communities affected by surface and subsurface hydrologic features of perennial or intermittent water bodies (e.g., rivers, streams, lakes). Riparian forests have one or both of these principle characteristics: 1) distinctively different tree and shrub species than the adjacent areas and/or 2) tree species similar to adjacent areas but exhibiting more vigorous or robust growth forms (FWS 2009). Riparian vegetation typically creates a transition between inundated and upland areas (Naiman and Décamps 1997, FWS 2009). Riparian habitats are among the most ecologically productive and diverse terrestrial environments in the West (Naiman et al. 1993). With respect to spotted owls, riparian forests can provide the habitat structure used for nesting, roosting, foraging, and dispersal (e.g., Ganey and Dick 1995, Stacey and Hodgson 1999).

Naiman and Décamps (1997) point out that delineating riparian zones can be problematic specifically because they are transition zones or ecotones from wet to upland areas and are generally more spatially heterogeneous due to increased disturbance and differing life-history strategies of the constituent plants. They suggest that the riparian zone "encompasses the stream channel between the low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water". Within the range of the owl, riparian forests generally are characterized by:

1) Presence of riparian species, such as cottonwoods, maples, sycamores, or willows .

2) Presence of larger growth forms of species found in adjacent upland community, e.g., quaking aspen, Douglas fir. Prominence of these species is more extensive within higher elevation riparian forests.

3) Generally higher BA, stem densities, and above-ground biomass than adjacent upland communities (Naiman and Décamps 1997).

We distinguish between riparian forests that could frequently be used by owls for foraging, roosting, daily movements, dispersal, and potentially for nesting (Riparian Recovery Habitat) and riparian forests that are not regularly used by owls, but that may occasionally provide stepping stones for movement between population segments or be used by owls during the non-breeding season (Other Riparian Forest). Riparian Recovery Habitats are considered to be a key habitat for owl recovery. Other Riparian Forests may facilitate long-term gene flow, provide connections among EMUs, and/or facilitate survival of owls during winter.

c. Key to Forest Types Referenced in the Recovery Plan

Note: Bold-faced names on the right side of the key are identified forest cover types. Numbers on the right side refer the user to the corresponding number on the left side of the key.

1.	Trees deciduous and broadleaved, often confined to floodplain, drainage, or canyon bottom (Layser and Schubert 1979)	**Riparian Forest**
1.	Dominant trees evergreen and/or needle-leaved	2
2a.	Series = Douglas-fir, white fir, limber pine or blue spruce	3
2b.	Series not as above	5
3a.	>80% of dominant and codominant trees are species other than Douglas-fir, white fir, southwestern white pine, limber pine, or blue spruce	**Classify by Dominant Species**
3b.	Stand not as above	4

4a.	Aspen contributes >50% of stand BA	**Quaking Aspen Forest**
4b.	Not as above	**Mixed-Conifer Forest**
5a.	Series = Chihuahuan pine	**Pine-oak Forest**
5b.	Series not as above	6
6a.	Series = Ponderosa pine	7
6b.	Series not as above	10
7a.	Habitat type or phase includes Gambel oak	8
7b.	Not as above	**Ponderosa Pine Forest**
8a.	Area is located within UGM EMU, BRW EMU, or the southeastern portion of the CP EMU (Zuni Mountains, Mount Taylor)	9
8b.	Area not located as above	**Ponderosa Pine Forest**
9a.	>10% of stand BA or 4.6 m^2/ha (20 ft^2/ac) consists of Gambel oak >13 cm (5 in) in diameter at root collar	**Pine-oak Forest**
9b.	Not as above	**Ponderosa Pine Forest**
10a.	Series = bristlecone pine, Englemann spruce, or corkbark fir	11
10b.	Series not as above	13
11a.	Stand can be defined as pure for bristlecone pine, Englemann spruce, or corkbark fir	**Spruce-fir Forest**
11b.	Stand not as above	12
12a.	Bristlecone pine, Englemann spruce, or corkbark fir contribute >50% of the stand BA, either singly or in combination	**Spruce-fir Forest**
12b.	Stand not as above	**Mixed-conifer Forest**
13a.	Stand located in BRW EMU	14
13b.	Stand not located as above	**Other**

14a.	A plurality of stand BA is contributed by ponderosa pine, Englemann spruce, or Chihuahuan pine, either singly or in combination	15
14b.	Stand not as above	**Other**
15a.	>10% of stand BA or 4.6 m2/ha (20 ft^2 ac) consists of any oak >13 cm (5 in) in diameter at root collar	**Pine-oak Forest**
15b.	Stand not as above	**Other**

d. Defininition of Rocky-Canyon Habitat

Mexican spotted owls occupy rocky-canyon habitats that differ in many ways from forest habitats. Although rocky-canyon habitat is primarily located within the CP EMU, structurally similar canyon habitats also occur within other EMUs. Review of available studies suggests several habitat characteristics are closely associated with owl sites in rocky-canyon environments, especially steep canyon walls with large vertical cliffs. Cliff faces contain numerous caves and ledges that create protected microsites for nesting and roosting, and canyon walls are typically dissected by narrow, tributary canyons that provide relatively cool and humid roost and nest sites. In essence, rocky cliffs and slot canyons provide complex nesting and roosting habitat structure similar to that typically associated with late-seral forest (Rinkevich and Gutiérrez 1996, Johnson 1997, Willey 1998a).

Rocky-canyon environments that provide nest, roost, and foraging habitats for Mexican spotted owls are diverse, but also possess common emergent properties. These rocky-canyon habitats are associated with complex vertical and horizontal landscape structure, complex geomorphology, and canyon-forming geologic substrates. Rocky-canyon habitat is typically defined by:

1) Canyon walls comprised of steep cliffs that usually extend for at least 1 km (0.6 mi) along parallel sides of the canyon reach (Willey et al. 2007).

2) Relatively narrow canyon widths (<1 km rim to rim) (Willey 1998b).

3) Presence of large cliff faces (normally >15-m [16.25-yd] tall and ~ 90 deg. slopes) with complex vertical structuring including numerous ledges and caves that provide locations with cool and shaded microclimates (D. Willey, Montana State University, pers. comm.).

4) Key geologic layers that form steep, narrow entrenched canyon and cliff complexes. On the CP these formations generally consist of hard sandstones or limestone, but other forms of bedrock can create these conditions within the range of the owl.

5) Forest vegetation, when present, that includes riparian, mixed-conifer, ponderosa pine, pine-oak, or pinyon-juniper woodland. Late seral conditions including large trees and multi-storied canopies typically dominate.

Willey and Spotskey (2000) and Willey et al. (2007) developed Geographic Information Systems (GIS)-based regression models that predicted the potential distribution of nest and roost habitat in Utah. Those models were parameterized using variables that represented the habitat characteristics outlined above. GIS maps produced by these models provided an approximation of the distribution and extent of habitats that meet characteristics defining the rocky-canyon habitat. Similar GIS models are available for managers working in other areas where owls are using rocky-canyon habitat (e.g., Johnson 2003, Mullet 2008).

3. General Management Recommendations

Here, we provide general management recommendations for the Mexican spotted owl. These recommendations apply throughout the range of the owl, although specific recommendations will be more applicable to some locations than others. We provide additional management recommendations specific to particular threats below and emphasize management priorities in sections on individual EMUs (see Part II.C of Recovery Plan), when warranted by differences among EMUs.

General management recommendations focus on three categories relative to land management: Protected Activity Centers (PACs), Recovery Habitat, and Other Forest and Woodland Types. These categories are discussed below.

PACs are established around owl sites (defined below) and are intended to protect and maintain occupied owl habitat. Given our lack of experience and demonstrated expertise in purposely creating the forest structure used by owls, the recommendations for PACs focus on minimizing management. We recognize that these areas cannot be set aside and protected indefinitely, but we regard this as an appropriate interim strategy pending recovery of the species and development of a long-term management plan.

Recovery Habitat occurs in forest types and in rocky canyons used by owls for roosting, foraging, dispersal, and other life history needs, but outside of PACs. Recovery Habitat is intended to: 1) provide protection for areas that may be used by owls; 2) foster creation of roost/nest habitat; 3) simultaneously provide managers with greater management flexibility than is allowed in PACs; and, 4) facilitate development and testing of management strategies that could be applied in PACs.

Areas not classified as either PACs or Recovery Habitats are classified as “Other Forest and Woodland Types” and “Other Riparian Forest Types” for purposes of this plan. These generally include forest, woodland, or other habitat types that appear to be little used by nesting owls but are likely used for foraging and dispersal. Given their relatively limited importance to nesting owls, we propose no owl-specific recommendations in these forest types.

Thus, management recommendations proposed here are tightly targeted, with relatively strict guidelines proposed for occupied roost/nest habitat, flexible guidelines proposed for other areas with potential for use by owls, and no owl-specific guidelines proposed for large portions of the landscape little used by owls. Our intent is to protect the owl and its habitat while

simultaneously minimizing conflicts with management for other resource objectives. PACs and Recovery Habitat under this plan comprise only a portion of the landscape (Box C.2).

a. Protected Activity Centers (PACs)

PACs are intended to sustain and enhance areas that are presently, recently, or historically occupied by breeding Mexican spotted owls. Minimum PAC area is 243 ha (600 ac; see below) and is based on the median size of the adaptive kernel contour enclosing 75% of the foraging locations for 14 pairs of radio-marked owls (241 ha [595 ac)]; Ganey and Dick 1995). Thus, PACS protect activity centers used by owls rather than entire home ranges. Consequently, there is no upper limit for PAC sizes; managers may create larger PACs if it is deemed appropriate.

All PACS should contain a designated 40-ha (100 ac) nest/roost core area, designed to offer additional protection to the nest or primary roost areas (see below). We emphasize protection of habitat used for nesting and roosting within PACs because the owls are most selective for such habitat (Ganey and Dick 1995; Appendix B) and these forest conditions are most limited across the landscape. These areas also provide resources to meet other life-history needs of the owl.

Protection of owl habitat does not always mean a hands-off approach. In some situations, protection of PACs may require active management in forested habitat to reduce fuel loads and fuel continuity in areas adjacent to and within these areas to reduce potential for high severity and stand-replacement fires. Treatments should be located strategically and informed by fire behavior modeling across the greater landscape. Results of such modeling will allow managers to optimize placement of treatments, thus ensuring maximum reduction in risk of severe fires while simultaneously minimizing area treated in PACs. In many cases, strategic treatments on surrounding and/or adjoining lands will reduce fire risk sufficiently so that, in the short term, treatments are not needed within PACs (Ager et al. 2007, Finney et al. 2007, Ager et al. 2010). Where fuels treatments are deemed necessary within PACs, managers must balance fuels reduction goals with short- and long-term conservation of owl habitat, recognizing that drastic alterations to PACs may render them of lesser value for Mexican spotted owls, at least in the short term.

The following guidelines pertain to the designation and management of PACs and supersede all other guidelines within the 1995 Recovery Plan:

i. Where Should PACs Be Established?

Survey any area that could be occupied by nesting spotted owls (i.e., mixed-conifer, pine-oak, or riparian forest and/or rocky canyons) using the established survey protocol (Appendix D) before implementing any management action that will alter habitat structure or influence owl behavior. Establish PACs at all Mexican spotted owl sites (see Box C.1 for site definition) through the life of the Recovery Plan. Exceptions to PAC establishment or continuance are possible; we discuss these situations below. PACs also should be established at historical sites (i.e., sites documented by professional wildlife biologists) that meet our definition of an owl site. Historical sites that do not meet our definition of an owl site may not require a PAC (see below: f. Can PACs Be Decommissioned?).

BOX C.1. DEFINING OWL SITES

Our definition of a Mexican spotted owl site strives to achieve a balance between being overly inclusive and overly exclusive. An overly inclusive definition could result in Protected Activity Centers (PACs) where they are not needed; an example might be the detection of a transient owl. In contrast, an overly exclusive definition could result in failure to designate a PAC in an area occupied by ≥1 Mexican spotted owl. While recognizing the need for balance, we also recognize serious consequences of failing to properly manage occupied owl habitat as the result of an overly exclusive definition. With those considerations in mind, we consider an owl location to be a "site," and thus eligible for PAC designation, if any of the following scenarios occur:

1. One daytime location (visual or auditory) of ≥1 adult or subadult Mexican spotted owl(s) within the breeding season (Mar-Aug);
2. Two nighttime auditory detections within 500-m (0.31-mi) of each other during the breeding season (Mar-Aug), separated by at least one week;
3. Two owls of different sexes heard on the same night within 500-m (0.31-mi) of each other; or
4. Locating one or more owls hatched during that breeding season (young-of-the-year) prior to 1 September.

The above criteria assume that daytime detections provide stronger evidence of owl residency than nocturnal detections, and that little dispersal occurs during the survey season. These assumptions are supported in the literature. The 500-m (0.31-mi) distance seems reasonable based on current knowledge of movement patterns of radio-marked owls and results of demographic studies involving uniquely banded owls.

PACs are intended to protect the activity center of a single owl territory. Therefore, these criteria should *not* be interpreted to mean that multiple PACs need be drawn in areas where multiple detections may represent a single owl territory. In such cases, biologists should use their professional judgment in determining whether or not additional PACs are necessary or in creating PACs larger than 243 ha (600 ac). If biologists from land-management agencies are unsure how best to proceed, we encourage them to work with the appropriate FWS offices and the state wildlife agency in designating PACs.

A long-pending question has been whether high-elevation forest (>2,440 m [8,000 ft]) in CP and SRM EMUs should be surveyed or treated as potential habitat (see Box.C.3). We evaluated what is known about use by owls of high-elevation, mixed-conifer forest in the CP and SRM EMUs. Given information provided from the North Kaibab Ranger District, Dixie National Forest, Carson National Forest, and SRM-CO Working Team, it appears that use of high elevation forest varies. We know of few records of breeding owls above 2,740 m (9,000 ft) west of US Highway 191 in Arizona and Utah. Those found in CP tended to be on the Cibola National Forest in New Mexico, which is east of US Highway 191, but very few owls were found in the high-elevation forests of Utah. Records exist of owls breeding at elevations above 2,740 m (9,000 ft) in SRM EMU. Based on this information, surveys are not recommended for forested Mexican spotted owl habitat above 2,740 m (9,000 ft) occurring west of US Highway 191. Surveys in this region would still be required for forests below 2,740 m (9,000 ft). These areas should still be managed as Recovery Habitat (see discussion below) anticipating that owls and their habitat might shift both north and upwards in elevation as climate changes. Range-wide management recommendations (including the need to survey for owls) for mixed-conifer forest should remain in place for CP east of US Highway 191 and for SRM EMU.

ii. How Should PACs and Core Areas Within PACs Be Established?

1) Identify an activity center around which to designate a PAC. The activity center is defined here as a nest site or a roost grove or cliff area commonly used during the breeding season in absence of a verified nest site, or as the best potential roosting/nesting habitat if both nesting and roosting information are lacking. Site identification should be based on the best judgment of a biologist familiar with the area. Lacking radio-marked birds, spotted owl surveys conducted to locate nests, pairs, or young generally provide the best information for defining activity centers (Ward and Salas 2000).

2) Delineate a PAC at least 243 ha (600 ac) in area configured around the activity center. In areas that are mostly forested, construct PACs as compactly as possible to include the best owl habitat roughly centered on the activity center. Boundaries of the PAC should correspond to habitat polygons and/or topographic features, such as ridgelines or canyon rims, as appropriate. The PAC should include as much roost/nest habitat as is necessary to buffer the activity center, supplemented by potential foraging habitat. For example, in a forested area containing mixed conifer on north-facing slopes and ponderosa pine on south-facing slopes, it may be prudent to include some south-facing slopes as potential foraging habitat rather than 243 ha (600 ac) of north-slope habitat. In many rocky-canyon environments, more complex or linear PACs along the canyon axis will better represent owl habitat than creating circular PACs. The PAC polygons should include opposing canyon slopes and may include some habitat along canyon rims as well (e.g., Bowden 2008), but most PAC area should consist of area below the canyon rim where owls spend approximately 88% of their time (Willey and Van Riper 2007).

3) Within the PAC, designate 40 ha (100 ac) arranged around the activity center. This is identified in paragraph a. above. This nest/roost core area should include habitat that resembles the structural and/or floristic characteristics of the nest and/or roost sites as much as possible. The intent of the core area is to define parts of the PAC that should receive

maximum protection by limiting activities that have a high likelihood of disturbing owls or causing abandonment (primarily habitat alteration and certain forms of mechanical noise). The boundary of the core area should be drawn to include features commonly used by these owls for roosting and nesting (e.g., areas with concentration of conifers or oaks >46 cm [18 inches] diameter, or cliffs with ledges and caves or riparian vegetation, first or second order drainage basins [Ward and Salas 2000]). Cores should be one contiguous polygon unless site-specific information indicates that two or more areas would better meet the intent of core areas. In such cases, coordination with the appropriate FWS office is recommended. If a nest cannot be found, other evidence can be used to designate the core area (see Box C.4).

4) In general, boundaries of adjacent PACs may abut but not overlap. In some local areas of high owl density, this may be difficult to accomplish. In such cases, exceptions to this guideline can be negotiated in consultation with FWS.

5) PACs may be larger than 243 ha (600 ac) if deemed appropriate. Larger PACs may be needed to protect owls that shift activity centers across years or in other special situations. Over time, occupants of a PAC may be replaced by new owls, and the new owls may use different nest or roost groves or canyon sections. If the new owls are found outside of a nearby PAC and the former occupants are not located, the biologist must decide whether to establish a new PAC or enlarge the old one. Where owls are found outside of an unoccupied PAC but within 400 m (0.25 mi) of its boundary, the original PAC should be enlarged to include the new owls unless surveys verify that two PACs are needed for two different owls or pairs. If an owl or pair is found roosting beyond 400 m (0.25 mi) of an existing PAC boundary, a new PAC should be established. In this case, the former PAC should be retained as well, unless it meets criteria described in e, below.

iii. What Activities Are Allowed in PACs Outside of Core Areas?

1) All activities within PACs should be coordinated with the appropriate FWS office.

2) No mechanical or prescribed fire treatments should occur within PACs during the breeding season unless non-breeding is inferred or confirmed that year per the accepted protocol (Appendix D).

3) Removal of hardwoods, downed woody debris, snags, and other key habitat variables should occur only when compatible with owl habitat management objectives as documented through reasoned analysis.

4) Road or trail maintenance, repair, and building in PACs should be undertaken during the non-breeding season (1 Sep - 28 Feb) to minimize disturbance to owls unless non-breeding is inferred or confirmed that year per the accepted survey protocol (Appendix D). We recommend that no new roads or construction occur in PACs.

5) Within all PACs, light burning of surface and low-lying fuels may be allowed following careful review by biologists and fuel-management specialists. Generally, burns should be

done during the non-breeding season (1 Sep - 28 Feb) unless non-breeding is inferred or confirmed that year per the accepted protocol (Appendix D).

6) In some situations prescribed fire alone may be insufficient to reduce fuels and protect PACs. Mechanical treatments used singly or in combination with prescribe fire may be needed to reduce fire risk to owl nest/roost habitats and may enhance owl habitat. As a general guide, forest management programs in PACs should be structured as follows:

Strategic Placement of Treatments. Conduct a landscape-level risk assessment to strategically locate and prioritize mechanical treatment units to mitigate the risk of large wildland fires while minimizing impact to PACs. Treatments should also strive to mimic natural mosaic patterns.

Area Limitations. Mechanically treat as needed up to 20% of the non-core PAC area *within an EMU* identified through the landscape-level assessment. This landscape proportion may be allocated flexibly. That is, this does not mean that 20% of each PAC should be treated, or that only 20% of any PAC can be treated. Treatment placement and extent should be guided by fire modeling as discussed above.

Designate Nest/Roost Core. Within each PAC identified for treatment, designate a 40-ha (100-ac) nest/roost core area as described above.

Types of Treatments. Within the remaining PAC acreage (202+ ha [500+ ac]), combinations of mechanical and prescribed fire treatments may be used to reduce fire hazard while striving to maintain or improve habitat conditions for the owl and its prey (see desired conditions in Table C.2).

Seasonal Restrictions. Treatments should occur during the non-breeding season (1 Sep - 28 Feb) to minimize disturbance to resident owls during the breeding season, unless non-breeding is inferred or confirmed that year per the accepted survey protocol (Appendix D).

Monitoring Treatment Effects on Owls. Monitoring must be designed and implemented to evaluate effects of treatments on owls and retention of or movement towards desired conditions. The monitoring design must be rigorous and adhere to strict quality assurance/quality control standards. Designing such a monitoring study requires a coordinated effort across administrative units. Ideally, the monitoring design should be developed by a scientific committee and implemented by the action agencies. We do not advocate conducting this monitoring in every PAC that is treated; rather, subsets of the landscape (e.g., Four Forest Restoration Initiative, Sacramento Mountains) can be identified for the conduct of this monitoring and will inform fuels treatments within PACs in other locations. We recognize that there is much uncertainty regarding treatment effects and the risks to owl habitat with or without forest treatment. Box C.5 provides a framework for development of monitoring studies.

iv. What Activities Are Allowed Within Nest/Roost Core Areas in PACs?

1) All activities within PACs should be coordinated with the appropriate FWS office.

2) Management activities should be deferred from the nest/roost core during the breeding season (1 Mar - 31 Aug), except where non-breeding is confirmed or inferred that year per the accepted survey protocol (Appendix D).

3) Planned ignitions (prescribed fire) and unplanned ignitions (wildland fire) should be allowed to enter cores only if they are expected to burn with low fire severity and intensity. Fire lines, check-lines, backfiring, and similar fire management tactics can be used to reduce fire effects and to maintain key habitat elements (e.g., hardwoods, large downed logs, snags, and large trees).

4) Other activities should be conducted outside of the breeding season unless pressing reasons dictate otherwise. These activities include trail maintenance, road repair, removal of hazard trees, and utility-line maintenance. If the activity is conducted during the breeding season with owls present, owl locations should be known and documented during the conduct of the management action. Management actions should not be conducted in the vicinity of nesting owls, where vicinity is defined by the intensity of disturbance.

5) Research projects that evaluate effects of a specific activity on owl behavior or life history are allowed and in fact encouraged (see Part V.F). For example, determining the influence of noise disturbance would require that the activity is done close to roosting or nesting owls. These activities will require scientific permits from FWS and state or tribal wildlife agencies.

v. Should Salvage Logging Occur in PACs Impacted by Disturbance?

If a stand-replacing fire, windthrow event, or large-scale mortality due to insects or disease occurs within a PAC, timber salvage plans should be evaluated on a case-specific basis in consultation with the FWS. Salvage logging in PACs should be allowed only if sound ecological justification is provided and if the proposed actions meet the intent of this Recovery Plan, specifically to protect existing nest/roost habitat and accelerate the development of recovery nest/roost habitat. Management actions that do not protect soil integrity, that impede recovery of disturbed systems, or that fail to maintain and enhance native species and natural recovery processes should not be implemented (Betchta et al. 2004, Karr et al. 2004).

Fires within PACs are not always detrimental to owls. Patchy fires result in habitat heterogeneity and may benefit the owl and its prey (Bond et al. 2009). In such cases, adjustments to PAC boundaries are probably unnecessary and salvage should not be done. Salvage and boundary adjustments should be considered in PACs only when the disturbance is extensive in size and tree mortality is extensive and substantial. We make the following recommendations:

1) In all cases where salvage logging is being considered, the PAC and a buffer extending 400 m (433 yd) from the PAC boundary should be surveyed for owls before non-occupancy is inferred. This survey should occur during the breeding season following the fire or other large-scale mortality events and should adhere to the accepted protocol (Appendix D) except that it could be completed with four visits in a single season.

2) If owls are located within the PAC or within 400 m (433 yd) of the PAC boundary, then managers should evaluate the extent and severity of the disturbance and consider reconfiguring of PAC boundaries and potential modification of the proposed action in consultation with FWS.

3) If no owls are detected, Section 7 consultation should be used to evaluate the proposed salvage plans.

4) Salvage prescriptions should be designed to maintain or enhance the desired conditions described in Table C.2 and to minimize the spread of exotic invasive species.

5) New road construction should be avoided whenever possible, and temporary road and skid trail construction should be designed to minimize impacts on soil integrity and natural recovery processes. All new and temporary roads and skid trails should be decommissioned and obliterated after use.

vi. Can PACs Be Decommissioned?

In general, PACs should not be decommissioned. Once a PAC has been established it should remain in place, with a few exceptions discussed below. Site occupancy by Mexican spotted owls is related to owl density, and owl density changes over time (e.g., Seamans et al. 1999). As a result, a territory may be occupied during periods of high owl density and vacant during periods of lower density. Therefore, failure to detect owls in one or even a few years does not necessarily indicate that an area no longer provides useful habitat, or that protecting such habitat is inappropriate. Some circumstances may warrant removing areas from being managed as PACs, however. These situations are:

1) Situations where PACs were established or converted from previously established management territories using less stringent criteria than the criteria we recommend for defining owl sites (Box C.1) and surveys conducted post-establishment have failed to detect owls.

2) Situations where vegetation within a PAC was altered substantially by wildland fire, insect kill, windthrow, or similar disturbances to the extent that they would not be expected to support breeding owls, and non-occupancy is documented through surveys conducted to protocol (Appendix D).

vii. How Can PACs Be Decommissioned?

When PACs were designated based on information that does not meet the Recovery Plan definition for an owl site, then:

1) Coordinate with the appropriate FWS office when considering removing PAC status.

2) If surveys were conducted according to the accepted protocol (Appendix D) and owl-site criteria were not met, then no PAC is necessary. For historical locations that have not been surveyed according to the accepted protocol, surveys should be conducted following the accepted protocol.

   Retaining PAC Designation. If owls are detected and these detections meet Recovery Plan criteria for an owl site, PAC status should remain in place. In this situation, if new survey information supports adjusting PAC boundaries, adjustments should be made.

Removing PAC Designation. If no owls are detected during these surveys, PAC designation can be removed. Once the PAC is removed, the area should be managed according to other designations, namely Recovery Habitat or Other Forest and Woodland Types, as appropriate.

3) In areas that have undergone extensive vegetation change to the point that land managers question the ability of the area to function as a PAC, then:

Contact FWS. Coordinate with the appropriate FWS office when considering removing PAC status.

Survey for Owls. The area should be resurveyed for owls using the accepted survey protocol (Appendix D). If no owls are located, then changes in PAC designation should be considered on a case-specific basis. If owls are found, the PAC should remain, although adjustments to the boundaries can be considered where appropriate based on survey results and landscape configuration.

viii. Rationale Underlying PAC Guidelines

We recognize that landscapes are dynamic. The intent of these guidelines is not to preserve designated PACs forever, but to protect them until it can be demonstrated that recovery nest/roost habitat can be created through active management and/or the owl is delisted. In the following section (Recovery Habitat) we describe one approach for managing to create nest/roost habitat. Once that approach or other approaches have been shown to be effective in creating or enhancing the types of habitat structure used by owls, the PAC concept could be abandoned in favor of a long-term management plan based on maintaining owl habitat well-distributed across a dynamic landscape. Until such an approach has been tested and such a plan is in place, however, we believe it wise to continue to protect occupied owl habitat using the current approach.

We recognize that protection status carries some risk with respect to probabilities of stand-replacing fire. We believe that PACs can be afforded substantial protection by emphasizing fuels reduction and forest restoration in surrounding areas outside of PACs and nest/roost habitat. However, we recognize that in some cases protection of nest/roost habitat and human communities requires reduction of fuels loads and disruption of fuel continuity within PACs. We provide guidance for such treatments above, and urge a deliberate and cautious approach to such activities within PACs emphasizing monitoring and feedback loops to allow management to be adaptive.

b. Recovery Habitat

The PAC guidelines discussed above are intended to protect the core use or activity centers of resident owls. In focusing on activity centers, however, those guidelines do not provide protection to all areas within owl home ranges; most owl home ranges are considerably larger than 243 ha (600 ac). Further, owls may use areas outside of their usual home ranges at times. Examples include seasonal migration or adult and juvenile dispersal. Finally, it seems logical to strive to provide additional habitat in planning for recovery of a threatened species, as increasing population size is a logical goal of recovery efforts and providing additional habitat is one way to accomplish this. This is particularly true given uncertainty over the effects of climate change on

habitat quantity, quality, and distribution. Additional habitat well-distributed across the landscape may be needed to offset unpredictable changes in quantity, quality, and distribution of owl habitat. Consequently, here we provide additional guidelines focused on what we term Recovery Habitat. These guidelines are intended to maintain and develop nesting and roosting habitat now and into the future, and are stratified by two broad categories: Forested Recovery Habitat and Riparian Recovery Habitat.

i. Forested Recovery Habitat

Forested Recovery Habitat occurs in mixed-conifer and pine-oak forests (see definitions in Appendix C.2) that are not included in PACs. Our primary intent here is to maintain and create recovery nest/roost owl habitat where appropriate, while providing for both diversity in ecological conditions across the landscape and flexibility for managers. As noted earlier, we assume that the primary limiting factor for Mexican spotted owls in forests is the amount and distribution of nesting and rooting habitat, but we also assume that these habitats provide key foraging habitat as well. A logical conclusion from this premise is that the landscape should be managed to sustain owl nesting/roosting habitat that is well-distributed spatially. This does not mean that all forests should be managed as recovery nest/roost habitat. Rather, we recommend that a portion of the landscape should be managed for conditions suitable for nesting and roosting, and that portion differs among EMUs (see Tables C.2, C.3). We recognize that nest/roost habitat cannot be sustained in perpetuity at specific sites, and that nest/roost habitat will continue to be lost to senescence and human and natural disturbance. We assume that providing a dynamic supply of nesting and roosting habitat requires that various parts of the landscape be in various stages of ecological succession. Our goal is to allocate those stages so as to create a landscape mosaic that ensures adequate nesting, roosting, and foraging habitat for the owl, as well as providing habitats for its major prey.

Managing forested Recovery Habitat requires knowledge of both existing and desired conditions. Ideally, existing conditions should be assessed at multiple spatial scales (Kaufmann et al. 1994). We recognize that information needed to conduct assessments at larger spatial scales frequently is lacking. We encourage agencies to develop the types of information needed for such large-scale assessments, however, and note that such information will be necessary to move from recovery guidelines based on protecting habitat to guidelines based on managing dynamic landscapes.

In reality, most short-term assessments will focus on evaluating forest structure at the scale of individual forest stands. In particular, existing vegetative conditions within mature-old stands must be assessed to determine the treatment potentials within those stands. Given the relatively high frequency of recent stand-altering disturbances, many areas likely are deficient in mature to old-growth forests. Thus, any treatments to these stands should be applied judiciously.

1) Reference Conditions: Nesting and Roosting Conditions in Forested Environments

We defined reference conditions for management in Forested Recovery Habitat based on current knowledge of forests used by spotted owls. Forest stands used by spotted owls for nesting and roosting have certain structural features in common. These typically include relatively high tree

BA, large trees, multi-storied canopy, multi-aged trees, high canopy cover, and decadence in the form of downed logs and snags (Ganey and Dick 1995). Many stands also contain a prominent hardwood component. This is generally provided by Gambel oak in ponderosa pine-Gambel oak forests, by a variety of evergreen oaks and madrone in Madrean pine-oak forests, and by various species (e.g., oaks, maples, boxelder, aspen) in mixed-conifer and montane riparian forests.

We used tree BA and large tree (>46 cm [18 inches] dbh) density to describe minimum conditions for owl nesting/roosting habitat (Table C.3). Other structures such as canopy cover, snags, and downed logs are important as well. However, we assume that when tree BA and density approach the levels given in Table C.3, then adequate amounts of canopy cover, snags, and downed logs either exist already or will develop over time. See Box C.7 for a description of how Table C.3 parameters were developed.

2) Recovery Habitat Guidelines for Forest Habitats: General Approach

For planning purposes in Forested Recovery Habitat, there are two types of stands with respect to desired nest/roost conditions: those that meet or exceed the conditions and those that do not. The overriding goal is to manage a specified portion of the landscape (see Table C.3) as recovery nest/roost habitat. Thus, managers should identify and protect stands that meet or exceed nest/roost conditions and then assess whether or not these stands satisfy the area requirements in Table C.3. If these stands are not sufficient to meet the area requirements in Table C.3, managers should identify those stands in the planning area that come closest to meeting nest/roost conditions and manage those stands to develop nest/roost conditions as rapidly as reasonably possible to meet recommended percentages. Prescriptions may include thinning to promote growth of large trees. Stands that do not meet nest/roost conditions and are not designated for development of such can be managed to meet other resource objectives.

Because most project planning occurs at limited spatial scales, the percentages of area in Table C.3 should be regarded as a **minimum** level for a given planning area. If a deficit occurs within the planning area, additional stands should be identified and managed as described above. Even if the proportion of the planning area that meets nest/roost conditions is greater than the percentages in Table C.3, we recommend that no stands be lowered below these conditions until ecosystem assessments at larger spatial scales (e.g., landscape, subregion, and region) demonstrate that desired conditions occur in recommended amounts at these larger scales. Using watersheds in allocating percentages of area to manage for nest/roost conditions should reduce the potential for creating excessively fragmented nesting habitat.

3) Guidelines for Forested Recovery Habitat Managed as Nest/Roost Habitat

Treatments are allowed within Recovery Habitat stands identified as meeting nest/roost conditions, as long as stand conditions remain at or above the values given in Table C.3 in (but see discussion under "Treatments Within Recovery Nest/Roost Stands" below). This approach allows for treatments to reduce fire risks, lessen insect or disease problems, maintain seral species, or meet other ecosystem objectives. Management activities that influence the owl and its habitat should be conducted according to the following guidelines:

Manage for Nest/Roost Habitat. Manage mixed-conifer and pine-oak forest types in the designated proportions of Table C.3 to provide continuous nest/roost habitat over space and time. Management of particular stands should be based on their capability to attain the desired conditions (Table C.2).

Treatments Within Recovery Nest/Roost Stands. No stand that meets Table C.3 conditions should be treated in such a way as to lower that stand below those conditions until ecosystem assessments can document that a surplus of these stands exist at larger landscape levels (e.g., no less than the size of a FS District). This does not preclude use of treatments to reduce fire risks or lessen insect or disease problems, nor does it preclude management to meet other ecosystem objectives, as long as stand-level conditions remain at or above the values given in Table C.3.

Select Appropriate Stands to Manage. Management should emphasize attainment of nest/roost conditions as quickly as reasonably possible. Identify and assign stands that will reach these conditions soonest to satisfy area requirements in Table C.3.

Retain Large Trees. Stand conditions that provide the owl's nesting habitat frequently vary above the minimum values given in Table C.3. Further, important stand conditions cannot be replaced quickly. In particular, removing large trees in a stand identified as habitat could reduce its suitability as nesting habitat or increase the time required to develop suitable nesting habitat. Because it takes many years for trees to reach large size, we recommend that trees ≥46- cm (18 inches) dbh not be removed in stands designated as recovery nest/roost habitat unless there are compelling safety reasons to do so or if it can be demonstrated that removal of those trees will not be detrimental to owl habitat.

Strive for Spatial Heterogeneity. Incorporate natural variation, such as irregular tree spacing and various stand/patch/group/clump sizes, into management prescriptions. Strive for heterogeneity both within and between stands. Owls currently use uneven-aged stands, and we do not know if landscapes composed of even-aged clumps will provide suitable owl habitat; this idea should be evaluated as described in Box C.5 before wide-scale implementation of management based on even-aged clumps. Attempt to mimic natural disturbance patterns and natural landscape heterogeneity. Allow natural canopy gap processes to occur, or mimic those processes through active management, thus producing horizontal variation in stand structure.

Manage for Species Diversity. Maintain all species of native vegetation on the landscape, including early seral species. Allow for variation in existing stand structures and provide for species diversity.

Emphasize Large Hardwoods. Within pine-oak and other forest types where hardwoods are a component of owl habitat, emphasis should be placed on management that retains, and promotes the growth of additional, large hardwoods.

4) Guidelines for Forested Recovery Foraging/Non-breeding Habitat

The following guidelines are intended to minimize threats to Mexican spotted owls within Forested Recovery Habitat not managed as nest/roost habitat (i.e., habitat that does or could provide foraging, dispersal, or winter habitat). Although we emphasize fuels and restoration treatments, these guidelines are applicable to other management scenarios as well. Our intent is to manage Recovery Habitat so that important but difficult-to-replace habitat elements are conserved while allowing management flexibility. Management should strive to maintain

conditions where multiple components occur in proximity to one another. For example, if a stand contains large trees, logs, and snags, prescriptions should be designed to keep as many of these components as possible while achieving management objectives such as fuels reduction and ecosystem restoration. Such prescriptions can result in the short-term reductions of key habitat components, but they should strive to maintain some of these components within the stand. Unfortunately, specific targets or quantities of these components to maintain cannot be provided because research has not been conducted to address this information need. Ideally, research in the form of management experiments will address this knowledge gap. In the meantime, management should be based on the best judgment of the professionals involved to balance our intent with the objective(s) of the prescription.

We provide the following guidelines for Recovery foraging/non-breeding habitats:

Emphasize Large Hardwoods. Within pine-oak and other forest types where hardwoods are a component of owl habitat, emphasis should be placed on management that retains, and promotes the growth of additional, large hardwoods.

Retain Large Trees. Strive to retain (do not cut) all trees >61 cm (> 24 in) dbh, the average diameter of nest trees, unless overriding management situations require their removal to protect human safety and/or property (e.g., the removal of hazard trees along roads, in campgrounds, and along power lines), or in situations where leaving large trees precludes reducing threats to owl habitat (e.g., creating a fuel break). To the extent practical, fuel breaks should be designed to avoid the removal of larger trees (trees over 18 in [46 cm] dbh). We recognize that prescribed fire is an inexact tool and that applying prescribed fire may result in the loss of large trees. However, we strongly recommend that action agencies take reasonable steps to minimize the loss of trees >61 cm (24 in) dbh. Steps can include using light burn prescriptions and removal of ladder fuels proximal to large trees. Even with such actions, some large trees may be killed. This should not preclude proceeding with necessary treatments. Large trees killed by fire will provide a source for recruitment of large snags and eventual large logs; these snags should be retained unless their removal is necessary for public or worker safety.

Retain Key Owl Habitat Elements. Design and implement management treatments within Forested Recovery Foraging/Non-breeding habitat so that most hardwoods, large snags (>46 cm [18 in] dbh), large downed logs (>46 cm [18 in] diameter at any point), trees (>46 cm [18 in] dbh) are retained, unless this conflicts with forest restoration and/or owl habitat enhancement goals. Treatments adequate to meet fuels and restoration management objectives in Recovery Habitats may result in the short-term loss of some habitat components in areas that could be occupied by spotted owls. We view these losses as acceptable where they result from actions that otherwise further longer-term protection and sustainability of forests occupied by owls. When implementing this guideline, managers should strive to achieve a balance between retaining a sufficient density and distribution of important features that spotted owls may require and reducing the risk of losing existing roosting and nesting habitat from insect epidemics and stand-replacing fires. Previous wording of this guideline (USDI FWS 1995) was interpreted to mean that trees >46 cm (18-in) dbh may not be removed. That is not our intent. However, large trees are a key habitat correlate for owls, and removal of such trees should be done judiciously and only when truly necessary to meet specific resource objectives.

5) Rationale for Recovery Habitat Guidelines

The collective goal of guidelines for Forested Recovery Habitat is to provide spotted owl habitat that is well distributed over space and time. Accomplishing this goal requires maintaining or creating stand structures typical of nesting and roosting habitats, and sustaining them in sufficient amounts and distribution to support a healthy population of Mexican spotted owls. The approach outlined above provides a template for the development of a long-term management strategy that recognizes and incorporates landscape dynamics. If this approach can be validated, it may be possible to replace short-term protection of owl habitat with a longer-term approach that incorporates the dynamic nature of natural landscapes.

ii. Riparian Recovery Habitat

Riparian forests are plant communities affected by surface and subsurface hydrologic features of perennial or intermittent water bodies (e.g., rivers, streams, lakes). Riparian forests have one or both of these principle characteristics: 1) distinctively different tree and shrub species than the adjacent areas and/or 2) tree species similar to adjacent areas but exhibiting more vigorous or robust growth forms (FWS 2009). Riparian forests typically create transition zones or ecotones between water bodies and upland areas (Naiman and Décamps 1997, FWS 2009). These ecotones makes riparian habitats among the most ecologically productive and diverse terrestrial environments in the arid western United States and Mexico (Naiman et al. 1993). Because of their productivity and diversity, because they differ in important ways from other habitats occupied by spotted owls, and because recommendations for riparian habitats in the original Recovery Plan (USDI FWS 1995) were so broad that they caused considerable confusion, we discuss riparian communities separately here. Our primary focus is on forested riparian areas, because these areas are most likely to provide the habitat structure used for nesting, roosting, foraging, and dispersal (e.g., Ganey and Dick 1995, Stacey and Hodgson 1999).

We distinguish between Riparian Recovery Habitat and Other Riparian Forests. Riparian Recovery Habitat consists of riparian forests outside of PACs that could frequently be used by owls for foraging, roosting, daily movements, dispersal, and potentially for nesting. Riparian Recovery Habitat is considered to be a key habitat for owl recovery. Other Riparian Forests are not regularly used by owls, but may occasionally provide stepping stones for movement between population segments or be used by owls during the non-breeding season. These forests may facilitate long-term gene flow, provide connections among EMUs, and/or facilitate survival of owls during winter. We recommend that Other Riparian Forests be managed similarly to Other Forest and Woodland Types.

1) Threats to Riparian Recovery Habitat

Riparian habitats are threatened by a long list of anthropogenic activities and natural events (see discussion in II.H.3). Our focus is on the influences described in that section and that fall within the temporal scope of this plan. We also note that improper management of adjacent upland habitat types can threaten riparian habitats. However, management of adjacent upland forests for proper functioning ecological condition (e.g., soil retention) and Recovery Habitat removes this threat. While the definition of PFC for riparian areas may vary somewhat by management

agency, we provide the definition from USDI BLM (1998) as an example: "Proper Functioning Condition - Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity. The functioning condition of riparian-wetland areas is a result of interaction among geology, soil, water, and vegetation."

2) Guidelines for Riparian Recovery Habitat

Specific recommendations to address threats and maintain or restore riparian habitats include:

Manage for Proper Functioning Condition. Manage for PFC to attain the highest ecological status and potential natural community structure (i.e., mid- to late-seral conditions) possible within the capability and potential of the site. Attaining the goals described, dependent on site potential, should benefit habitat for the owl (e.g., regeneration of riparian tree cover) and its prey species (e.g., provide dense ground cover for small mammals).

Manage for Species Diversity. Manage for a diversity of age and size classes of native riparian trees and shrubs along with a diverse understory of native riparian herbaceous species to provide potential roost/nest sites for owls and cover for owl prey species.

Manage Grazing Effects. Where needed, minimize negative impacts of ungulate grazing on riparian vegetation by modifying livestock grazing systems (i.e., changing seasons and duration of use, establishment of riparian pastures, and providing periods of complete rest), reducing grazing pressure by livestock and wild ungulates through stocking and population management, and/or establishing riparian exclosures (i.e., either livestock or livestock/wildlife ungulate exclosures).

Minimize Construction Activities. Avoid construction activities (e.g., road or trail building) in recovery riparian areas except on a case-specific basis where pressing management needs can be demonstrated.

Selective Tree Removal. Minimize effects of tree removal by eliminating removal where possible or by restricting removal so that habitat components (e.g., large trees, snags, and large downed logs) are conserved. We support the use of vegetation manipulation, especially removal of non-native vegetation, as a tool to restore, enhance, or maintain riparian conditions. Thus, thinning trees and shrubs is encouraged where such thinning restores properly functioning condition and improves the habitat or protects it against stand-replacing fire.

c. Other Forest and Woodland and Other Riparian Forest Types

We propose no specific guidelines for several forest and woodland community and other riparian forest types where they occur outside PACs. These include ponderosa pine, spruce-fir, pinyon-juniper, aspen, and other riparian forest types (as defined above). However, the lack of specific

management guidelines within this plan does not imply that these forest and woodland and riparian types are unimportant to the Mexican spotted owl.

The lack of specific recommendations in other forest and woodland types is based on extant information on the natural history of the Mexican spotted owl as summarized in Appendix B and detailed in the original Recovery Plan (USDI FWS 1995). These other forests and woodlands typically are not used for nesting and roosting but do provide habitat for foraging, dispersing, and wintering spotted owls. Although information on habitat features needed for foraging, dispersing, and wintering is limited, it appears that owls use a broad array of conditions to meet these needs. Furthermore, some of the best foraging habitat should be protected in PACs and Recovery Habitat. Consequently, we can be less restrictive in these other forest and woodland community types without harming the owl or compromising its primary habitat.

We assume that existing and planned management for these forest and woodland types will maintain or improve habitat for these needs of the owl. Our assumption is based largely on the premise that existing, late-seral stands will be maintained or restored where necessary across the landscape, silvicultural practices will favor uneven-aged over even-aged cuts, and management will be guided by ecosystem approaches that strive to provide sustainable conditions, which fall within the natural range of variation, across the landscape. Guidelines developed for PACs and Recovery Habitat may have useful applications when judiciously administered in these other forest and woodland types. Such guidelines include managing for landscape diversity, mimicking natural disturbance patterns, incorporating natural variation in stand conditions, retaining special features such as snags and large trees, and utilizing fire as appropriate. We also emphasize the need for proactive fuels management where appropriate. Decreasing fire risks within these types, particularly ponderosa-pine forests, also will decrease fire risks to adjoining PACs and Recovery Habitats by reducing the probability of large, landscape-level crown fires that could impinge upon occupied or potential nesting habitat.

Other Riparian Forests currently do not appear to be used for nesting and breeding season roosting but may provide habitat for dispersing and wintering spotted owls. As such, and similar to recommendations for Other Forest and Woodland Types, we offer guidelines specific to Other Riparian Forest management. The goals of the guidelines for managing Other Riparian Forests are to: 1) maintain and/or restore riparian habitats to proper functioning ecological condition (USDI BLM 1993, 1994, 1998a, 1998b); and, 2) where ecologically feasible, provide a mix of size and age classes of both trees and shrubs that should include snags and large trees, vertical diversity, and other structural and floristic characteristics that typify riparian systems in proper functioning ecological condition.

Many riparian systems within the range of the Mexican spotted owl are extremely degraded as the result of past land-use practices (Stacey and Hodgson 1999). Our underlying premise is that if riparian systems are restored to properly functioning ecological conditions, they will meet the needs of the owl (and numerous other species). This is particularly true in canyon-bottom situations at middle and lower elevations where little other typical nesting or roosting habitat may be available. Because canyon bottoms are used extensively by the owl (Ganey and Dick 1995, Rinkevich and Gutiérrez 1996, Johnson 1997, Willey 1998a, Stacey and Hodgson 1999), it is important to preserve and increase the quality of such habitat. We anticipate that PACs will

include some of the best canyon riparian habitat that still exists, but increasing the quantity and distribution of properly functioning riparian habitats provides the potential for increasing the amount and extent of spotted owl habitat.

Table C.1. Summary of recommended management actions in Core Areas, PACs, and Recovery Habitats.

Mexican spotted owl Management Categories	Summarized Recommended Management Measures*
*****Please review Appendix C for detailed information regarding this summary table.*****	
Core Area: 40 ha (100 ac) established within PACs to protect Mexican spotted owl nests or primary roost areas.	• All activities within the core area should undergo consultation with the appropriate FWS office. • All management activities should be deferred from the core during the breeding season (March 1 through August 31), except when non-breeding is confirmed or inferred that year per the accepted survey protocol. • Planned or unplanned fires should be allowed to enter core areas only if they are expected to burn at low intensity with low severity effects.
Protected Activity Center (PAC): ≥243 ha (600 ac) established around Mexican spotted owl nest/roost sites (core areas). This refers to activities located outside the core area. See Box C.1 for establishing PACs.	• All activities within the PAC should undergo consultation with the appropriate FWS office. • Mechanical treatments can be conducted in up to 20% of the total non-core PAC area within each EMU (treatments can exceed 20% of the non-core acreage within a single PAC) • No mechanical or prescribed fire treatments, or road or trail maintenance should occur within PACs during the breeding season unless it has been determined that the PAC is unoccupied or the owls are not nesting that year as inferred from results of surveys conducted according to protocol. • Removal of hardwoods, downed woody debris, snags, and other key habitat variables should occur only when compatible with owl habitat management objectives as documented through reasoned analysis. • New road or trail construction is not recommended in PACs • Monitor treatment effects as described in Appendix C. • See Table C.2 for desired conditions for PACs.
Recovery Habitats: Currently unoccupied Mexican spotted owl habitat occurring in pine-oak, mixed conifer, and riparian forests and/or rocky canyons. These habitats may be or have the potential to be used by owls for nesting, roosting, foraging, dispersal, and/or other life history needs.	
Forested Recovery Habitat: Forested habitat occurring in mixed-conifer and pine-oak forests outside of PACs (see next page).	

Recovery Nest/Roost Habitat: Forested stands identified as meeting or exceeding owl nest/roost conditions.	Guidance provided in Tables C.2 & C.3 • Manage for nest/roost replacement habitat. • Do not treat stands in such a way as to lower stand conditions below thresholds in Table C.2 • Emphasize attainment of nest/roost conditions as quickly as reasonably possible. • Retain large trees. • Strive for spatial heterogeneity. • Manage for species diversity. • Retain key owl habitat elements (large trees, snags, large logs, hardwoods, etc.). • Emphasize large hardwoods, where appropriate
Recovery Foraging/Non-breeding Habitat: Forested stands managed to provide foraging, dispersal, wintering, or other habitat needs.	• Emphasize large hardwoods, where appropriate • Retain key owl habitat elements (e.g., large trees, large snags, large logs, hardwoods, etc.). • Minimize tree removal.
Riparian Recovery Habitat: Riparian forests are plant communities affected by surface and subsurface hydrologic features of perennial or intermittent water bodies. Riparian forests are: 1) distinctively different tree and shrub species than the adjacent areas; and/or, 2) tree species similar to adjacent areas but exhibiting more vigorous or robust growth forms.	• Manage for proper functioning ecological conditions. • Manage for species diversity. • Manage grazing effects. • Minimize construction activities. • Maintain key habitat components (e.g., large trees, large snags, large logs, hardwoods, etc.). • Minimize tree removal.
Other Forest and Woodland Types and Other Riparian Habitat: Forest, woodland, or other habitat types that appear to be little used by nesting Mexican spotted owls, but are likely used for foraging and dispersal.	No specific guidelines are provided for several forest and woodland community types (ponderosa pine, spruce-fir, pinyon-juniper, and aspen) where they occur outside of PACs.

*This box provides a summary of management recommendations for Mexican spotted owl habitat. For more detail, see Appendix C.

Table C.2. (Below) Generalized description of key habitat variables comprising Desired Conditions in forest, riparian, canyon, and woodland cover types typically used by Mexican spotted owls for nesting and roosting. **Desired conditions should guide management within PACs and recovery nest/roost habitats.** The ecological relevance of each desired condition to this owl subspecies and examples of variables that may be useful to quantify desired conditions are also shown. Where possible numbers are derived from past research, where information was unavailable we used the collective best professional knowledge of the Recovery Team.

Desired Condition	Relevance to Owl	Potential Variables (Examples)
Strive for a diversity of patch sizes with minimum contiguous patch size of 1 ha (2.5 ac) with larger patches near activity center; mix of sizes towards periphery (Peery et al 1999; Grubb et al 1997; May and Gutiérrez 2002). Forest type may dictate patch size (i.e., mixed conifer forests have larger and fewer patches than pine-oak forest). Strive for between patch heterogeneity.	Nest/roost habitat patches are the most limiting habitat for the owl. Patches should enhance spatial heterogeneity, provide nest/roost options, provide varied microclimates (thermoregulation) options, and create edges for prey species (e.g., *Neotoma*).	Size, cumulative acreage, density of patches, % of landscape, amount of edge habitat, average patch canopy cover, average age of dominant overstory component of patch. Frequency distribution of patches by size class, total edge, core to edge distance, fractal index of patch (area to edge ratios).
Horizontal and vertical habitat heterogeneity within patches, including tree species composition.* Patches are contiguous and consist of trees of all sizes, unevenly spaced, with interlocking crowns and high canopy cover (Ganey et al. 2003).*	Provides roosting options, thermal and hiding cover for the owl, and habitat for a variety of prey species.	Patch size and configuration (shape), juxtaposition (topology of patches), interspersion, edge length; canopy cover by height strata; number of vegetation strata present (herbaceous, shrub, sapling, pole, mature trees); uneven tree spacing.
Tree species diversity, especially with a mixture of hardwoods and shade-tolerant species (Willey 1998).* For example, Gambel oak provides important habitat for woodrats and brush mice (Block et al. 2005, Ward 2001)	Provides habitat and food sources for a diversity of prey, roosting options, and perches and hiding cover for young owls during early flight development. Large tree-form Gambel oaks are an important nesting substrate for owls (Ganey et al 1992; SWCA 1992; May and Gutiérrez 2002). Diversity increases probability of some tree species setting seed in a given year. Owls use hardwoods (e.g., big-toothed maple, western hop hornbeam and chinkapin oak) for roosting (Mullet and Ward 2010)	Species occurrence (presence), diversity indices (including richness and equitability), BA by species, density/species.
Diverse composition of vigorous native herbaceous and shrub species (Ward 2001).*	Provides sustainable habitat for a variety of prey; fine fuels to carry surface fire.	Cover/plant group; plant height; vertical density profile; diversity measure (e.g., richness and equitability); vertical distribution; maximum height.
Opening sizes between 0.04 - 1 ha (0.1 - 2.5 ac).* Openings within a forest are different than natural meadows. Small canopy gaps within forested patches provide for prey habitat diversity. Openings should be small in nest/roost patches, may be larger in rest of PAC.	Openings provide habitat for a variety of prey and can slow or reduce fire severity by breaking the continuity of dense tree canopies and ladder fuels.	Frequency distribution of openings by size class, % of landscape in openings. Grass and herbaceous cover in openings (Daubenmire plots for coverage percent).
Minimum canopy cover of 40% in pine-oak and 60% in mixed conifer (Ganey et al. 2003).* Measure canopy cover within stands.	Provides thermal environment needed for nesting/roosting and prey habitat.	Canopy cover line or point intercept method).

Diversity of tree sizes with goal of having trees ≥16" DBH contributing ≥50% of the stand BA (Willey 1998, May and Gutiérrez 2002, Ganey et al. 2003, May et al. 2004)	All life history needs (nesting, roosting, foraging). By emphasizing large trees, should provide for large snags and logs (Ganey et al. 2003).	Patch size/tree stage; vegetation strata;; tree size distribution.

*Rocky Canyon Recovery Habitat: results from habitat studies suggest these desired conditions are important in canyon environments where forest, woodland, and riparian habitats are present (e.g., Zion National Park).

Table C.3. Minimum desired conditions for mixed-conifer and pine-oak forest areas managed for Recovery nesting/roosting habitat. Forest types are defined in Appendix C, above. Parameter values are based on averages among plots sampled within forest stands. Numbers of stands included in analysis: 74 for Basin and Range-East (BRE), 27 for mixed-conifer forest in other EMUs, and 47 for pine-oak forest.

EMU(s) Forest Type	% of area[1]	% BA by size class		Minimum tree BA[2]	Minimum density of large trees[3]
		30-46 cm dbh (12-18 in)	>46 cm dbh (>18 in)		
BRE Mixed-conifer	20	>30	>30	33.3 (145)	37 (15)
CP, UGM, SRM, BRW Mixed-conifer	25	>30	>30	27.5 (120)	30 (12)
CP[4], UGM, BRW Pine-oak	10	>30	>30	25.3 (110)	30 (12)

[1] % of area pertains to the percent of the planning area, subregion, and/or region in the specified forest type that should be managed for threshold conditions.

[2]BAs in m^2/ha (ft^2/acre), and include all trees >1 inch dbh (i.e., any species). We emphasize that values shown are **minimums**, not targets.

[3]Trees > 46 cm (18 inches) dbh. Density is tree/ha (trees/acre). Again, values shown are minimums rather than targets. We encourage retention of large trees.

[4]Pine-oak forest type: ≥10% of the stand BA or 4.6 m^2/ha (20 ft^2/ac) of BA consist of Gambel oak ≥ 13 cm (5 in) drc.

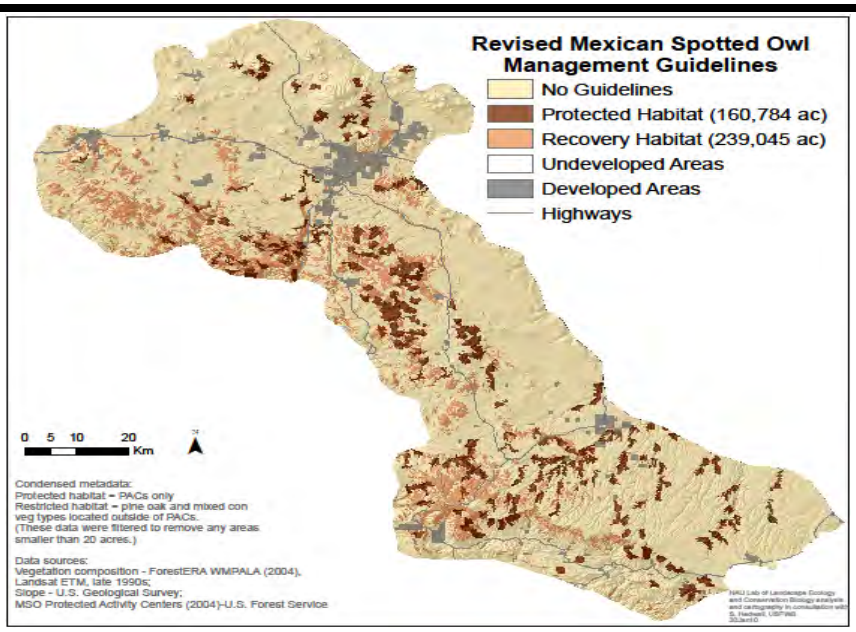
[5]Pine-oak recommendations apply only to the Mount Taylor and/or Zuni Mountains regions within the CP EMU.

BOX C.2. SPATIAL INTERPRETATION OF MEXICAN SPOTTED OWL MANAGEMENT GUIDELINES

Figure 1, below, shows a spatial interpretation of the current Mexican spotted owl management guidelines (i.e., guidelines in this revised Recovery Plan) across the western Mogollon Plateau, Arizona. This interpretation was created by the ForestERA project using spatial data layers collected by or created by project members.

The spatial extent of the map includes approximately 812,000 ha (2.04 million ac) within the belt of continuous ponderosa pine forest (and associated vegetation types) extending from north and west of the city of Flagstaff, south along the plateau to the edge of the 2002 Rodeo-Chediski Fire. Approximately 75% of the land within this area is managed by the FS (Coconino, Kaibab, Apache-Sitgreaves, and Tonto National Forests). The remainder of the land is a patchwork of private, state, and military lands.

PACs (referred to as "Protected Habitat" in Figure 1 below) cover approximately 8% (65,067 ha [160,784 ac]) and recovery habitat covers 12% (96,738 ha [239,045 ac]) of the area analyzed,. Thus, approximately 80% of the land base covered falls in areas not subject to specific Recovery Plan guidelines.



Box C.2: Figure 1. Habitat map produced for the Mexican spotted owl Recovery Team by ForestERA Project (see www.forestera.nau.edu) showing the distribution of lands in 2010 within the western portion of the UGM EMU covered by Recovery Plan designations.

BOX C.3. HIGH-ELEVATION, MIXED-CONIFER FOREST

The greater use of canyons and reduced use of upland forests in the northern part of the owl's range has raised questions about whether high-elevation (>2,440 m [8,000 ft]), mixed-conifer forests provide breeding habitat for spotted owls in these areas. This in turn has raised the issue of whether or not these areas should be surveyed and managed for owls. Under the original Recovery Plan (USDI FWS 1995), these areas were subject to the same management guidelines as mixed-conifer forests elsewhere within the owl's range.

Based on past discussions with Working Teams and land-management agencies in these areas, the Recovery Team recommended an amendment to the original Recovery Plan to deal with this situation. This amendment was approved by the FWS's Regional Director for the Southwestern Region in 1999. This amendment did not provide an elegant solution to this issue and pleased no one, including the Recovery Team. Consequently, the issue still exists. Therefore, we re-evaluated what is known about owl use of high-elevation, mixed-conifer forest. Specifically, we requested data on extent of surveys within the former SRM-Colorado, SRM-New Mexico, and CP EMUs. We received useful, but not necessarily conclusive information, from SRM-Colorado EMU, Carson National Forest, Kaibab National Forest, and the FS's Intermountain Region (Region 4).

Data on survey extent and results in Colorado were provided by the working team for that EMU. The Kaibab National Forest provided results of survey data for the North Kaibab Ranger District, the Carson National Forest provided results of survey on that forest, and FS Region 4 provided information on surveys conducted on multiple forests in that region. T. H. Johnson (Yomi Enterprises) performed the analysis for all EMUs by overlaying known owl records on 7.5 min digital elevation models and determining elevation at these locations (see Table 1, below).

Based on the available data, we conclude that owls in parts of the northeastern extent of the range use high-elevation, mixed-conifer forests. Therefore, blanket exemptions of such forests from range-wide management recommendations are not warranted. Data provided from Colorado recorded owls in high-elevation forests and that several PACs are at elevations >2,440 m (8,000 ft).

Given the use by owls of areas above 2,440 m (8,000 ft) and even 2,740 m (9,000 ft) in the northeastern part of their range, we recommend that range-wide management recommendations for mixed-conifer forest remain in place for these areas. If agencies within these EMUs believe that these high-elevation forests do not provide suitable habitat, they should compile the data to support that contention. Specifically, data provided should include:

1. For all future surveys conducted, action agencies create GIS coverage maps of areas surveyed; these should include forest types, survey points or routes, and survey results (spotted owl locations and associated attribute data).
2. In conjunction with the previous point, interested agencies could work with the Working Teams to compile currently available information on past survey efforts and results within their EMU. Minimum information required for this assessment includes: 1) total acres of mixed-conifer forest above 2,440 m (8,000 ft) in elevation; 2) acres of the

aforementioned mixed-conifer that were surveyed to protocol; 3) how many years areas were surveyed; and, 4) owl locations with associated attribute data. It may also be helpful to provide similar information for other cover types, if possible. For example, if a unit has surveyed 40,080 ha (100,000 ac) of high-elevation, mixed-conifer and 20,040 ha (50,000 ac) of rocky canyons, and found all owls in canyons, that information presented together is more convincing than simply presenting acres of mixed-conifer surveyed.

Box C.3: Table 1. Summary of elevation data based on daytime records of Mexican spotted owls in the database compiled in 1993 by the recovery team, based on agency survey data. Elevation data were compiled by T. H. Johnson (Yomi Enterprises), by overlaying owl locations on 7.5-min digital elevation maps (DEMs).

Ecological Management Unit	N	% above 2,440 m (8,000 ft)	% above 2,743 m (9,000 ft)
Colorado Plateau	69	15.9	7.2[a]
Southern Rocky Mountains	30	46.6	10

[a] Represents detections only on the Cibola NF.

BOX C.4. CRITERIA USEFUL IN DESIGNATING CORE AREAS IN THE ABSENCE OF NEST LOCATIONS

If no nest location is known, the following criteria (after Ward and Salas 2000) may be useful in determining where to locate the core area within a PAC:

- A circle with a 359 m (1,179 ft) radius centered on a location of one young-of-the-year Mexican spotted owl observed during the day prior to 1 August of any year.
- A 40 ha (100 ac) area that surrounds daytime observations of adult or subadult Mexican spotted owls documented over four different breeding seasons.
- Lacking this information, managers should rely on experienced spotted owl biologists to exercise their best professional judgment to identify likely habitat for nest/roost cores and delineate the 40 ha (100 acre) area.

Once designated, cores should remain in place and not be moved without sound biological rationale for making any adjustments.

BOX C.5. ASSESSING TREATMENT ACTIVITIES WITHIN PACs, OUTSIDE OF CORE AREAS

Several types of restoration activities (e.g., various silvicultural prescriptions and burning) are allowed in portions of landscapes that include Mexican spotted owl PACs. The effects of these treatments are not fully known and well-designed monitoring can provide valuable information on the effects of these activities on the owls and their habitat. The following recommendations provide general guidance for monitoring forest and fire management treatments that will occur in PACs but outside of nest-roost core areas. This monitoring should be designed, implemented, and analyzed in cooperation with scientists to ensure adequate sampling procedures and reliable inferences about potential effects of planned treatments on the owls and their habitats.

General Guidance for Monitoring and Estimating Effects of Treatments in PACs

Guiding Questions (these are not a complete list of potential questions; local managers will likely develop additional, site-specific questions of interest)***:***

- Do planned treatments (e.g., thinning, prescribed fire) affect key spotted owl responses (identified below)?
- How do identified effects vary among potential treatment types (e.g., fire severity and duration, total area affected, thinning acreage and intensity)?

Response Variables:

- Owl occupancy rate (corrected for detection probability; the percent of PACs occupied before and after treatments).
- Owl reproductive output (the number of fledglings observed per adequately checked pair before and after treatments).
- Habitat change (the immediate effect of a treatment type on key variables selected from Table C.1 showing description of desired conditions [DCs]) in forest and woodland cover types typically used by Mexican spotted owls for nesting and roosting. Analysis should incorporate what is retained as well as extent of change.

Planned Treatments:

- We assume these will vary by EMU and be agency defined at local scale, but they may also require regional EMU coordination across agencies.
- Treatments will likely be variable in spatial extent and intensity (intensity measured by degree of change in key habitat variables related to DCs [see Table C.1]).

General Study Design Approach:

- For each planned treatment(s), monitoring should be designed to robustly contrast a set of reference PACs (with no planned treatments) to a set of treatment PACs.
- PACs may be stratified by treatment type.
- Reference PACs should match the environmental conditions in PACs where treatments are planned, as closely as possible.

BOX C.5, Continued

Sampling Considerations:

- Identify set of PACs for a planned type of treatment.
- Identify set of reference PACs for each geographic area and cover type.
- Sample response variables for owls each year, using a design that allows estimation of effects to occupancy, detection probability, reproductive output, and habitat DCs.
- Sample timing: one year pre-treatment, during treatment year, and one, three, and five years post-treatment.
- Identify DC variables (Table C.1) that measure habitat change to calibrate treatment effects.

Potential Analytic Approaches

- Will depend on sample size.
- Possibilities include:
  - Simple treatment effect stratified by treatment type and geographic area/cover type. Two-sample tests, ANOVA, regression-based approaches, power dependent on sample size and variability.
  - Subsequent analyses only if treatment effects are apparent – gradient analysis, AIC based model selection if sample size permits use of treatment/habitat covariates.

Quality Control / Assurance

- A monitoring plan should be written that includes the details for sample selection, treatment specifics, measurement protocols including timing, and planned analyses.
- The monitoring plan should be reviewed as part of the consultation process for treatments planned to occur within PACs.

BOX C.6. DEFINING AND USING REFERENCE CONDITIONS FOR MEXICAN SPOTTED OWL NESTING/ROOSTING HABITAT

In the original 1995 Recovery Plan, two primary types of information were used to formulate recommendations for habitat management. In one analysis, quantitative descriptions of site- and stand-scale habitat conditions were used to describe characteristics of nesting/roosting habitat. In a second analysis, forest vegetation simulators were used to estimate the proportion of the landscape that could sustain those conditions through time (see USDI FWS 1995). Thus, information developed was used to define both desired forest structure at the scale of individual stands or patches, and the desired proportion of the landscape to manage for that structure.

Much of the information used to describe forest structure in the original 1995 Recovery Plan was derived from samples at relatively fine scales (i.e., sub-stand scales). Forest management typically is focused at larger scales such as forest stands, however, and stands are not entirely homogeneous. Owls locate and use distinct patches within stands, and stand descriptors based on characteristics of those used sites may not be representative of overall stand characteristics. To be most useful, descriptors of stand characteristics should be based on the same type of sampling and data that will be available to land managers faced with assessing stands. Consequently, we revised values in Table C.2 based on an analysis of nest stands used by Mexican spotted owls in Arizona and New Mexico as described by existing FS stand-exam data.

We queried the FS Southwest Region's database of common stand exams for data representing identified spotted owl nest stands. We then summarized these data in a two-step process. In step one, we aggregated values across plots *within* individual stands, to estimate average characteristics within individual stands. In step two, we averaged stand parameters *across* nest stands, to estimate mean stand characteristics and 95% confidence intervals around those mean values. We conducted analyses in step two separately for mixed-conifer and pine-oak forests. In addition, we analyzed mixed conifer separately for the BRE vs. other EMUs due to the relatively high density of owls in the Sacramento Mountains (BRE), and thus the high percentage of that landscape protected with existing PACs.

The values provided in Table C.2 define desired conditions to be achieved with time and management, or to be maintained where they already exist. **These values are based on the lower bound of 95% confidence intervals around estimates of means computed across stands.** Consequently, we view these values as minimum targets for managers. We also stress that values in Table C.2 must be met simultaneously. Management can occur within stands that exceed these minimum conditions, but such activities should not lower stand characteristics below these levels unless large-scale assessments demonstrate that such conditions occur in a surplus across the landscape (see below).

BOX C.6, Continued

We reiterate that we developed the table values from analyses that first averaged stand characteristics across plots within stands. Owl nest stands are not homogeneous. A typical nest stand may contain both pockets of large trees and greater basal area and areas of more open forest. We suspect that this heterogeneity and within-stand diversity is valuable (Ganey and Dick 1995), and we encourage managers to retain that variability. In particular, small areas with high basal area, canopy cover, and densities of large trees appear to be important for providing suitable nest and roost sites (Ganey and Dick 1995, Ganey et al. 2003), and such patches should be retained where they exist.

A frequent criticism levied at the precursor to Table C.3 in the original Recovery Plan (USDI FWS 1995:Table III.B.1) was that the specified stand conditions could not be sustained on the landscape. The portions of the landscape specified for management in this table were based on simulations using table parameter values and established models of forest succession and stand prognosis conducted by FS personnel with expertise in the use of such models (USDI FWS 1995). These simulations clearly demonstrated that such conditions are sustainable on the portions of the landscape specified, and to date no empirical data or modeling results have surfaced to support the claim that the specified stand conditions cannot be supported on the landscape in the indicated amounts. A more recent, spatially explicit analysis evaluated possible constraints imposed by the 1995 Recovery Plan on conducting fuels-reduction treatments (Prather et al. 2008). Results indicated that 1995 Recovery Plan guidelines applied to less than one third of an 811,000 ha study region, and that the majority of the forest even in these conflict areas could be managed to reduce fire hazard without eliminating owl habitat (Prather et al. 2008).

We did not repeat the modeling efforts used in the original Recovery Plan to generate percentages of the landscape capable of sustaining nest/roost conditions. In most cases, we reduced values for describing required stand parameters in the revised Table C.3 relative to values in the original Recovery Plan. Logically, if it was possible to sustain the conditions in the original Recovery Plan over a specified portion of the landscape, it should be possible to sustain the revised, and more lenient, conditions over that same portion of the landscape.

As in the original Recovery Plan, the percentage of landscape area recommended for management for nest/roost conditions is lower in the BRE EMU than it is in other EMUs. This is based on the observed high density of owls in the Sacramento Mountains, which effectively places a large proportion of that landscape in protected status. Also as before, we do not provide guidance on how to allocate future owl habitat across the landscape. Although this is a critically important issue, we lacked the information and resources to accomplish this allocation.

4. Threat-specific Management Recommendations

In this section, we provide recommendations as they relate to specific threats or activities. Some recommendations are similar to those presented in the General Recommendations, but we repeat them here for clarity.

a. Fire Management

Overarching forest management goals should embrace the restoration of ecosystem health, historical and/or natural conditions, and the range of variability in forest structure, composition, and function. In places, these restoration goals may likely include the ecological role of fire and the emulation of past fire regimes and ecological processes. Fortunately, the Southwest has one of the largest compilations of ecological research that documents and reconstructs historical reference conditions such as past stand structure, density, and fire frequencies for many forest types, with research sites throughout the region. These references along with our recommendations should help guide and quantify future restoration activities.

Guidelines

The appropriate management of prescribed fire and wildland fire outside of PACs to moderate fire severity and the potential for stand-replacing fire may provide most alternatives to mitigate severe fire threats. Mechanical treatments, however, may be necessary in some areas before fire can be effectively and safely applied to meet management objectives. The focus of mechanical thinning will likely be concentrated in the WUI communities at risk to fire, where fires are a greater threat to people and property and where fire applications have much greater risk and liabilities. Planning and implementing fire risk-reduction activities should balance the intensity and arrangement of treatments needed to reduce the landscape risk of high-severity fire yet maintain owl habitat. Due to the current magnitude of forest fuel accumulations, some preliminary treatments (e.g., thinning combined with pile and low intensity prescription burning) will be required to reduce the severity of wildland fires and to allow for the safer management of prescribed fire and wildland fires. Cumulative effects of multiple treatments across the watershed, downstream effects, and effects to spotted owl habitat will need to be evaluated through landscape analyses and modeling, and effects should be moderated to promote Mexican spotted owl recovery.

i. Wildland fire Suppression

Protect Public Safety and Property. Fire fighter safety and community protection are the utmost priorities during ES and BAR activities.

Wildland fire Behavior and Incident Planning. Conduct landscape-level fire behavior assessments to strategically locate and prioritize fire suppression activities/tactics to mitigate the effects of high-severity fire and suppression activities on PACs and recovery habitat. Potential strategies include locating fire-line construction and other suppression activities where possible outside of PACs, and conducting night burning ahead of approaching moderate-high severity wildland fire in areas surrounding PACs to reduce wildland fire severity within PACs.

Retain Key Habitat Elements. Where possible, wildland fire suppression activities should be applied that limit high-severity fire and loss of key habitat elements within PACs and recovery habitats.

Applied Research. Research should be conducted to evaluate the short- and long-term correlates of wildland fire severities and their spatial extent on Mexican spotted owls and their habitat.

ii. Burned Area Emergency Response (BAER - FS), Burned Area Emergency Stabilization (ES-DOI) and Burned Area Rehabilitation (BAR-DOI).

Protect Public Health, Safety, and Property. Personnel safety and community protection are the utmost priorities during ES and BAR activities.

Seasonal Restrictions. BAR treatments where deemed necessary in or near PACs should occur during the non-breeding season (1 Sep - 28 Feb) to minimize disturbance to resident owls during the breeding season, unless non-breeding is inferred or confirmed that year per the accepted survey protocol (Appendix D).

Treatment Priorities. ES and BAR treatments should be only be considered when critical to stabilize soils, retain key habitat elements, and enhance ecosystem recovery. Soil stabilization should be considered only where crucial and implemented through local biomass mulching or other seed-free mulching materials to minimize risk of introduced exotic species. Seeding is not recommended due to its limited effectiveness, lack of local genetically compatible seed stock, and exotic contaminants found in most seed mixes (Peppin et al. 2010a, 2010b; Dodson et al. 2010; Stella et al. 2010). Measures to protect remaining green trees from insect and disease may also be necessary.

iii. Prescribed Fire, Hazardous Fuels Treatments, and Wildland Urban Interface (WUI).

We propose the following recommendations for prescribed fire and hazardous fuels treatments. Much of the work needed to reduce broad-scale fire risk to owl habitat can be accomplished by first treating areas down-slope from and surrounding PACs. We recognize, however, that other management considerations like WUI may require treatments within PACs. In these situations, treatments should be done with adequate safeguards to minimize loss of key habitat components for owls and their prey.

Protect Public Health, Safety and Property. Fire fighter safety and community protection are the utmost priorities during prescribed fire and hazardous fuels treatment activities.

Area Limitations. Mechanically treat as needed up to 20% of the non-core PAC area within an EMU identified through the landscape-level assessment (see above Assumptions and Guiding Principles).

Seasonal Restrictions. Light burning of surface and low-lying fuels may be conducted within PACs following careful review by biologists and fuel-management specialists on a case-specific basis. Mechanical or prescribed fire treatments should occur during the non-breeding season (1 Sep - 28 Feb) to minimize disturbance to resident owls, unless non-breeding is inferred or confirmed that year per the accepted survey protocol (Appendix D). Treatments should be planned when environmental conditions provide enhanced opportunities to achieve fuel reduction and forest-restoration objectives. These

activities however should be deferred in severe drought years and times of high-to-extreme wildland fire risk.

Types of Treatments. Combinations of mechanical and prescribed fire treatments may be used to minimize risk of high-severity fire effects while striving to maintain or improve habitat conditions for the owl and its prey.

Strategic Placement of Treatments. Treatments should be placed strategically to minimize risk of high-severity fire effects to the nest core while mimicking natural mosaic patterns.

Treatment Priorities. Emphasize treatments in other forest and woodland types over those of PACs and recovery habitats to the extent practicable. Treatments in these areas might buffer owl habitat as well as provide fire risk reduction to WUI communities. Where appropriate, areas surrounding PACs could be treated with higher prescribed fire and mechanical treatment intensities to better achieve management objectives (e.g., reduction of hazardous fuels and potential for stand-replacing fires, enhancement of landscape, and forest structural diversity).

Landscape Assessment. A landscape-level assessment should be conducted to strategically locate and prioritize prescribed and hazardous fuels treatments to best mitigate the risk of stand replacing fires and high severity fire effects to current and future spotted owl habitat elements (Tables C.2, C.3).

Monitoring. Monitoring should be designed and implemented to evaluate the effects of prescribed fire and hazardous fuel reduction treatments on spotted owl habitat, and to retain or move towards Mexican spotted owl desired conditions (Table C.2). Box C.5 provides a framework for development of monitoring studies.

Applied Research Experiments. Management experiments should be conducted in places to evaluate the short-term, long- term, cumulative, and watershed effects of these activities on Mexican spotted owls and their habitats.

These recommendations, when implemented, should help reduce high-severity fire effects across broader forest landscapes and help protect Mexican spotted owl PACs, potential habitats, and suitable nesting/roosting habitat locations from future stand-replacing wildland fires and enhance landscape-level forest resiliency to climate variability. Additionally, these recommendations are supported by current research and monitoring on Mexican spotted owl fire effects that show limited, short-term effects from moderate- to high-severity fires (Bond et al. 2002, 2009; Jenness et al. 2004).

b. Insects and Disease

Biotic disturbance agents most influential to forest habitat of the Mexican spotted owl are bark beetles, defoliating insects, dwarf mistletoes, root disease fungi, and rust fungi (USDA FS 2004). Many agents act in concert with abiotic factors; the current aspen decline in northern Arizona is an example of a complex disturbance. The course of an outbreak can be characterized by its rate of increase and spread, duration, and spatial scale. Impacts consider the spatial extent and intensity of tree mortality as well as the values of killed and remaining trees ("value" can be in the sense of ecosystem function).

Although knowledge of forest condition and predisposition allows managers to assess the risk and potential impacts of an insect or disease outbreak, control is difficult (Holling and Meffe

1996). Management has limitations in techniques, resources, and reaction time; social and natural systems are complex and dynamic. Nonetheless, management intervention can be useful to change forest conditions predisposing areas to outbreak and to influence the extent, course, and impact of outbreaks. Effective treatments are generally tailored for a specific insect or pathogen, instituted early, executed in multiple stages, monitored, and modified as needed to achieve objectives (adaptive management).

Guidelines

1) Resource managers should work with forest insect and disease specialists to develop ecological assessments of these kinds of disturbances at various scales. Evaluations should be based on the role these organisms play in directing succession toward, or away from, desired conditions at different spatial-temporal scales.

2) Managers, in consultation with specialists, can use these organisms to strategic advantage in creating, enhancing, or maintaining habitats for owls (and associated biota) in accord with landscape goals.

When considered a threat to owl or prey habitat, various tools—prescribed fire, thinning, other silvicultural treatments—can be used to limit the spread of insects or diseases. Management actions include sanitation, thinning, maintenance of mixed species stands (coarse-filter techniques), chemical protection of individual trees, and use of insect-behavior modifying chemicals (fine-filter techniques). Methods used are often specific to the organism and should be done in consultation with owl biologists, insect and disease specialists, fire personnel, and silviculturists.

c. Grazing

As discussed in II.9.D.a.vii, improperly managed grazing can adversely affect spotted owls primarily through four indirect effects: 1) diminished prey availability and abundance (Ward 2004, Willey 2007, Willey and Willey 2010); 2) increased susceptibility of habitat to destructive fires; 3) degradation of riparian and meadow plant communities; and, 4) impaired ability of plant communities to recover or develop into more suitable spotted owl habitat. These indirect effects flow from the livestock management practices that result in long-term alterations in plant species composition, density, vigor, and vegetation structure. Therefore, in order to provide for recovery of the spotted owl and adequate protection of its habitat, livestock management within the owl habitat should be designed with the following objectives: 1) to maintain or enhance prey availability; 2) to maintain potential for beneficial surface fires while inhibiting potential for destructive stand-replacing fire; and 3) to promote natural and healthy riparian, meadow, and upland plant communities including their functional processes.

Guidelines

Appropriate grazing management should be designed to provide a target level of residual vegetation that would attain or sustain moderate to high similarity to potential natural vegetation,

or otherwise favorable habitat characteristics for the spotted owl and its prey. "Key areas[1]," "critical areas[2]" and "key species[3]," as defined by the Society for Range Management (1998), should be identified for the purposes of managing grazing and monitoring its effects on herbaceous and woody vegetation. The following guidelines are provided for grazing management in all PACs and recovery habitats:

1) Resource managers should conduct site-specific assessments, utilizing pertinent research information and standardized monitoring techniques to identify: a) habitat conditions for availability of prey species to Mexican spotted owl; b) conditions of riparian and meadow habitats including their functional processes (USDI BLM 1996*a*,*b*; Ruyle et. al. 2000); and, c) conditions and processes required for the restoration and maintenance of historical fire regimes and native plant communities where fire has historically influenced habitat structure and plant composition. These assessments should be conducted during both dormant and growing seasons to provide favorable habitat characteristics throughout the year.

2) Resource managers should establish and enforce residual vegetation (e.g., residual leaf length or stubble height) targets during plant growth and dormant periods that are consistent with light to moderate grazing intensity within protected and recovery habitats. Established targets should be: a) attained at a minimum in at least four out of every five years; b) reviewed by resource managers periodically (every five to seven years) to determine if desired vegetation conditions are being achieved or maintained; and, c) modified appropriately when vegetation conditions indicate the need.

3) Resource managers should coordinate to implement grazing and other management strategies for livestock and wild ungulates that will improve degraded riparian communities in owl habitats to proper functioning ecological condition as soon as possible and implement monitoring programs to evaluate improvement in habitat conditions (USDI FWS 1995, Winward 2000). Management strategies may include (Kennedy 1977; Rickard and Cushing 1982; Clary and Webster 1989; Platts 1990; Chaney et.al. 1990, 1993; Krueger 1995; Leonard et al. 1997):

- *Reduce Grazing Pressure*. Reductions in grazing intensity in riparian areas through the use and enforcement of appropriate vegetation utilization or residual vegetation standards and timely livestock removal;
- *Seasonal Grazing.* Changes in seasons of grazing use (e.g., allow livestock grazing in riparian areas only during plant dormancy periods where possible);
- *Reduce Numbers.* Reduction in numbers of grazing animals (i.e., both livestock and wild ungulates if needed) to attain sufficient residual riparian vegetation levels and improvement in riparian habitat conditions; and,
- *Exclusion of Grazing.* Total exclusion of ungulate grazing use from sensitive riparian areas for extended time periods (e.g., multiple years) through the use of exclusion fencing

[1] Key Area - A relatively small portion of a range selected because of its location, use, or grazing value as a monitoring point for grazing use. It is assumed that key areas, if properly selected, will reflect the overall acceptability of current grazing management over the range (SRM 1998).
[2] Critical Area - An area that must be treated with special consideration because of inherent site factors, size, location, condition, values, or significant potential conflicts among uses (SRM 1998).
[3] Key Species - (1) Forage species whose use serves as an indicator to the degree of use of associated species. (2) Those species which must, because of their importance, be considered in the management program. (SRM 1998)

to improve riparian herbaceous plant cover, promote regeneration of riparian shrub and tree cover, and protect stream banks and channels.

4) Resource managers should coordinate to implement livestock and elk population management strategies that will reduce browsing impacts on upland deciduous woody species in areas where the recruitment of these species into the overstory is lacking due to browsing pressure within owl habitats. Strategies developed under this guideline should not be focused solely on domestic livestock management, rather they should be focused on reducing the impacts of all browsers that contribute to the identified threat.

d. Energy-Related Development

We provide general recommendations related to energy development below. However, in most cases, specific recommendations will depend on case-by-case evaluations of the timing and duration of the proposed action. The timing of an action is pertinent in that a disturbance during the breeding season (1 Mar - 31 Aug) is more likely to impact owls than a disturbance outside the breeding season. Pertaining to length of disturbance, actions should be categorized as temporary or long-term according to the following definitions:

- *Temporary:* An action that leaves no long-term structure or long-term habitat loss and does not result in persistent noise pollution (e.g., occasional helicopter overflights).
- *Long-term:* An action that causes a loss of owl habitat, increases the probability of mortality through collision, increases human access to an area, or creates a persistent owl disturbance from noise (i.e., noise above 69 dBA at 50 m [165 ft] from nest or PAC if nest site is not known; e.g., creation of long-term facilities such as utility lines, mines, pits, well pads, roads, pipelines, compressor stations).

Guidelines

The following guidelines pertain to PACs and Recovery Habitats. In most cases, temporary actions that occur outside of the breeding season will require no occupancy surveys and no mitigating actions. If activities will be long-term or take place during the breeding season, conduct occupancy surveys according to the standard protocol approved by FWS. Where owls are found, PACs should be established and the PAC guidelines should be followed. Where owls are not found, temporary actions may be allowed either during or outside of the breeding season. Long-term actions may, on a case-by-case basis, be allowed to proceed in Recovery Habitats outside of PACs, provided that the actions avoid detrimental habitat alteration, minimize the risk of owl mortality from collision, and conform to the recommendations for Recovery Habitats. Collision risk is best minimized through proper siting of structures (e.g., away from likely owl travel corridors).

The following guidelines apply to areas within PACs during the breeding season (1 Mar - 31 Aug) unless otherwise stated. If owls are not detected in a PAC, restrictions on temporary activities may be relaxed depending on the nature and extent of the proposed action.

1) No seismic activities or construction of new facilities or expansion of existing facilities should take place during the breeding season. Any construction within PACs during the non-

breeding season should be considered on a case-specific basis (see item b below). Modifications to existing facilities pertaining to public health, safety, and routine maintenance are excepted. However, when implementing such activities, those conducting the work should use all measures possible to avoid potential effects on owls (e.g., use least disruptive machinery, time project to minimize disturbance).

2) Construction and seismic activities may take place outside of the breeding season or during the breeding season if non-occupancy or non-breeding is inferred through protocol surveys. Long-term activities should avoid loss of habitat through, for example, use of directional or multi-lateral drilling and locating new facilities within existing rights of way. Long-term activities that increase the risk of owl collision with structures (e.g., turbines, power lines) should not be allowed in PACs.

3) The potential for noise disturbance to nesting owls should be assessed on a case-specific basis. Breeding season restrictions should be considered if noise levels are estimated to exceed 69 dBA (~80 dBO) [owl-weighted noise level, Delaney et al. 1999a]) consistently (>twice/hour) or for an extended period of time (>1 hr) within 50 m (165 ft) of nesting sites (if known) or within entire PACs if nesting sites are not known. Noise reduction may be accomplished through proper placement of facilities and use of noise dampening equipment (e.g., hospital-grade mufflers, electric pump motors) as well as other techniques.

e. Land Development

The following guidelines are provided to mitigate potential threats to owls due to land development. Guidelines are based on the assumption that most land development threats to Mexican spotted owls are edge effects influencing adjacent Federal lands, and that mitigation of threats following guidelines for WUI treatments and recreation on applicable lands, combined with implementation of the general recommendations, will maintain current levels of owl habitat.

Guidelines

1) Managers are encouraged to pursue coordination on a case-by-case basis with local governments and developers to encourage development in areas least likely to directly influence habitat use of known owls. When possible, managers should encourage maintenance of existing habitat conditions on private lands. Development of positive incentive programs may be a feasible approach.

2) Managers should implement recreation-disturbance guidelines (below).

f. Water Development

Water development includes dams, permanent flooding of riparian habitats, bed degradation below dams, stream and spring dewatering, water diversions, and altered-flow regimes of streams and springs. Effects of water development on spotted owls vary, depending upon the size of the water development, and can range from loss or degradation of habitat to habitat fragmentation, disruption of migration corridors, inhibited gene flow, altered prey habitat, and

altered grazing patterns by wild and domestic ungulates. Recommendations for addressing water development vary. In some situations, options are limited for addressing effects of established water developments on spotted owls (e.g., Lake Powell). Greater flexibility exists for addressing developments before they occur or for slightly modifying practices that might reduce effects on the owl.

Guidelines

1) If considering development of large water projects assess the potential effects on spotted owl movement.

2) Discharge water from dams in such a way to sustain and enhance native riparian vegetation.

3) Conduct surveys following accepted survey protocol prior to initiating any water development that would modify owl habitat or result in effects to nesting owls. Implementation of projects should be done in consultation with the FWS.

g. Recreational Exploitation

Recreational exploitation can result in harm, harassment, and even mortality of Mexican spotted owls. Management, education, and/or enforcement actions may be needed to protect spotted owls from this threat.

Guidelines

1) Calling, hooting, or playing of taped recordings to elicit responses from or to locate owls is prohibited without a section 10(a)(1)(A) recovery permit from the FWS. Where recreational exploitation is known to be a problem, managers should report continued issues to the appropriate FWS Law Enforcement Office.

h. Recreation Disturbance

The following guidelines apply to PACs during the breeding season, (1 Mar - 31 Aug). If non-breeding is inferred or confirmed that year per the accepted survey protocol, restrictions on noise disturbances can be relaxed depending on the nature and extent of the proposed disturbance. Recommendations are based in part on Swarthout and Steidl (2001, 2003). Guidelines for noise management related to recreation are provided below in the noise management recommendations.

Guidelines

1) No construction of new facilities (e.g., trailheads, OHV trails) or expansion of existing facilities should take place in PACs during the breeding season. Any construction within PACs should be considered on a case-specific basis. Modifications to existing facilities pertaining to public health, safety, and routine maintenance are excepted (e.g., removal of dangerous trees in a campground; replacement of road culverts within campgrounds, etc.). However, when

implementing such activities, those conducting the work should use all measures possible to avoid potential effects on owls (e.g., use least disruptive machinery; timing of the project to minimize disturbance).

2) Managers should, on a case-specific basis, assess the presence and intensity of currently allowed (permitted and non-permitted) recreational activities. The assessment should include distance, frequency, duration, and source of the disturbance. If recreation is determined to be a problem (e.g., increased OHV or hiking use), limit human activities during the breeding season in areas occupied by owls (timing may vary depending on local nest chronology). Disturbance here is defined as the presence of 1 -12 people; group sizes exceeding 12 people should not be allowed. In areas where nest and roost sites are not identified, human disturbance should be limited to ≤2 disturbances per hour (averaged over a 24 hour period) throughout the PAC. Where nest and roost sites are known, disturbance should be limited to ≤2 disturbances per hour (averaged over a 24 hour period) within line of sight of the nest/roost sites. In some cases, disturbances may be avoided by routing trails and recreational uses (e.g., OHV use) outside of PACs through signing in order to designate zones free from human disturbances during critical periods.

3) Seasonal closures of specifically designated recreational activities (e.g., OHV use, rock climbing, or biking) should be considered where disturbance to breeding owls seems likely.

4) Conduct education through signing, interpretation events, access permitting, or other information sources to inform the public of proper and legal behaviors when encountering owls. For example, land managers in some areas are maintaining permanent, all-weather signs that inform the public that the area is home to a sensitive species; visitors should stay on the trail and be as quiet and unobtrusive as possible.

5) If owls are not detected in a PAC during the breeding season, restrictions on non-habitat-altering recreation can be relaxed depending on the nature and extent of the proposed disturbance.

i. Scientific Exploitation

Although we do not view research and monitoring activities as a significant threat to the Mexican spotted owl (see Part II.H.3.b of Recovery Plan), such activities may on occasion alter owl habitat, influence owl behavior, or harm or kill owls. Whereas long-term benefits to owls from these activities can be substantial, safeguards are needed to ensure that any negative short-term effects are acceptable.

Guidelines

1) Quality assurance and quality control procedures should be applied to all scientific studies that may directly or indirectly affect owls or owl habitat. Quality assurance requires that study plans undergo appropriate levels of review, revision, and approval. Quality control means that methods of data collection adhere to prescribed standards.

2) All scientific activities that have potential to harm owls or owl habitat should undergo FWS review and concurrence. Concurrence is demonstrated by granting appropriate permits. Applications for these permits routinely requires a review of the techniques to be used and a finding that those techniques are generally acceptable and have a low risk of causing harm or death.

3) Contingency plans (e.g., how an injured owl will be treated or transported and where an injured owl will be taken) for dealing with injured owls should be included as part of the study proposal submitted with the permit application. In addition, many researchers must undergo approval of animal care and use by their employing institutions.

4) Annual reports are required from all permit holders.

5) All owl mortalities are reported to FWS within 48 hours of being discovered. If a particular study or a particular activity results in an undue number of mortalities, FWS will convene an independent expert panel to evaluate the situation and propose recommendations to continue, adjust, or cease the activity resulting in mortalities.

6) Radio-marking spotted owls likely poses the highest risk among typical research activities. This risk may be alleviated partially by adhering to marking requirements issued by the Bird Banding Lab. For example, these guidelines restrict transmitter packages (includes the transmitter, antenna, and attachment materials) to ≤3% of body weight. We endorse that restriction but also note that past studies have demonstrated that spotted owl body mass can fluctuate by up to 5% between years and/or seasons. Therefore, we recommend that transmitter packages used on Mexican spotted owls not exceed 16 g for female owls and 14 g for male owls. These guidelines should ensure that transmitter packages are light enough to be tolerated even if owls undergo significant loss of body mass.

7) Radio transmitters have been attached to spotted owls successfully using both backpack and tailmount attachments. Any other attachment methods should be viewed as experimental and should be tested on captive spotted owls before deployment in the field, if possible. If captive spotted owls are not available, experimental attachment methods should be tested on captive barred owls, with transmitter weight adjusted to account for increased body mass of barred owls. If neither of the above options are possible, then experimental attachments should be tested on a very small sample of wild spotted owls, and results should be monitored before allowing widescale use of the method.

8) All radios should be attached by researchers with demonstrated expertise in handling raptors and attaching transmitter packages to raptors. Experience with spotted owls and the specific attachment method in use is preferable here.

j. Noise

The following guideline applies to areas within PACs during the breeding season (1 Mar - 31 Aug). If non-breeding is inferred or confirmed that year per the accepted survey protocol, restrictions on noise disturbances should be relaxed depending on the nature and extent of the

proposed disturbance. The recommendation is based in part on Delaney et al. (1999a,b), Delaney and Grubb (2003), and Pater et al. (2009).

Guidelines

1) Managers should, on a case-specific basis, assess the potential for noise disturbance to nesting owls.

2) Breeding-season restrictions should be considered if noise levels are estimated to exceed 69 dBA (A-weighted noise level) (~80 dBO [owl-weighted noise level, Delaney et al. 1999b]) consistently (i.e., >twice/hour) or for an extended period of time (>1 hr) within 50 m (165 ft) of nesting sites (if known) or within entire PAC if nesting sites are not known.

3) If owls are not detected during approved-protocol surveys in a PAC during the breeding season, restrictions on noise disturbances can be relaxed depending on the nature and extent of the proposed disturbance.

k. Climate Change

Given mounting empirical evidence and model-based predictions for effects of climate change in the United States, a central dictum, under an uncertain future, is that no single management approach for intervention will fit all situations (Spittlehouse and Stewart 2003, Hobbs et al. 2006). A toolbox approach, from which various treatments and practices can be selected and combined to fit unique local settings, will be most useful (Millar et al. 2007). Our recommendations for addressing the effects of climate change on the owl are primarily based on the Intergovernmental Panel on Climate Change's *Climate Change and Biodiversity* technical paper (Gitay et al. 2002), Mawdsley et al. (2009) adaptation strategies for wildlife management, and the Millar et al. (2007) conceptual framework for managing forested ecosystems. Our recommendations include mitigation strategies (i.e., actions that reduce causes of stress) and adaptation strategies (i.e., actions that help forested ecosystems accommodate change). Our recommendations for climate change are consistent with all other guidelines and recommendations for the owl within this plan.

Mitigation Strategies

1) *Reduce Non-Climate Stressors*. Reduce or remove other non-climate stressors, including: scientific exploitation, noise disturbance, recreation disturbance, negative effects from grazing, and land development (see specific recommendations). Ameliorating non-climate stressors will provide the owl sufficient time to respond to local effects of climate change, including, for example, future range shifts or modifications in home range boundaries.

2) *Prioritize Forest Management*. Increased fire severity and incidence of stand replacing wildland fire, and extensive tree mortality as a result of insect and disease, are predicted to be primary sources of unintentional carbon emissions from forests in the western U.S. (Stephans et al. 2005). We support management strategies that will decrease release of carbon from forests and increase forest resistance to fire, drought, and disease. Priority-setting approaches (e.g.,

triage) will be necessary for rapidly changing conditions, for example, reducing the density of small trees (see our recommendations for thinning in PACs), increasing BA of large trees, and protecting old-growth stands following Table C.3.

Adaptation Strategies

1) *Promote Forest Resistance*. Resistance strategies forestall impacts and protect highly valued resources. Resistance practices are recommended because they have potential to improve forest defense against direct and indirect effects of rapid environmental changes. An obvious strategy to promote resistance that will benefit the owl would include reducing undesirable or extreme effects of fires, insects, and disease through active forest management (see our recommendations and guidelines regarding fire management, WUI, and insect and disease).

2) *Promote Forest Resilience*. Resilience strategies improve the capacity of ecosystems to return to desired conditions after disturbance. Promoting resilience is the most commonly suggested adaptive option discussed in a climate-change context. Resilient forests are those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance. This strategy intentionally accommodates change rather than resisting it but has the goal of enabling or facilitating forest ecosystems to respond adaptively as environmental changes accrue. The strategic goal is to encourage gradual adaption and transition to inevitable change, and thereby to avoid rapid threshold or catastrophic conversion that may occur otherwise. One way to achieve resilience is to promote diverse age classes and species mixes both within-stand and across landscapes and reduce stressors to forest habitat (i.e., by thinning overstocked stands and restoring fire-adapted ecosystems). Treatments implemented should mimic, assist, or enable ongoing adaptive processes such as owl dispersal and range expansion, for example promoting connected landscapes and minimizing physical and biotic impediments to movements (see our recommendations for Recovery Areas).

3) *Anticipate Surprises*. Evidence is accumulating that species interactions and competitive responses under changing climates can be complex and unexpected. Abrupt invasions, changes in population dynamics, and long-distance movements of native and nonnative species are expected in response to changing climates. Managers should strive to anticipate events outside the range of conditions in recent history. For example, changes in barred owl distribution and abundance should be monitored for potential effects on spotted owls.

4) *Use Adaptive Management and Monitor.* Given long-term uncertainty, it is imperative to "learn-as-you-go," following an adaptive management strategy. Although general principles will hopefully emerge, the best preparation is for managers and planners to remain informed about emerging climate science as well as land-use changes in the Southwest, and to use that knowledge to shape effective management decisions for owl habitat. Following our General Management Recommendations, we recommend that vegetation manipulations be designed within an adaptive management framework. Rigorous monitoring systems will provide information that managers can use to adjust or modify objectives and activities. Long-term monitoring of owl site occupancy, extinction, and recolonization rates using appropriate designs will be imperative in light of climate change and evaluating efficacy of management objectives.

l. West Nile Virus

The Recovery Team does not currently view West Nile virus (WNV) as a threat to Mexican spotted owls, as the virus has never been detected in this subspecies to our knowledge. However, given the fact that the virus occurs within the range of the Mexican spotted owl and that spotted owls have shown vulnerability to it, we believe the following measures are prudent.

Guidelines

1) As suggested by Hull et al. (2010) in reference to their work on California spotted owls in the Sierra Nevada, estimating spotted owl survival rates and identifying causes of death would help determine whether WNV is a significant threat to the population. We recommend that well-distributed demographic studies be carried out and that populations exhibiting significant downward population trends, especially in absence of other identifiable causes, be investigated for the possibility of WNV-caused epizootics.

2) Similarly, if routine spotted owl surveillance indicates the disappearance of birds from a given area, the possibility of WNV should be investigated.

3) Local biologists should monitor reports of avian mortality on the Centers for Disease Control and Prevention (CDC) website (www.cdc.gov) as well as those of state and county health departments.

4) If any of the above situations lead to suspicion of a WNV epizootic, conduct surveillance for the disease using standard arbovirus surveillance techniques. The CDC website contains a wealth of information on this subject, and state and county public health agencies can also be of assistance.

5) Finally, although we do not recommend that spotted owls be captured and sampled specifically for WNV absent the exigent circumstances described above, biologists who become aware of spotted owl captures for other purposes should look into asking researchers to collect saliva swabs or other minimally invasive samples. If researchers are also collecting blood or other tissue samples, testing of those for WNV antibodies is advised. Again, state and county health departments can provide information on this process.

APPENDIX D - MEXICAN SPOTTED OWL SURVEY PROTOCOL

U.S. FISH AND WILDLIFE SERVICE, 2012

INTRODUCTION

The following field survey protocol is designed for detecting Mexican spotted owls (hereafter, "owl"; *Strix occidentalis lucida*) and for surveying areas where human activities might remove or modify owl habitat, or otherwise adversely affect the species. The owl was federally listed as threatened on March 16, 1993 (58 FR 14248). Federal agencies are not required to conduct surveys for listed species prior to preparing a biological assessment under the Endangered Species Act ["Act"; see 50 CFR 402.12(f)]. However, Federal agencies are required to provide the best scientific information available when assessing the effects of their actions to listed species and critical habitat [50 CFR 402.14(d)]. In the absence of necessary information, the U.S. Fish and Wildlife Service (FWS) gives the benefit of the doubt to the listed species [H.R. Conf. Rep. No. 697, 96th Cong., 2nd Sess. 12 (1979)].

This survey protocol expresses the FWS's scientific opinion on adequate owl survey methods and includes guidance and recommendations. It does not constitute law, rules, regulations, or absolute requirements. Our knowledge is continuously developing and changing; therefore, this protocol, which is based upon the best scientific data available, is a work in progress. This protocol will be modified as new information becomes available. The public will be notified of changes to the protocol and surveyor qualifications through postings to the FWS's Arizona Ecological Services Field Office (AESO) (http://www.fws.gov/southwest/es/arizona/MSO). We encourage submissions to us (email submissions to Shaula_Hedwall@fws.gov) at any time of any information that can add to our understanding of what is needed to provide for long-term conservation of this species and its ecosystem. Persons conducting owl surveys must be covered under a research and recovery permit under Section 10(a)(1)(A) of the Act in order to avoid unauthorized harassment of owls, which could violate the prohibitions of Section 9 of the Act. However, no other Federal permitting requirements are implied, though individual states might have their own permitting requirements. Circumstances dictate how owl surveys are implemented. If surveys cannot be accomplished pursuant to this protocol, we recommend contacting the nearest FWS Ecological Services Field Office (ESFO) for guidance on additional survey methods before proceeding.

The FWS endorses the use of this protocol for obtaining information on owl occupancy within and adjacent to proposed project areas. This protocol helps the public and agency personnel determine whether proposed activities will have an impact on owls and/or owl habitat. A properly conducted survey will help agencies determine whether or not further consultation with the FWS is necessary before proceeding with a project. Any information on owl presence within and/or adjacent to the proposed planning or activity areas is important, even if it does not meet the guidelines described below. However, if the only owl location information available for a proposed project was acquired through surveys not conducted in accordance with this protocol, the FWS may conservatively assess the impacts of the proposed management activity on owls, (e.g.) assume the species is present in or near the action area if the best available information

makes such an assumption reasonable. This survey protocol is not designed for monitoring owl population trends or for research applications.

The generally accepted protocol for inventorying Mexican spotted owls was developed by the Southwestern Region of the U.S. Forest Service (FS) in 1988. The protocol was revised in 1989 and in 1990 it was appended to the Forest Service Manual. The protocol, as an element of Interim Directive No. 2, had an official duration of 18 months but has served as the guidance accepted by most agencies and individuals conducting surveys for owls on public lands throughout Arizona, New Mexico, Utah, and Colorado through 2003. The FS reissued the inventory protocol in 1994, again in 1995, and then issued the latest version in February 1996. The FS incorporated recommendations from the draft and subsequent final Recovery Plan for the Mexican Spotted Owl (USDI FWS 1995) regarding the designation of protected activity centers (PACs) around owl locations but did not modify the overall survey design.

Through application of and the use of the data gathered by the existing protocol under informal and formal consultations under Section 7 of the Act, the FWS has found instances where the refinement of the protocol would benefit both the species and those working with it. On January 26, 1998, the FWS met with a group of experts to review the FS protocol and available literature and to improve and update the document. The following draft document is the result of those discussions and subsequent review by FWS biologists and Mexican Spotted Owl Recovery Team members.

This protocol provides a FWS-endorsed method to: 1) make inferences regarding the presence or absence of owls in a defined area; 2) assess occupancy and nesting status, and locate nests, in PACs or in areas where habitat alterations or disturbances to owls are likely to occur; and, 3) provide information to allow designation of PACs.

The primary objective of conducting surveys using this protocol should be to locate and observe the nest of a Mexican spotted owl or young. These observations provide the most reliable and efficient information for documenting presence and delineating potential nest core areas or roost sites (Ward and Salas 2000). Because spotted owls do not nest every year, the alternative, and often default outcome, is to observe adult or subadult spotted owls at daytime roosts. However, it can take up to four years of roost location data to effectively delineate owl core activity areas (Ward and Salas 2000). Locating a resident owl's nest or young may be accomplished most effectively using the mousing technique described in the protocol below (and see Forsman 1983). The mousing technique requires that personnel are trained in proper care and handling of live animals for research, and that, when conducting daytime follow-up surveys, they procure and carry "feeder" mice into the field (American Society of Mammalogists 1998, National Academy of Sciences 1996).

Individuals surveying for owls should meet certain training standards. Experience will be reviewed and approved during a surveyor's application for an FWS issued Section 10(a)(1)(a) recovery permit. These standards strongly encourage surveyors to have knowledge of this protocol and the ability to identify owls visually and vocally, determine sex and age of owls, imitate vocal calls of the owls if not utilizing a tape recording of the calls, and identify other local raptor species. Orienteering skills, including use of map, compass, and/or Global

Positioning System (GPS) units, are essential. Surveyor safety should be of primary importance. Those surveying for owls who do not meet these training standards could "take" owls by harming or harassing them, resulting in criminal or civil penalties.

MEXICAN SPOTTED OWL SURVEY PROTOCOL

The most efficient way to locate owls is to imitate their calls (Forsman 1983). The owl is territorial and responds to imitations of its common vocalizations. Night calling is used to elicit responses from owls and locate the general areas occupied by them. Daytime follow-up visits are used to locate roosting and/or nesting owls and to further pinpoint the activity centers of individual owls. If owls are located, mice are offered to them to locate mates, nests, and young. The information collected from nighttime calling surveys and daytime follow-up surveys assist biologists and land managers to determine whether areas are occupied or unoccupied by owls and to determine the owl's reproductive status.

Throughout this protocol, all bold-faced terms are included in the glossary. Only the first use of the term is bold-faced. An outline summarizing the primary steps for implementing the protocol appear below.

1. Survey Design

The survey design uses designated **calling routes** and **calling stations** to locate owls. The intent of establishing calling routes and calling stations is to obtain **complete coverage** of the survey area so that owls will be able to hear a surveyor calling and a surveyor will be able to hear the owl(s) responding.

A. The survey area should include all areas where owls or their habitat might be affected by management actions. If an area is relatively large, it can be subdivided into manageable subunits to achieve the best survey results. In general, the survey area should include the survey area and an 800-meter (0.5-mile) area from its exterior boundaries. Within the project area, all areas that contain forested **recovery habitat**, riparian forest, and canyon habitat, or might support owls, are surveyed as defined in this revised Recovery Plan. Descriptions of owl habitat for different areas and physiographic provinces should be available from various state and Federal wildlife agencies.

   Where known **protected activity centers (PACs)** exist within the survey area, calling routes can be adjusted to lessen disturbance to established PACs.

B. Owl surveyors should establish calling routes and calling stations to ensure complete coverage of the survey area. The number of calling routes and calling stations will depend upon the size of the area, topography, vegetation, and access. Calling stations should be spaced from approximately 400 meters (0.25 mile) to no more than 800 meters (0.5 mile) apart depending upon topography and background noise levels. Nighttime calling routes and calling stations should be delineated on a map, reviewed in the field, and then relocated, as necessary, to improve the survey effectiveness.

2. Survey Methods

Owls are usually located using nocturnal calling surveys where a surveyor imitates the territorial calls of an owl (Forsman 1983). Upon hearing a suspected intruder within their territories at night, most owls respond by calling to and/or approaching the intruder.

A. CALLING

1. Owls call during all hours of the night. However, optimal survey times include two hours following sunset and two hours prior to sunrise, and surveys should be concentrated around these periods.

2. Surveys should use nighttime surveys for all calling routes in the survey area unless safety concerns dictate that a daytime survey is necessary.

3. Calls can be imitated by the surveyor or by playing recordings of owl vocalizations. If a tape recorder is used, both the tape and tape deck used should be of high quality. Tape decks should have a minimum output of 5 watts (Forsman 1983).

4. The vocal repertoire of owls consists of a variety of hooting, barking, and whistling calls (Ganey 1990). Three call types accounted for 86 percent of calling bouts heard in Arizona: four-note location call, contact call, and bark series. The four-note call appears to be used the most frequently by owls defending a territory. It is suggested that surveyors use all three of these calls during surveys, with the four-note call as the primary call.

5. Surveyors should discontinue calling when a potential owl **predator** is detected, and should move on to another calling station out of earshot of the predator before resuming calling. Surveyors should return at a later time to the station(s) skipped to complete the calling route. If the predator is detected again, the surveyor may try active listening rather than calling at the station. Other solutions completing routes with high-densities of predators, such as great-horned owls, may include active listening at these stations in order to complete the route. Please contact the FWS Mexican spotted owl lead if there are concerns regarding spotted owl predator detections on survey routes.

6. Surveyors should avoid calling for owls during periods of rain or snow, unless there is only a light misting of rain or snow that would not affect the surveyor's ability to detect owls. Surveying during inclement weather could prevent a surveyor from hearing owl responses and reduce the quality of the overall survey effort. Negative results collected under inclement weather conditions are not adequate for evaluating owl presence/**absence**. There is also the added risk of inducing a female owl to leave the **nest** during inclement weather and potentially jeopardizing nesting success.

7. Calling should not be conducted when the wind is stronger than approximately 24 km (15 miles) per hour or when the surveyor feels that the wind is limiting their ability to hear an owl. Consider using the Beaufort Wind Strength Scale. Level 4 describes winds 21 to 29

km (13 to 18 miles) per hour as a moderate breeze capable of moving thin branches, raising dust, and raising paper.

B. SURVEYS

To ensure complete coverage of the survey area, surveyors should select the best survey method for the situation and/or terrain. An owl survey might require a combination of methods, which are defined below, including: 1) calling stations; 2) continuous calling routes to obtain complete coverage of an area; and, 3) leapfrog techniques. Each of these methods is designed for nighttime calling and involves calling for owls and listening for their responses. All surveys where occupancy status is unknown should include nighttime calling.

It is imperative that, whatever method is used, surveyors actively listen during owl surveys. Owls may respond only once; therefore, surveyors must concentrate on listening at all times during surveys. In addition to active listening, surveyors should watch for owls that might be drawn in but do not respond vocally.

1. CALLING STATIONS

a. **Spacing** - Calling stations should typically be spaced approximately 400 meters (0.25 mile) to no more than 800 meters (0.5 mile) apart depending on topography and background noise. In some situations (i.e., complex topography, etc.), establishing calling stations <400 meters apart and more calling stations increases the likelihood of detecting owls. In canyon habitat, if surveying from the canyon bottom, stations should be placed at canyon intersections. If surveying canyons from the rims, calling stations at points and canyon heads should be included.

b. **Timing** - Surveyors should spend at least 15 minutes at each calling station: 10 minutes calling and listening in an alternating fashion, and the last 5 minutes listening. Owl response time varies, most likely because of individual behavior. Some owls will respond immediately, some respond following a delay, and some do not respond. In canyon habitat, it is recommended that surveyors spend a minimum of 20 minutes (30 minutes, if possible) at each station.

c. **Visitation** - Vary the sequence of visitation to calling stations, if possible, during subsequent visits to the area. For example, the order of the calling stations can be reversed. Varying the order of calling stations avoids potential bias related to time of night or other factors.

d. **Intermediate calling stations** should be used when factors decrease the probability of achieving complete coverage using the originally designated stations, or as triangulation points for determining nighttime owl locations. Use of intermediate calling stations can increase the likelihood of detecting owls and, thus, allow for stronger inference regarding the absence of an owl within the area.

2. CONTINUOUS CALLING METHOD

In some cases, using continuous calling is appropriate. Continuous calling involves imitating owl calls at irregular intervals while walking slowly along a route and stopping regularly to listen for owl responses. Because of the sounds produced by walking (e.g., snapping twigs, pinecones, etc.), surveyors utilizing this calling method must concentrate on active listening. In canyon habitat, the continuous calling method is only recommended when combined with calling stations.

a. The surveyor should walk slowly (5 km per hour [3.3 miles per hour]) so as to minimize the possibility that an owl responds after surveyors are out of hearing range (i.e., allow time for owls to respond).

b. The surveyor must stop regularly (400 meters [0.25 mile]) along the route to listen for owl responses.

3. LEAPFROG METHOD

The leapfrog method is very useful when roads allow for coverage of all or a portion of the survey area. This method requires two people and a vehicle.

a. One surveyor is dropped off and begins calling while the other person drives the vehicle ahead at least 800 meters (0.5 mile). The second person then leaves the vehicle for the first person and proceeds ahead while calling.

b. Each surveyor should follow the continuous calling method. The first person continuously calls as he or she walks towards the vehicle, drives the truck at least 800 meters (0.5 mile) past the second person (i.e., "leapfrogs"), leaves the vehicle there and resumes calling along the survey route.

c. Surveyors should repeat this procedure until complete coverage of the survey area is accomplished.

3. Number and Timing of Surveys

Owl detection rates change with season, owl activity, and habitat. Ganey (1990) found that calling activity was highest during the nesting season (March-June). Information from past survey efforts indicate that owl response can also vary with habitat type and/or reproductive chronology (Fig. D.1). Generally, late March through late June is the optimal time period to detect owls. Surveys conducted during March-June will increase the likelihood of detecting owls. Additionally, if owls are <u>not</u> detected when surveys are conducted properly and at these peak times, then inferences about absence of owls in a given area will be stronger. It should be noted that responses in September can be used only to document presence. Surveys in September are not reliable for locating nests, delineating PACS, and/or inferring absence.

Specific criteria on number and timing of surveys are used to determine whether a **complete inventory** has been accomplished. A complete inventory requires that at least four properly scheduled complete surveys be accomplished annually for two years. Additional years of surveys strengthen any inferences made in cases where owls are not detected. If habitat-modifying or potentially disruptive activities are scheduled for a particular year, the second year of surveys should be conducted either the year before or the year of (but prior to) project implementation. In other words, projects should occur as soon as possible after completion of surveys to minimize the likelihood that owls will be present during project implementation. If more than five years have elapsed between the last survey year and the initiation of the proposed action, then one additional year of survey is recommended prior to project implementation.

A. In compliance with the guidelines in B through G below, surveyors should conduct four **complete surveys** during each breeding season. A complete survey can be a combination of a pre-call (daytime reconnaissance of habitat to be night called), a nighttime calling survey, and, if owls are detected, a **daytime follow-up survey**. If owls are not detected during daytime calling, night calling must be completed. However, if owls are located during a pre-call, night calling of the survey area is not required. Surveyors might want to conduct additional surveys if there is evidence that additional owls remain undetected in the area.

B. The four complete surveys must be spread out over the breeding season (1 March - 31 August) by following one of three recommended scheduling scenarios:

    1. Conducting two to four surveys during 1 March - 30 June, with no more than one survey in March. Owl calling activity tends to increase from March through May (Ganey 1990), so this time period is optimal for locating owls.

    2. Completing all surveys by 31 August, with no more than one of the four required surveys conducted in August. Owl response rates tend to decrease by July (Ganey 1990). By September, juveniles have usually dispersed and adults are not necessarily on their territories. If additional surveys are needed (e.g., more than the recommended four surveys), then more than one complete survey could be completed in August.

    3. Allowing at least five full days between surveys. For example, assume a visit ends on 30 April. Using a proper five-day spacing (1-5 May), the next possible survey date would be 6 May (see section 3.D below for an exception to this rule).

C. A complete survey of the area should be conducted within seven consecutive days. If the area is too large to be surveyed in seven consecutive days, it should be divided into smaller subunits based on available owl habitat, topography, and other important factors.

D. In **remote areas,** surveyors can conduct two complete surveys during one trip into the area, so long as surveyors allow a minimum of two days between complete surveys. Conduct all field outings required for a complete survey prior to repeating any route for the second survey. Wait a minimum of 10 days before starting the next two surveys. **Areas defined as remote should be cleared with the FWS prior to proceeding with this deviation from the survey protocol.**

E. The two- to three-hour periods following sunset and preceding sunrise are the peak owl calling periods and the best times to locate owls in or near day **roosts** or nests.

F. Surveys can be discontinued in a given area when data indicate that the entire survey area is designated as PACs.

G. Vocal or visual locations of owls outside the breeding season (1 September - 28 February) as extra information can be of assistance in locating nesting owls in the upcoming breeding season.

4. Methods After Detecting a Mexican Spotted Owl

Once an owl has been detected, the following should be done:

A. Record the time the owl(s) was first detected, the type(s) of call(s) heard (if any), the owl's sex, and whether **juveniles** were detected.

B. Record a compass bearing from the surveyor's location to the location where the owl was heard and/or visually observed. If possible, triangulate the owl's location, taking compass bearings from three or more locations and estimate the distance to the owl. Record both the location where the owl responded from and the surveyor's calling location and triangulation locations on a map or photo attached to the survey form. The surveyor should know her/his location at all times. Triangulating provides an accurate means to map the owl's location. Attempt to confirm the presence of the owl(s) with a daytime follow-up visit (see section 5 below). Daytime owl locations, particularly of nests and young of the year, are very important in determining activity centers.

C. If the owl is heard clearly, and the call type and direction are confirmed, there is no need to continue calling. If, however, there is some doubt as to whether a response was detected, or from which direction, the surveyor should listen carefully for a few minutes, as an owl may call again if given the opportunity. If the owl does not respond after two to five minutes, the surveyor should continue calling to confirm owl presence and better assess the direction of the call. Do not call any more than is necessary. By stimulating the owl(s) to move you may harass a female owl off a nest or increase an owl's risk of predation.

D. Owls may move before or after they begin calling. Every effort should be made to estimate the location of the owl when the first response was heard. After you have determined the owl's location (see section 4.B above), move approximately 800 to 1,200 meters (0.5 to 0.75 mile) away (depending upon topography) before continuing surveys to avoid response by the same owl. If the owl responds from the original detection area, then move farther away before continuing to call.

E. Record the approximate location (bearing and distance), sex, age, and species of all other raptors heard in the survey area.

F. Conduct a daytime follow-up survey as soon as possible (see section 5 below).

5. Conducting Daytime Follow-up Surveys

As with nighttime surveys, follow-up daytime searches ensure quality of results and standardization of effort. Calling to elicit territorial responses is also used during daytime follow-up visits. A daytime follow-up survey helps locate owl roosts, nest sites, and young of the year (during 1 Jun - 1 Aug) by conducting an intensive search within the general vicinity of the original night response location. Owls tend to be more active in the early morning and late evening. During the day, owls are sleepy and do not always readily respond to calling, especially on warm days. Therefore, it is critical that surveyors conduct a thorough daytime search of the response area. Surveyors should spend enough time within the response area to cover all habitats within at least an 800-meter (0.5 mile) radius of the response location. This involves walking throughout the area, calling, listening, and watching for owl sign (e.g., whitewash, pellets, etc.). The FWS recommends that a minimum of one hour be spent searching for owls (regardless of the number of people surveying).

A. Complete a daytime follow-up survey as soon as possible, but within a maximum of 48 hours after owls are detected during nighttime surveys. The optimum daytime follow-up time is the morning following the nighttime detection. In general, the longer the time delay between the nighttime response and daytime follow-up survey, the smaller the probability of locating the bird and finding its roost or nest location. This is especially true if the owl(s) are not nesting. If the daytime follow-up survey is performed longer than 48 hours after the nighttime detection and no owls are found, the survey is considered incomplete and the survey must be re-done.

B. Conduct daytime follow-up surveys in the early morning or late afternoon/early evening. The optimal dawn period is 0.5 hour before sunrise to two hours after sunrise and the optimal dusk period is two hours prior to sunset; each daytime follow-up visit should include one of these time periods. Investing time in searching for the owl during these times will provide a more reliable inference of absence in the case where the owl cannot be located. For areas where spotted owls have been observed during the daytime during previous years, an initial survey in late April through mid-May can often elicit a response. However, non-responses are not that meaningful in documenting absence without nighttime surveys because owls could have moved to another nesting or roosting grove. Initial daytime surveys can be an efficient way to start each survey season where owls have been found in the past. If the initial daytime survey is unsuccessful (i.e., no response is heard), then nighttime surveys should be used to locate owls before attempting additional daytime surveys.

C. The search area for a daytime follow-up survey is a specific, smaller area within the broader survey area in which an owl was detected.

1. Minimum search area is all recovery habitat within at least an 800-meter (0.5-mile) radius of a nighttime owl response.

2. The search area should center on the location of the owl or owls that were heard during the nighttime survey. If there is some uncertainty, focus the search on the best nesting and roosting habitats (e.g. see Ward and Salas 2000).

3. Aerial photos and maps of the area should be studied to identify habitat patches and topographic features, such as canyons or drainages, to prioritize daytime survey locations. In forested areas, spotted owls often roost in first- and second-order tributaries (Ward and Salas 2000).

D. To conduct a thorough search for owls, the surveyor should systematically walk and call all forested recovery, riparian forest, and canyon habitats within the search area. As with nighttime surveys, be aware that owls often fly into the area to investigate; thus, surveyors must also attentively watch for owls. Surveyors should also search for signs of owls such as pellets, white wash, or molted feathers. However, pellets and whitewash alone are not sufficient to document owls. Mobbing jays or other birds can also be a sign that an owl is present.

E. If a daytime follow-up visit is not completed for any reason, or the search effort was not thorough because of the presence of predators or weather, a second follow-up visit should be conducted as soon as possible.

F. If no owl(s) are located during complete daytime follow-up visits, the surveyor should return to conduct nighttime surveys. Four complete surveys to an area are recommended by the survey protocol, but surveyors should assess the confidence of the nighttime and daytime responses and determine if additional nighttime surveys are needed to more accurately determine the location of the responding owl(s). Field personnel conducting surveys need to be given the flexibility to return as many times as necessary to find the owl(s).

G. As with nighttime surveys, daytime follow-up surveys should not be conducted in inclement weather and surveyors should avoid calling when potential owl predators are present.

H. Surveyors should minimize the amount of incidental disturbance to owls. For example, surveyors must not linger in nest sites or over-call in an area.

6. Methods If Mexican Spotted Owls Are Located on a Daytime Follow-up Visit

Mousing is the primary tool to locate an owl's mate, young, and/or nest. Mousing entails feeding live mice to **adult**/**subadult** owl(s) and observing the owl's subsequent behavior. Surveyors should be prepared to offer four mice (one at a time) to at least one member of the pair or to a single owl located on the daytime follow-up visit. For surveyors to draw conclusions about reproductive status, the owl must take at least two mice before refusing them. A mouse is considered "refused" if, after 30 minutes, it has not been taken by an owl.

If an owl takes a mouse and flies away, the surveyor should follow it as closely as possible to determine where it takes the mouse. If the surveyor is unable to follow the owl, and doesn't know if it took the mouse to a mate, nest, or fledged young, then the fate of that mouse cannot be counted toward the four-mouse minimum described above. Surveyors should be ready to rapidly pursue owls that take mice, as owls sometimes fly several hundred meters with mice to reach their nests or young. It is not necessary to complete the four mice minimum after a mouse has unequivocally been taken to a nest.

Owl pairs are determined to be non-nesting if a single owl eats and/or caches all four mice or eats and/or caches two mice and refuses to take a third. A mouse is cached when the owl puts the mouse in a tree or on the ground and then leaves the mouse or the owl perches with the mouse for at least one hour and gives no sign of further activity. Do not feed any more mice than necessary to determine pair status, nest location, and/or reproductive status (i.e., if all observed juveniles have received a mouse then number of young produced is determined and there is no need to continue mousing). Dropped mice or mice whose fates are unknown do not count toward the total of four mice needed to complete the protocol.

Ancillary notes on an owl's behavior during the mousing attempts are also very important to record. These observations can help clarify situations in which incomplete information was collected. For example, if a male is given a mouse and begins to make single-note contact calls while looking in a specific direction in April-June, that is often a good clue that a mate, nest, and/or young may be present. Sometimes observers are too close to other owls or the nest for the "true" mouse fate to be observed. Such observations should trigger another daytime follow-up to secure the location of a mate, nest, or young of the year. For these types of additional follow-up surveys, nighttime calling is usually not necessary.

7. Determining Status from Nighttime Surveys and Daytime Follow-up Visits

A. "Pair status" is established by any of the following:

1. A male and female owl are heard and/or observed in proximity (500 meters or 0.31 mile apart) to each other on the same visit.
2. A male takes a mouse to a female (see section 6 mousing guidelines).
3. A female is observed or heard on a nest.
4. One or both adults are observed with young.
5. At least one young of the year is observed.

B. "Single status" is inferred from:

1. A daytime observation on a single occasion or nighttime responses of a single owl within the same general area (within 500 meters or 0.31 mile) on two or more occasions, with no response by an owl of the opposite sex after two complete inventories (two years of survey); or

2. Multiple responses over several years from a bird of the same sex (i.e., two responses in the first year of surveys and one response in the second year of surveys, from the same general area).

   Determining if the responses occur within the same general area should be based on topography and the location of any other known owls in the surrounding area.

C. "Two birds, pair status unknown" is inferred from:

   The presence or response of two owls of the opposite sex where pair status cannot be determined.

D. "Status unknown" is inferred by:

   The response of a male and/or female spotted owl that does not meet any of the above criteria. We recommend additional years of survey if this is the site status following a complete inventory of the site.

E. "Absence" is inferred:

   If a complete inventory has been conducted according to this protocol, or an alternative protocol approved by the FWS, and no owls are heard. However, absence does not necessarily indicate that owls never occupy the area.

F. Separate territories are inferred by:

   When two responses are recorded from owls that are more than 800 meters (0.5 mile) apart. These responses should be considered from individuals in separate territories unless daytime follow-up visits indicate otherwise. Ideally, surveyors on two or more crews should coordinate efforts to begin calling simultaneously near each suspected activity area to rule out the existence of multiple territories. If more than one survey crew elicits responses from owls of the same sex at roughly the same time, then two or more territories probably exist. However, if responses vary from those above, the results are considered inconclusive and additional attempts to determine status should continue. Keep in mind that some spotted owls shift their use of an area after failing to nest in a given season. Hence, responses heard in July that are 800 meters (0.5 mile) from a pair that was nesting in April or early May could be from the same individuals.

8. Determining Nesting Status and Reproductive Success

Determining reproductive success is not required if breeding season restrictions that protect owl reproduction are applied to all management projects in any given year. However, reproduction surveys are always valuable as they can provide information on nest tree locations, which provide the best data for determining 100-acre **core areas** (Ward and Salas 2000) and delineating PAC boundaries as recommended in the revised Recovery Plan. If the exact location of the nest is not determined, but juveniles are seen prior to August, the area where the juveniles are seen

can be referenced as the **nest stand**. There are two stages of reproduction surveys: nesting status and reproductive success.

A. Determining Nesting Status:

1. Nesting-status surveys should be conducted between 1 April and 1 June. The start date is based on nesting initiation dates. Young identified after 1 June would still confirm that nesting occurred but would not allow identification of the exact location of the nest. However, young observed prior to August are usually within 400 meters (0.2 miles) of the nest of that year (Ward and Salas 2000) and this information can be useful in delineating a 100-acre nest buffer.

2. Mousing should be used to determine nesting status. The site is classified as nesting, non-nesting, or unknown nesting status based on the surveyor's observations.

3. Two observations at least one week apart are necessary to determine nesting status if the first observation occurs before 1 May. This is necessary because the owls may show signs of initiating nesting early in the season without actually laying eggs and their behavior could be mistaken for nesting behavior. After 1 May, a single observation of nesting behavior is sufficient.

4. The owls are classified as nesting if, on two visits prior to 1 May, or one visit after 1 May:

    a. The female is seen on the nest;

    b. Either the male or female member of a pair carries a mouse to a nest; or

    c. Young-of-the-year are detected.

5. The owls will be classified as non-nesting if any of the following behaviors are observed. Two observations, minimum three weeks apart, are required during the nest survey period (1 April - 1 June) in order to infer non-nesting status. Because nesting attempts might fail before surveys are conducted, the non-nesting status includes owls that did not attempt to nest as well as those that had a failed nesting attempt. Non-nesting status is inferred during a daytime follow-up visit if:

    a. The female is observed roosting for a full 60 minutes (1-30 April) during the time she should be on a nest. The female should not be in an agitated state and should be given every opportunity to return to the nest. Surveyors should attempt to mouse the female.
    b. The surveyor offers prey to one or both members of the pair and they cache the prey, sit with the prey for an extended period of time (30-60 minutes), or refuse to take additional prey beyond the minimum of two prey items. To be considered a valid nesting survey, one owl must take <u>at least</u> two prey items.

c. All pairs considered to be non-nesting should receive at least one daytime follow-up visit between 15 May and 15 July to confirm that no young were produced.

6. Nesting status is unknown if:

   a. Owls are found after 1 June without young-of-the-year; or

   b. No adult or young owls are found after 1 June at those sites where adult owls were present prior to 1 June.

B. Determining Reproductive Status:

1. Once a pair is classified as nesting, reproductive success surveys should be conducted after the time the young-of-the-year leave the nest (fledge), usually in early to mid-June. For pairs whose nesting status was not determined, reproductive success surveys should be conducted between 15 May and 15 July.

2. At least two visits to the site spaced at least one week apart should be conducted to locate and count fledged young, and the timing of the visits should be scheduled so that the fledged young are observed as soon after leaving the nest as possible.

3. Visual searches and/or mousing should be used to determine reproductive success. The mousing protocol is the same as for determining non-nesting. If young are present, the adults should take at least some of the prey to the young. The sight of an adult with prey can stimulate the young to beg, revealing their number and location.

4. If the owls take at least two prey items and eventually cache, sit with, or refuse further prey without ever taking prey to fledged young during the proper time period and no other indicative behaviors like contact calls or searching are observed, then zero young are recorded. If one individual adult or subadult owl takes and eats four mice on one visit during the proper time period, then zero young are recorded. If, however, other behaviors indicate young may be in the area, another follow-up survey is recommended to verify that zero young were produced, particularly if the pair had been observed nesting earlier that year.

9. Annual Reporting

An annual report of the activities conducted (including field data forms, if appropriate) should be submitted to the FWS Permits Office in Albuquerque, New Mexico, as well as the appropriate state FWS ESFO. If applicable, hard copies of any unpublished or published reports generated by the study and other data that would be useful for the conservation or recovery of the owl should be submitted to the appropriate FWS ESFO(s).

10. Disposition of Dead, Injured, or Sick Mexican Spotted Owls

Upon locating a dead, injured, or sick owl, initial notification should be made to the FWS's Law Enforcement Office in Arizona (telephone: 480-967-7900), Colorado (telephone: 303-274-3560), New Mexico (telephone: 505-346-7828), or Utah (telephone: 801-625-5570) within two working days (48 hours) of its finding. Written notification should be made within five calendar days and should include information on when (date, time) and where (exact location) the owl was found, photographs of the owl and/or area, if possible, and any other pertinent information. The notification should be sent to the Law Enforcement Office with a copy to the appropriate FWS ESFO. Sick and injured owls should be transported by an authorized biologist to a licensed and permitted wildlife rehabilitator or veterinarian, and care must be taken during handling to ensure effective treatment. Should the treated owl(s) survive, the FWS should be contacted regarding the final disposition of the animal. Salvaged specimens or owls that did not survive rehabilitation should be handled with care to preserve the biological material, and the remains of intact owl(s) should be provided to the appropriate FWS ESFO (as noted in the Section 10 permit). If the remains of the owl(s) are not intact or are not collected, the information noted above should be obtained.

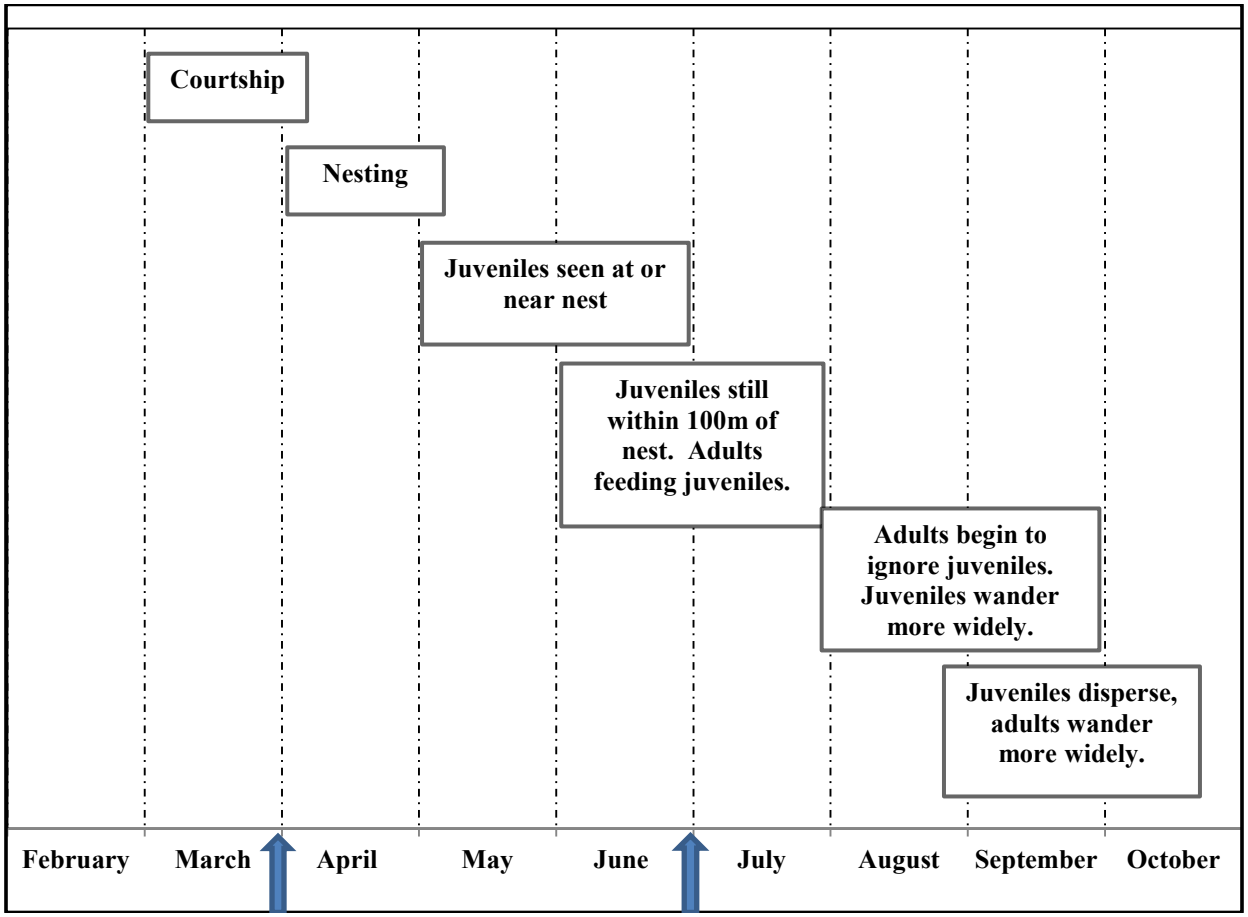


Figure D.1. Generalized reproductive chronology for the Mexican spotted owl. The area between the arrows at the bottom of the table indicates periods of high probability of detecting owls. Chronology may vary slightly with area, elevation, and/or in response to weather.

11. Glossary for Appendix D - Survey Protocol

Absence	Absence of Mexican spotted owls can be inferred when no response is recorded after a complete inventory has been completed in a defined area. Absence does not necessarily indicate that Mexican spotted owls do not or never occupy the area.
Adult	A Mexican spotted owl ≥27 months old. Tips of retrices (tail feathers) will be rounded with white and mottled color. Subadults will have triangular all white tips on tail feathers. For more information on identifying adult and first and second-year subadult Mexican spotted owls, see Moen et al. (1991).
Breeding Season	The time period from 1 March through 31 August that includes courtship, nesting, and nestling- and fledgling-dependency periods. **This is the period of time in which surveys should be conducted.** This time period will vary by geographic locale.
Calling Route	An established route within a survey area where vocal imitations or recorded calls of Mexican spotted owls are used to elicit a response.
Calling Stations	Point locations used to conduct surveys, distributed throughout an area so as to attain complete coverage of the survey area.
Complete Coverage	Complete coverage is obtained when the calling stations have been located within a survey area so that a Mexican spotted owl anywhere in the survey area would be able to hear surveyors and vice-versa.
Complete Inventory	When the following are met: 1) four complete surveys have been conducted in one year; 2) consecutive surveys have been conducted a minimum of five days apart; 3) no more than one survey has been conducted in March; 4) a minimum of two surveys have been conducted by 30 June; 5) all surveys were completed by 31 August, with no more than one survey conducted in the months of July and August; and, 6) two years of survey have been completed.
Complete Survey	A survey is complete when all calling stations or calling routes within a survey area are called within a seven-day period, including daytime follow-up visits for all Mexican spotted owl responses. If every reasonable effort has been made to cover the survey area in one outing but this is not accomplished, then additional outings will be scheduled to cover the remaining area. The entire survey area must be covered within seven consecutive days in order to be considered one complete survey. Although adverse weather conditions may present problems, an effort should be made to complete survey visits on consecutive days. If the survey area is too large to be completely surveyed in seven days, it may be

	divided into smaller areas based on available habitat, topography, drainages, etc.
Core Area	A 40-ha (100-acre) area within designated protected activity centers (PACs) circumscribed around the nest or roost site. The nest or roost area should include habitat that resembles the structural and floristic characteristics of the nest site. These 100-acre areas will be deferred from mechanical treatment. For additional details on delineation, see Ward and Salas (2000).
Daytime Follow-up Visit	A daytime follow-up visit is conducted around Mexican spotted owl responses. The objective of a daytime follow-up visit is to locate Mexican spotted owl(s), their nests and their young by conducting an intensive search within an 800-meter (0.5-mile) radius of the original nighttime or last known response location. The follow-up visit is conducted during daylight hours and should be completed as soon as possible following the initial detection, but no later than 48 hours after detection. If Mexican spotted owls are located during the daytime follow-up visit, the surveyors use the mousing technique to determine nesting and reproductive status.
Intermediate Calling Stations	Calling locations between identified calling stations or routes used to triangulate a Mexican spotted owl's location or used to improve calling coverage of an area when weather or other conditions require. These stations are not required to be established prior to the field outing in which they are used.
Juvenile	A Mexican spotted owl is considered a juvenile in its first five months after hatching. Juveniles one to three months old are very white and have downy plumage over all of the body or evident on breast and head; at four to five months old, juveniles begin losing downy plumage but retain white triangular tips on their tail feathers (Moen et al. 1991).
Mousing	Mousing is a term used to describe the act of offering prey items to owls or other birds of prey. The purpose of mousing Mexican spotted owls is to find mates and determine the reproductive status of the owl(s) (i.e., pair, nesting, non-nesting). In some instances, a male Mexican spotted owl will take a prey item to an unseen female or an adult owl will take prey items to unseen young.
Nest	Mexican spotted owls use broken-topped trees, old raptor nests, witches brooms, caves, cliff ledges, and tree cavities for nests. A Mexican spotted owl must be observed using the structure in order to designate a nest site.
Nest Stand	An area of vegetation that contains a Mexican spotted owl nest.

Nestling	A young owl that is still in the nest; may also be called a hatchling.
Predator	Potential predators of Mexican spotted owl eggs and young include the following: great-horned owl (*Bubo virginianus*), northern goshawk (*Accipiter gentilis*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), common ravens (*Corvus corax*) and procyonid mammals (e.g., coati [*Nasua nasua*] and ringtail [*Bassariscus astutus*]).
Protected Activity Center (PAC)	An area of at least 243 ha (600 acres) surrounding the "core area," which is the nest site, a roost grove commonly used during the breeding season in absence of a verified nest site, or the best roosting/nesting habitat if both nesting and roosting information are lacking. The 243 ha (600 acres) (minimum size) is delineated around the activity center using boundaries of known habitat polygons and/or topographic boundaries, such as ridgelines, as appropriate. The boundary should enclose the best possible Mexican spotted owl habitat, configured into as compact a unit as possible, with the nest or activity center located near the center. This should include as much roost/nest habitat as is reasonable, supplemented by foraging habitat where appropriate. For example, in a canyon containing mixed-conifer on north-facing slopes and ponderosa pine on south-facing slopes, it may be more desirable to include some of the south-facing slopes as foraging habitat than to attempt to include 600 acres of north-slope habitat. In many canyon situations, oval PACs may make more sense than, for example, circular PACs; but oval PACs could still include opposing canyon slopes as described above. All PACs should be retained until this subspecies is delisted, even if Mexican spotted owls are not located there in subsequent years.
Remote Area	Generally, any survey area that requires more than four hours of travel time by vehicle and/or foot during good road, trail, and weather conditions (good for the road or trail in question) to reach. All remote areas should be agreed upon by the FWS on a case-by-case basis prior to using the survey protocol to clear a project.
Recovery Habitat	Mixed-conifer and pine-oak forest types, and riparian forests as described in this revised Recovery Plan. Recovery nest/roost habitat either is currently or has the potential to develop into nest/roost habitat. Recovery foraging/non-breeding habitat currently does or could provide habitat for foraging, dispersing, or wintering life history needs. Specific guidelines for management activities and developing recovery nest/roost conditions are specified in this revised Recovery Plan.

Roost	Tree, cliff ledge, rock, or log used by a Mexican spotted owl for extended daytime rest periods. A roost site consists of the roost itself and the immediate vicinity. Roost areas are identified by observations of the Mexican spotted owls and/or the presence of pellets, whitewash, and other evidence.
Subadult	Mexican spotted owls in their second and third summers (5 to 26 months of age). Identified by characteristic tail feathers with white tips tapering to sharp points (i.e., triangular shaped). For more information on identifying subadult Mexican spotted owls, please see Moen et al. (1991).

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14. Mexican Spotted Owl Survey Protocol Outline

Complete Inventory Four complete surveys each year (minimum five days apart)
No more than one survey in March
Minimum of two surveys prior to June 30th
No more than one survey in each of July and August
All surveys completed by 31 August
Two years of complete surveys

1. Owl(s) Detected, go to 3

2. No Owls Detected, Absence inferred for survey area

3. PRESENCE - Conduct a daytime follow-up visit

   A. No owl(s) found on daytime follow-up visit:

      Status unknown, SINGLE STATUS inferred, return to night calling

   B. Single owl located on daytime follow-up visit:

      Feed maximum 4 mice to owl to determine status; if no other owl located, RESIDENT SINGLE CONFIRMED

   C. Pair of owls located on daytime follow-up visit:

      PAIR CONFIRMED for site, go to 4B

4. NESTING STATUS SURVEYS (1 April - 1 June)

   A. Pair not detected, non-nesting, non-reproduction inferred (for that survey)

   B. Pair located, mouse owls (1 of owl pair fed 4 mice)

      1. If one of the following occurs, nesting confirmed, reproduction unknown, go to 5B:

         a. Female on nest

         b. Owl takes prey to nest

         c. Young in nest with adult present

      2. If one of the following occurs, non-nesting inferred, non reproduction inferred (two visits to infer non-nesting, minimum three weeks apart):

a. One of owl pair fed four mice (know fate of all four mice)

b. Female refuses mouse and/or roosts for minimum one hour (1 April - 30 April)

3. Pair (but no young) located after 1 June:

a. NESTING STATUS UNKNOWN

b. Conduct reproductive visit, go to 5A

5. REPRODUCTIVE SUCCESS VISITS

A. NESTING STATUS UNKNOWN

1. Recommend two visits, one week apart, feed four mice to locate juveniles

B. NESTING STATUS KNOWN

1. One visit to look for juveniles (this may take more than one visit to locate all juveniles produced)

2. If surveyor does not find juveniles, mouse adults to locate juveniles

APPENDIX E - POPULATION AND RANGEWIDE HABITAT MONITORING PROCEDURES

In developing the original Recovery Plan (USDI FWS 1995), the Recovery Team assimilated, reviewed, and analyzed data generated by the Mexican Spotted Owl Monitoring Program of the FS Southwestern Region. The Recovery Team also compiled and reviewed data from the BLM and the Intermountain and Rocky Mountain Regions, FS. In addition, the Recovery Team evaluated results of a pilot study (Ganey et al. 2004) conducted to test the population-monitoring procedures proposed in USDI FWS (1995) and more recent studies that have estimated the probability of site occupancy by Mexican spotted owls (Lavier 2006, Mullet 2008). Based on lessons learned from these efforts, we offer an alternative design for monitoring the Mexican spotted owl population within the U.S. This approach would measure the critical variables – changes in owl site occupancy rates and changes in habitat – needed for delisting the species (see Part III.E).

Our proposed approach uses occupancy monitoring to evaluate trends in the owl population. Occupancy monitoring is based on mark-recapture theory (MacKenzie et al. 2002, 2003, see also MacKenzie et al. 2006) and allows for estimating detection probabilities and correcting directly observed estimates of occupancy rates. This detail is critical, because it is likely that not all resident owls will be detected in a given year and because detection probabilities may change over time. Such changes in detectability of owls could result in erroneous trend estimates and misguided conservation efforts.

Accurate and efficient protocols for occupancy monitoring require pilot studies to estimate detection probabilities and to estimate variances associated with detection probabilities, occupancy rates, and important habitat variables. For occupancy monitoring, these estimates then can be used to determine the number of call stations per survey plot and to refine the number of visits per plot. Most importantly, the numbers of plots required within predefined strata and EMU can be determined more precisely.

Habitat monitoring should entail remote sensing of habitat across the range of the bird and estimates of desired conditions (Appendix C, Tables C.2, C.3), some of which are best measured on the ground. Although we do not advocate a specific methodology for ground measures, the FS Forest Inventory and Analysis (FIA) program offers some promise. We describe some relevant details of this program below.

1. Population Occupancy Modeling

Monitoring habitat as a singular effort will not adequately reveal the true status of the owl population because numerous factors besides habitat can influence population levels. Thus, it is desirable to simultaneously monitor trends in both habitat and owl abundance (or an acceptable surrogate index).

A limitation of the monitoring scheme proposed here (and all known approaches) is that it monitors primarily territorial birds. The population of non-territorial "floaters" (Franklin 2001) is difficult to detect reliably. Evidence for Mexican spotted owls suggests that a large population

of floaters does not exist, however. Specifically, the proportion of subadult owls successfully holding territories is relatively high, suggesting that surplus older birds do not exist. For example, the proportion of the territorial population comprised of subadult females ranged as high as approximately 30–33% in two demographic study areas in Arizona and New Mexico over a seven-year period (Seamans et al. 1999: Fig. 1). Further, density of territorial owls in these study areas tracked reproduction with a short lag period (Seamans et al. 1999: Fig. 5; Gutiérrez et al. 2003), again suggesting that there were not substantial numbers of floaters available to fill territory vacancies. This evidence supports the use of trends in site occupancy as a reasonably sensitive measure of population trend.

In the following sections, we outline a framework and statistical estimation approach for monitoring owl populations via directly estimating the site occupancy rate of territorial owls. Critical design and sampling details were developed from a pilot study (Ganey et al. 2004). To illustrate the potential utility of FIA, we incorporated FIA into the occupancy monitoring plan so that microhabitat variables can be related to owl occupancy rates. Managers can consider other habitat monitoring programs in lieu of FIA if available or developed.

Monitoring Site Occupancy

Although we support the idea of estimating population size directly and collecting associated demographic data as described in USDI FWS (1995), the results of the pilot study suggest that the costs for such a monitoring program are daunting. Therefore, we propose this alternative monitoring program based on monitoring occupancy rates as an index of population size.

Occupancy

We define occupancy for Mexican spotted owls as the proportion of plots occupied by the species. Plots sampled will be square 1-km^2 (0.36-mi^2) blocks (UTM of 100 ha (247 ac) that can be easily mapped using GIS, located using GPS, and surveyed to detect Mexican spotted owls. The population of plots from which samples are to be drawn will be defined based on FIA Phase 2 state-wide maps. The number of occupied plots divided by the total number of plots sampled (n) provides an estimate of the proportion of sites occupied (O), referred to as occupancy rate.

We suggest that the owl monitoring plots be defined based on overlaying 16 of the 250-m (273-yd) raster cells of the FIA state-wide maps. The advantage of combining FIA plots and occupancy plots is that the FIA data can be used to determine which, if any, habitat variables sampled by FIA are associated with owl occupancy rates. This would allow for estimation of trends in those variables from the full FIA database and from repeated samples over time.

Statistical Model

The proportion of occupied plots (occupancy rate) in year i is taken as $O_i = \mu_O + \delta_i$, where δ_i is distributed with mean zero and variance σ^2, and μ_O is the mean of occupancy across years. The variance σ^2 is the temporal variation in the occupancy rate (i.e., the year-to-year variation in the proportion of sites occupied).

Because not all sites can be surveyed each time an estimate of occupancy is desired, a sample of plots is selected to estimate occupancy. The estimate obtained is $\hat{O}_i = O_i + \varepsilon_i$, where ε_i is distributed with mean zero and sampling variance Var($\hat{O}_i \mid O_i$). In actuality, the occupancy rate will be estimated through a stratified simple random sample without replacement.

Sampling Plan to Estimate O_i

Occupancy will be estimated by sampling occupancy sampling units (plots), consisting of square 1-km^2 areas. A plot size of 1 km^2 was selected to keep sampling units small and for operational simplicity. Small sampling units are desirable in this monitoring scheme because the response variable is basically owl presence-absence, and so it varies only from zero to one. As the number of owls present in a sample block increases above one, the occupancy index becomes less sensitive as an index of actual population change (i.e., as long as one owl remains, one or more birds could disappear with no change detected). Thus, it is desirable to minimize the probability that a sample unit overlays >1 owl territory. In addition, spacing constraints should be applied so that sampled blocks are separated by >4 km (2.5 mi), to minimize the probability of detecting the same owl(s) on >1 sampled unit. For example, mean nearest-neighbor distances between territorial owls in two study areas in Arizona (2.4 km [1.4 mi], n = 42 pairs, May and Gutiérrez 2002) and New Mexico (2.1 km [1.3 mi], n = 31 pairs, Peery et al. 1999), suggested that a separation of 4 km (2.4 mi) is appropriate. Both of these constraints (size and spacing) should help ensure that occupancy rate actually tracks abundance (i.e., no sampled unit should contain large numbers of owls and no owls should be sampled on >1 unit). We envision drawing a random sample of plots and sampling these same plots each year to minimize the variation between years. Drawing a new sample of plots each year has some advantages (see below) but would increase year-to-year variation over our proposed design.

Each of the Mexican spotted owl EMUs to be included in monitoring must be partitioned into occupancy sampling units consisting of existing FIA Phase 2 plots. This partitioning must be done before a sample is drawn so that a random sample can be drawn from the entire population of occupancy sampling units. Habitat characteristics of all sampling units must be known to estimate and implement a ratio estimator based on the estimated probability of occupancy for each potential plot (Cochran 1977, Bowden et al. 2003) and to estimate occupancy rate for all the plots in the sampling frame.

The sampling scheme will be a stratified random sample without replacement, with stratification consisting of at least the EMUs. Additional stratification should be based at least on elevation, as was done for the previous quadrat sampling scheme (Ganey et al. 2004), on topographic indices (see Bowden et al. 2003), and/or on FIA habitat maps. We expect that one stratum in each EMU will consist of non-habitat for owls, defined as low elevation, unforested areas lacking canyons or other topographic relief. Delineation of non-habitat will be based on validated owl habitat models and through Phase 1 FIA data and Phase 2 FIA state-wide maps. One important aspect of classifying owl habitat is that non-forested areas must be included in some locales, particularly owl habitat that occurs in non-forested canyons. Stratification variables such as forest type also should be used where available, and clearly the FIA Phase 1 and Phase 2 data can be used to provide stratification information. Likely, three forest types should be defined within each of the five EMUs: mixed conifer, ponderosa pine-Gambel oak,

and Madrean pine-oak. In addition, some plots should be placed in a canyon stratum in each EMU. The canyon stratum should be defined based on topographic roughness. Thus, we envision up to five strata in each of the five EMUs, for a potential total of 25 strata.

Stratification serves two purposes here. First, and most importantly, stratification distributes the sample across the sampling frame (and thus provides an argument for stratifying by EMU). With a simple random sample, there is a risk that all or most of the sampled plots are in one localized area. As a result, the sample is not considered representative of the sampling frame (even though such a sample has the same probability of being selected as a sample where the plots are more evenly distributed). Second, stratification provides improved estimates because proper stratification reduces the variability among plots, and thus results in more precise estimates. There is a need to make inferences from individual stratum estimates for the EMUs because each of these units must demonstrate a stable or increasing occupancy rate (see Part III.E). When inferences are stratum-specific, then each stratum must be considered a separate sampling frame. In the monitoring scheme we describe, the stratum-specific estimates are viewed as essential information, and it is thus necessary to obtain precise estimates of occupancy for each stratum. As we describe below, data from all the plots where owls are detected, regardless of which stratum a plot occupies, will be used to generate models of owl detection probabilities. Therefore, the effect of combining data across strata will improve the precision of the estimates across strata, but it will also result in a sampling covariance across strata that must be handled with the methods presented by Bowden et al. (2003).

Plots within strata should either be selected with simple random sampling, or preferably, using generalized random tessellation stratified (GRTS) sampling (Stevens and Olsen 1999, 2003, 2004) to obtain a spatially balanced sample within each stratum. GRTS sampling ranks the order of sampling of the plots within each stratum. Computer code for Windows is available at on the West-Inc web site, www.west-inc.com, for selecting a GRTS sample.

Estimation of occupancy for each sampling unit will be made from two or more visits, because detection rate can be estimated only when plots are visited >1 time. Based on at least two visits, estimates of the detection rate of owls on an occupancy sampling unit and occupancy rate for the sample can be estimated using the maximum likelihood approach of MacKenzie et al. (2002, 2003). Parameters estimated are the occupancy probability for the sampling unit (ψ) and probability of detection given owls are present (p) for the sample. To determine the proportion of false negative plots (i.e., proportion of plots that are occupied but on which owls are not detected), the modeling approach requires at least two visits to a sample of plots to be able to estimate p and then ψ .

Several examples will now be given to explain this estimator. First, assume one or more owls are detected on occupancy sampling unit j on each of the $t = 2$ visits, and assume that the probability of detection is not occasion-specific. The probability of this series of events is $\psi_j p_j p_j$. If owls are detected only on the first visit, then the probability is $\psi_j p_j (1 - p_j)$. If they are only detected on the last visit, then the probability is $\psi_j (1 - p_j) p_j$. If owls are never detected, then the probability is $\psi_j (1 - p_j)(1 - p_j) + (1 - \psi_j)$. These four probabilities sum to one because they are the only possible observations. Thus, these probabilities can be modeled in

a maximum likelihood estimation framework (using numerical optimization of the log likelihood) based on observed histories of owl detections on sampled units.

We expect that habitat information provided by FIA Phase 2 state-wide maps will provide useful predictors of owl occupancy rates. We envision two separate analyses of the occupancy data that incorporate habitat information. The first analysis would link FIA variables to occupancy rates, specifically the key variables listed above. Models that incorporate multiple covariates and possibly their interactions should be developed to identity habitat variables important for further analysis. That is, the trends in the identified variables will be examined with the FIA data base. These habitat variables will be constructed from the means or sums of variables provided by the 16 250-m (273-yd) cells of the FIA state-wide maps that underlie each of the 1-km^2 (0.36-mi^2) occupancy plots.

The FIA covariates may not prove useful as predictors of owl occupancy. If so, this should not necessarily be interpreted as evidence that owl occupancy is not related to habitat conditions. Several alternative explanations may better explain this outcome. For example, the variables included in the analysis may not relate directly to owls, or spatial scale issues may mask any existing relationship.

The second analysis will be to identity functions of the FIA variables that can be used in a ratio estimator sampling model (Cochran 1977). Typically, ratio estimators use a single variable to improve the precision of the desired estimate. For example, Ganey et al. (2004) found that the triangulated irregular network (TIN) ratio was an important variable for use as a ratio estimator, and the TIN ratio reduced the variance of the estimate by nearly a factor of four. We hope to identify ratio covariates that will be useful in improving precision of the occupancy estimates, although these models will likely need to be stratum-specific to accommodate the differences in the strata identified.

If plot-specific covariates from Phase 2 FIA state-wide maps do not improve the estimation of occupancy rate within a strata, then the estimate of ψ obtained without covariates for the plots would be an appropriate estimate of *O*, or model averaging might be used to average $\hat{\psi}$ from multiple models but still providing an estimate of *O*. However, plot-specific covariates would be expected to improve the estimate of occupancy probability for each plot, and also of *p* (see Bowden et al. 2003). The occupancy estimator has been implemented in Program MARK (White and Burnham 1999) so that the use of individual covariates, AICc model selection, and variance components capabilities already available in this software package (White et al. 2001) can be used with this model. In addition, Bayesian estimation methods were added to MARK in 2004, allowing estimation of process variances through the use of hyper-distributions. Plot-specific covariates can be used to build a model from the data on the sampled plots to estimate the probability of occupancy of a plot. The resulting model on a logit scale then could be used in a ratio (or regression) estimator to estimate the number of occupied plots for the sampling frame as we describe above. Thus the occupancy rate (O_i) for a stratum for year *i* would be estimated based on the covariate values for each of the plots in the strata. If the model (and associated covariates) predicting the probability of occupancy of a sampling unit is poor, in the sense that the model does not improve the predictions of the probability of occupancy, then the occupancy estimate from the sample is still a valid estimator of the occupancy rate of the stratum. However,

if the model is a good predictor, then using the covariate information from each potential sampling unit in the stratum will improve the estimate for the stratum. That is, the additional information available for each unsampled plot in the stratum is used, resulting in a less biased and more precise stratum-level estimate.

Multiple strata might be pooled in a MARK analysis to obtain better estimates of detection probabilities and the functional relationship between a covariate and probability of occupancy, but estimates of occupancy rate would still be specific to each stratum. However, if multiple strata are pooled to estimate occupancy, then a sampling covariance is induced between the strata estimates, necessitating the use of a ratio estimator incorporating this sampling covariance (Bowden et al. 2003).

Another possibility that could be explored is to use cluster sampling to sample plots (but see above concern about spacing of sample units). Biologists conducting the surveys could decrease travel time between plots, increasing the number of plots that could be surveyed on one occasion. The difficultly with cluster sampling is how to handle the lack of independence of plots within the same cluster and the effect of this lack of independence on estimation of ψ. Further, cluster sampling improves efficiency of the sampling design when the variance among cluster totals is small and, conversely, variance within the cluster is large (Scheaffer et al. 1986). Likely exactly the opposite is the case for clusters of 1-km^2 (0.36-mi^2) plots because of a high spatial autocorrelation between plots. Clusters would have to be quite large to make cluster sampling more efficient than random sampling. However, cluster sampling should still be an option that is considered to decrease travel time.

One fundamental part of the field methodology is yet to be resolved fully. We lean toward basing occupancy estimates on whether or not a bird was detected from a call point in a sample plot, for operational simplicity. That is, if a surveyor calls from within the plot and hears a response, the plot is considered occupied, regardless of whether the owl was physically on the plot. The alternative approach is to require the surveyor to verify that the owl responding is physically on the plot being sampled, which is a time-intensive (and often dangerous) nighttime activity. However, not requiring the owl to physically exist on the plot at the time of the survey will cause detection probabilities to be lower because of the heterogeneity caused by owl responses from varying distances off the plot. Peripheral birds may be detected on some occasions and not others. In contrast, birds residing on the plot would generally be detected with higher probability. As a result, there is a tradeoff here – if keeping detection probabilities high is a priority, only plots where owls are detected on the plot should be considered occupied. However, because of the objectivity of monitoring when the detections are not limited to just the plot being sampled, we tend to prefer this simpler approach.

An approach that could encompass both types of detections is the multi-state occupancy model developed by MacKenzie et al. (2009). That is, each plot would conceptually be classified into one of three states: unoccupied, owl(s) detected but unsure if phyisically on the plot, and owl(s) definitely detecton on the plot. Detections for which the observer is not sure if the owl is on the plot could define a lower state, and detections that are unquestionably on the plot are defined as a higher state. These observer-driven extensions are characterized by ambiguity in both species presence and correct state classification, caused by imperfect detection. A second applicaton of

the multi-state occupancy model might be to define the lower state as one or more owls detected on the plot, and a higher state as reproduction having occurred on the plot because young are present. This latter example is illustrated in MacKenzie et al. (2009) with California spotted owls.

Based on data from the pilot study on population monitoring (Ganey et al. 2004), detection probabilities for two occasions were sufficiently high when six to seven call points were visited within the 1-km^2 plot (Fig. E.1). The population monitoring pilot study was not intended to provide call points well-spaced to cover 1-km^2 plots, however, so this figure may present a worst-case scenario. It is suspected that five call points would be adequate for most UTM blocks. Further, because a site is classified as occupied if an owl is detected, the number of call points that a surveyor must actually visit will depend on when an owl is first detected (i.e., if an owl is detected from the first call point, the remaining call points need not be visited).

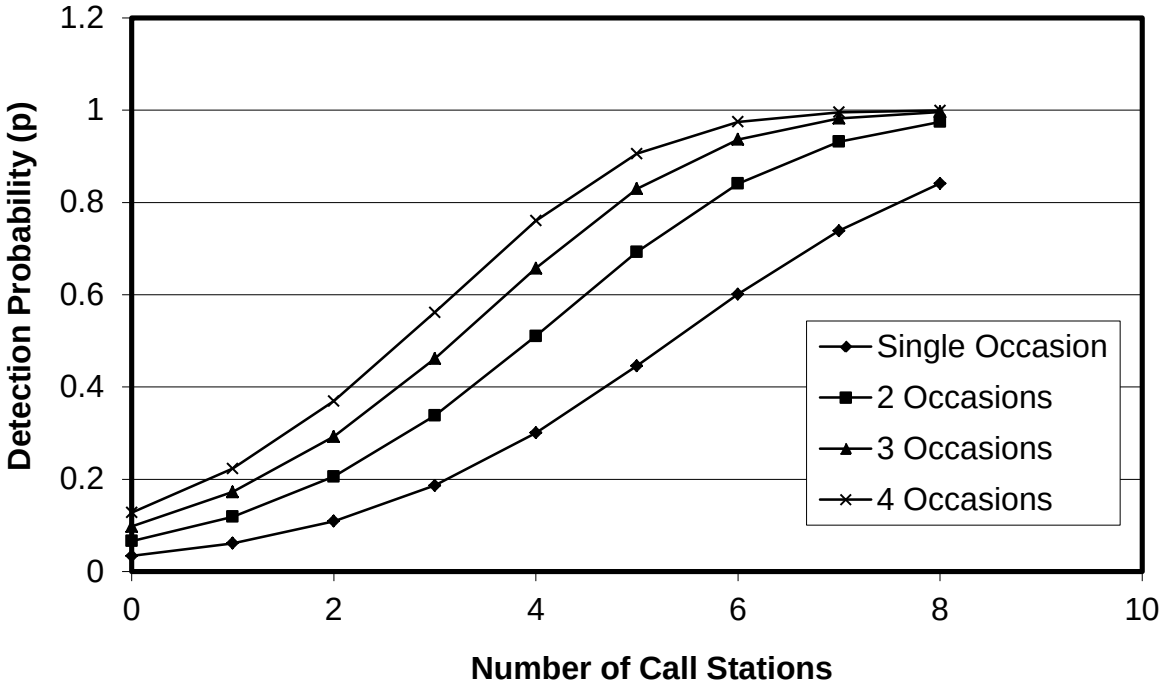

Figure E.1 Probability of detection for a 1-km^2 (0.36-mi^2) plot for the number of points on the plot from which owls are called and the number of occasions on which the plot is visited. For example, a plot with two visits and six points called would have a detection probability of >0.8 that an owl was detected on at least one of the visits. Note, however, that even though detection probabilities are provided for a single visit, a sample of plots must be visited twice to be able to estimate the probability of detection (p) and hence the probability of occupancy, ψ.

The results in Fig. E.1 above also demonstrate that increasing the number of visits to the plot from two to three or more provides only small increases in probability of detection. Thus, we suggest visiting more plots two times rather than fewer plots three or more times.

Statistical Estimation of Trend in Occupancy

The sequence of years for which occupancy rates are measured can be viewed as either a sample of all years, or as a fixed interval in time about which we desire to make inferences. Different statistical models are appropriate for these different sets of assumptions. A random effects model assumes that the sequence of years is a representative sample from a sampling frame of years. As a result, inferences are being made to the entire sampling frame. In contrast, the fixed effects model is only making inferences to the sequence of years measured.

Random Effects Model. Changes in occupancy across years are assumed to be a stochastic process, as we describe above. When the mean of the process (μ_O) is assumed to be constant in the stochastic model described above, changes in occupancy are strictly random. However, trends in occupancy may still be present, although the process generating these trends is purely random. That is, by chance alone, a set of realized temporal observations may show a trend, even though the mean of the underlying process is not changing. The hypothesis examined with a random effects model is that a trend in the occupancy process is taking place (i.e., that there is a trend in μ_O through time). The random effects estimator is supposed to detect a change only in the process. Therefore, potentially important trends in occupancy may be missed with the random effects estimator because these trends are only from variation due to δ_i, not from changes in μ_O. In addition, to detect trends in μ_O, a long time span of data is required. That is, the random effects model will not have much power to detect trends in relatively short spans (i.e., ≤10 years).

An important assumption of the random effects model is that the sample of $\hat{O}_i$ across years is a random sample from all possible years to which inferences are being made. In reality, this assumption is unobtainable because the years sampled are not randomly selected from a population of years.

Fixed Effects Model. The fixed effects model evaluates the trend in the realized sequence of occupancy estimates. That is, the process generating the occupancy rates may not be changing (i.e., μ_O is constant across time), but by chance alone, a realized sequence may show a trend. The fixed effects model will detect this trend, whereas the random effects model we describe above should not detect such "random" trends. Realistically, the statistical procedure used to detect such random trends is desired because the interest is in providing management action as soon as possible given a downward trend in occupancy rates. In such a situation, management actions will not have an impact because the process has not changed. However, this is the price paid to achieve a more sensitive monitoring system.

Therefore, we suggest that the sequence of occupancy estimates, $\hat{O}_i$, be analyzed with a fixed effects model. It is recognizing that the years sampled were not drawn at random from a population of years and that the interest is in detecting downward trends in occupancy, even if the underlying process has not changed, because management actions require some lead time to have an impact on the Mexican spotted owl population.

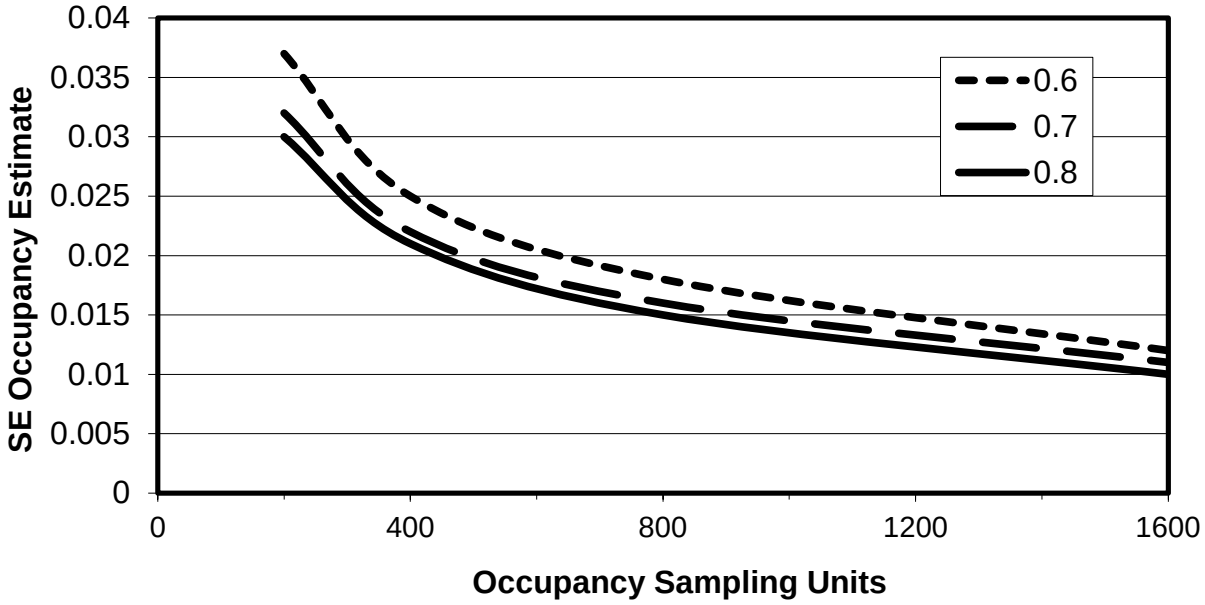

Figure E.2. Standard error of the estimate of site occupancy rate for three levels of the detection probability, *p*, and two visits per site, as a function of the number of occupancy sites sampled.

Expected Precision of Occupancy Estimates

We conducted simulations with Program MARK to determine the precision of the estimate of occupancy without individual covariates. We simulated a factorial design of N = 200, 400, 800, and 1,600 occupancy sampling units, p = 0.6, 0.7, 0.8, and ψ = 0.2. For each scenario, we conducted 1,000 simulations to estimate the expected precision. We based the detection probabilities of p = 0.6, 0.7, and 0.8 on the probability of detection from the quadrat sample (Ganey et al. 2004), where detection of an *individual* owl was ~0.5 in roadless areas, and ~0.9 in roaded areas. We also based the occupancy rate of 0.2 on results of the pilot study (Ganey et al. 2004), where >50% of the high elevation quadrats were occupied. However, because the quadrats were much larger than the occupancy sampling units, the expected occupancy rate of the occupancy sampling units will be considerably less, so we chose 0.2 as a reasonable value. Simulation results for the standard error of $\hat{\psi}$ are shown in Fig. E.2 above for three values of p and a range of sample sizes.

These results (Fig. E.2) suggest that a large number of occupancy sampling units must be measured in each stratum (or within an EMU) to obtain reasonable precision for $\hat{O}$. For example, sampling 1,600 occupancy sampling units in one stratum using a stratified random sample design would result in a standard error of 0.011 for p = 0.7. If three strata in an EMU with this same standard error were combined, the overall estimate would have a standard error of $0.011/\sqrt{3}$ = 0.00635, or approximately a ±6% confidence interval. With this sampling precision, two consecutive year's estimates with a 10% decline between years would likely be considered statistically different. However, if only 200 occupancy sampling units were sampled in one stratum, giving a standard error of 0.032, a ±18% confidence interval would result. This level of

precision would be adequate to detect a 25% decline between consecutive years. What this result suggests is that any occupancy monitoring scheme implemented will only be able to detect changes over a large geographic area. That is, multiple strata must be combined in order to obtain precise estimates of occupancy that will be useful in detecting changes.

Power of Fixed Effects Analysis of Occupancy Estimates

We conducted simulations using Program MARK and SAS to estimate the power of occupancy monitoring to detect trends in percent occupancy. We simulated all combinations of the following models: a linear trend in ψ = 0.00, −0.01, −0.02, and −0.03 each year; ψ values in year zero of 0.10, 0.15, and 0.20; process standard deviation of ψ of 0, 0.05, 0.10, 0.15, and 0.20; p = 0.6, 0.7, 0.8, and 0.9; years of sampling 10, 15, ..., 30; and 200, 400, 800, and 1600 sampling units. Note that annual declines of 1, 2, and 3% result in declines of 10, 18, and 26% over 10 years, respectively.

For 10 years of sampling, power of >90% was generally found for 1,600 sampling units and for 800 sampling units with a process standard deviation of zero and a trend in ψ of −0.03. Thus, this power analysis confirms that large sample sizes will be required to detect changes in occupancy. However, this power analysis does not incorporate plot-specific covariates that might greatly improve the precision of the annual occupancy estimates. For example, plot-specific covariates reduced the variance by half in the pilot population monitoring survey (Bowden et al. 2003, Ganey et al. 2004). Hence, the sample sizes we determine here to provide adequate power may be more than needed to achieve the same power with a ratio estimator. Without a pilot study to determine these relationships (i.e., the degree of correlation between occupancy and plot-specific covariates) and to provide some idea of the temporal process variation in site occupancy rate, inadequate information is available to estimate the necessary sample sizes and/or power of a site occupancy monitoring design at this time.

Relationship Between Occupancy Estimates and Population Abundance

In theory and practice, there is some relationship between occupancy rate and population abundance. Further, Royle and Nichols (2003) describe an approach for estimating occupancy rate or the proportion of an area occupied when heterogeneity in detection probability exists as a result of variation in abundance of the organism under study. Variation in abundance induces variation in detection probability so that heterogeneity in abundance can be modeled as heterogeneity in detection probability. Their method allows estimation of abundance from repeated observations of the presence or absence of animals without having to uniquely mark individuals in the population.

However, we do not foresee the method of Royle and Nichols (2003) as useful in quantifying population abundance. Their method requires some strong assumptions that will not be met with spotted owl data collected on 1-km^2 plots. First, their model assumes that owls are randomly distributed on a homogeneous landscape, i.e., that the number of owls observed on a plot follows a Poisson distribution. Clearly, this strong assumption is invalid for spotted owl data. Second, their model basically assumes that the plots are geographically closed, i.e., no immigration or emigration from the plots. As discussed above, there are issues with this

sampling plan about how well detections can be classified as coming from owls on the plot versus near the plot. Obviously the closure assumption is not met, and hence population abundance estimated from this model will not be useful.

2. Potential Experiments

Many habitat variables important to Mexican spotted owls cannot be monitored by remote sensing. Further, it is important to ensure that adequate habitat is provided for key prey as well. Thus, we propose some potential experiments to relate habitat conditions to owl population dynamics where key habitat characteristics would be measured on the ground. On-the-ground monitoring of relevant habitat characteristics would quantify their change at a local (i.e., within plot) scale and relate them to owl population dynamics.

Monitoring of owl population size based on randomly selected quadrats (as proposed in USDI FWS 1995) provides the opportunity to conduct experiments to extend our knowledge of the impact of habitat manipulation on Mexican spotted owl population dynamics. These experiments are proposed to produce credible, defensible, and reliable results (sensu Murphy and Noon 1991). Quadrats within the population monitoring design would serve as experimental units for examining the effects of future management such as fires, grazing, timber harvest, and recreation.

Given that a treatment is identified prior to its occurrence, vegetation measurements can take place on the site of the expected treatment and on a second, control quadrat that is selected based on its similarity to the expected treatment quadrat. This experimental design is not a true experiment because the treatment is not randomly allocated to one of the pair of quadrats. However, this quasi-experiment is still more powerful in developing cause-and-effect relationships between habitat manipulations and owl population dynamics than the more common correlative designs used by past researchers. Further, the capability to replicate the treatment exists because of the extensive number of quadrats that would be required for measuring changes in population size.

Areas where planned treatments result in some form of habitat alteration provide excellent opportunities for quasi-experiments. Vegetation measures should be taken immediately before and after the habitat-modifying event and thereafter at 5-year intervals. Vegetation measurements that seem especially important to examine are tree size-class distribution, log size-class distribution, canopy cover, and shrub cover. Results from these experiments, coupled with results of population monitoring, provide the basis for a predictive model of spotted owl habitat quality (assuming that owl occupancy reflects habitat quality).

Unfortunately, for logistic reasons we describe above, this revision of the Recovery Plan shifts from direct monitoring of population size to monitoring site occupancy. This modification in monitoring approach reduces our ability to detect impacts of management on owl populations because occupancy is not as sensitive a measure of the response of the owl population to manipulations as is the measurement of population change.

3. Alternative Designs for Occupancy Modeling

In developing the monitoring scheme proposed here, we considered many alternative schemes. Some of these are discussed here, simply to illustrate some of the alternatives considered and why they were rejected.

Drawing a New Sample of Plots Each Year

Instead of the proposed scheme of drawing an initial sample of plots from the sampling frame and monitoring these same plots through time, an alternative approach would be to draw a completely new random sample of plots each year. For repeated sampling of a set of plots to be legitimate, normal activities that occur in spotted owl habitat should continue during the monitoring program, provided these activities meet the requirements of Section 7(a)(2) of the Act by not likely jeopardizing the continued existence of the Mexican spotted owl. Because this Recovery Plan requires that PACs be placed around locations occupied by owls, management activities may be modified if an occupied site is found during the occupancy sampling. Thus, the monitoring process affects the management of occupied sites, an undesirable situation. The main advantage of a new sample each year is that it guards against the potential for land managers to manage areas within the plots differently than the remainder of the landscape. Such differences in management will likely occur because of the establishment of PACs. The price of this protection is relatively great, as illustrated by these three points: 1) the logistics of conducting the surveys each year would increase because of the new plots; 2) quasi-experiments to detect the relationship between habitat manipulations and owl occupancy rates would not be possible; and, 3) higher sampling intensities would be required because this design is less efficient (i.e., less precise) for estimating change. Our proposed design is to draw an initial sample of plots and monitor those same plots each year. Because the plots are small and randomly distributed, management activities probably cannot avoid them, even though PACs are established. As a result, a fixed sample of plots likely is appropriate, so we do not deem it necessary to draw a new sample of plots each year.

Conducting Surveys Less Often Than Yearly

Instead of surveying plots each year, effort and cost could be saved by conducting the surveys at longer intervals, such as every five years. An advantage of this approach is that costs will be lowered, and more precise estimates of population size could possibly be obtained by pooling money to conduct a few very good surveys instead of more frequent surveys with lower effort per survey. The main disadvantage of this approach is that funding would not be allocated each year, which would likely make procuring funding for intense efforts every five years difficult. Finally, the ability to detect relationships between habitat manipulations and occupancy would be greatly decreased because this approach is more sensitive to variability introduced by the years chosen for sampling. That is, less information is provided on temporal variation when samples are only taken every five years. Therefore, we recommend sampling each year as the most effective approach to occupancy monitoring.

PACs as Sampling Units for Monitoring Occupancy

The PACs would seem to be a natural sampling unit to monitor occupancy. The difficulty with this scenario is that PACs are not a representative sample of available owl habitat. The PACs can only be established by the presence of an owl. As a result, the occupancy rate of PACs can only decline, since each PAC is initially occupied. Additionally, PAC boundaries may change as neighboring sites are found to be occupied, creating a non-static sampling frame. Therefore, we recommend that the sampling frame consist of 1-km^2 plots rather than PACs.

One important use of PACs would be to improve stratification of the proposed sampling plan, since the presence of a PAC suggests the area is likely occupied, and a large number of PACs would suggest that much of an area is occupied.

4. Rangewide Habitat Monitoring

The primary objective of rangewide habitat monitoring is to validate the results of population occupancy monitoring. For example, if occupancy monitoring indicates stable (or increasing) occupancy rates, habitat monitoring will provide a general measure of whether there will be sufficient nest and roost habitat for occupancy rates to remain stable. We advocate no specific method for habitat monitoring and leave it up to management agencies to determine the best method(s) to use. One possible approach is to use data from Forest Inventory and Analysis (FIA). We provide a brief overview of that program below.

Introduction to the Forest Inventory and Analysis (FIA) Program

Habitat monitoring depends on remote-sensing and stand-level vegetation data of habitat across the owl's range, using vegetation measures from the FIA program. The FIA has been in continuous operation since 1930 with a mission to "…make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements for the renewable resources of the forest and rangelands of the U.S…"

The core design of FIA consists of three phases (http://fia.fs.fed.us/about.htm). Phase 1 is a remote sensing phase aimed at classifying the land into forest and non-forest and taking spatial measurements such as fragmentation, urbanization, and distance variables. This phase has historically been conducted using aerial photography, but it is changing to a system based on satellite imagery. Data from this phase will be useful for monitoring macrohabitat changes in the range of the Mexican spotted owl.

Phase 2 consists of field samples distributed across the landscape, based on a permanent grid system with an FIA plot approximately every 2430 ha (6,000 ac). Field plots are located systematically on a 5-km (3.1-mi) grid regardless of whether they are forest or non-forest, and regardless of land ownership. Permanent plots are installed on all land ownerships (after permission is granted by the landowner), but the actual locations are kept secret to prevent tampering with the site and to prevent the knowledge of plot presence to influence decisions. Plot locations that are in forested vegetation are visited by field crews who collect a variety of forest ecosystem data. Data are collected at the forested plots regardless of the landowner's

intended use or specific management actions. Non-forest locations are also visited as necessary to quantify rates of land use change. The following data are collected at FIA plots:

i. The general land use that was projected in Phase 1 is verified;
ii. On forested plots, general stand characteristics are collected, such as forest type, stand age, and evidence of disturbance;
iii. Individual tree measures such as diameter, height, damage, cull, and grade are recorded;
iv. Tree regeneration is documented.

The FIA Phase 3 program is based on a subset of the Phase 2 plots (located on a 22-km [13.7-mi] grid, sampling approximately 0.0405 ha every 38,881 ha [1 ac for every 96,000 ac]), from which an extended suite of ecological data (see list below) are collected. These measures relate to forest ecosystem function, condition, and health. Due to the seasonality associated with some of these measurements, the Phase 3 data are generally collected during a three-month window (Jun, Jul, and Aug). The measurements on the Phase 3 subset of plots can be grouped into the following categories:

i. Crown Conditions – generally, poor crown conditions are symptoms of trees under stress, and trees with good crown conditions are vigorous.
ii. Soil Erosion Potential – estimates of soil erosion potential help identify areas that may contribute to water quality degradation.
iii. Soil Chemical Analyses – collection and analysis of soil samples include estimates of site fertility and in some cases potential toxicity relating to acidic soils that relate to productivity.
iv. Lichen Communities – the presence or absence of certain lichen species is indicative of air quality and climate changes.
v. Ozone Bioindicator Plants – these plants have known sensitivities to ground-level ozone, although they are not necessarily collected on the Phase 3 plots (this effort can occur in the general plot area).
vi. Vegetation Structure – the composition of vegetation (species and growth forms), abundance, and spatial arrangement in the forest. Also the presence of exotic and introduced plant species can be extracted from the collected data.
vii. Down Woody Debris – this measurement is useful in determining fire fuel potential, and this information with the vegetation structure data can be used in wildlife habitat models.

Though the FIA program has been in existence since the 1930s, the data collection methods have been modified periodically, and the grid system was recently revamped to improve the statistical validity of the sampling. Currently, 10% of the plots in the western U.S. are scheduled to be sampled every year.

Regardless of whether a plot is Phase 2 or Phase 3, after two or more visits have occurred at a single plot location, it is possible to analyze the data to derive estimates of trends in desired conditions (see Tables C.1 and C.2 in Appendix C).

Habitat Monitoring Methods

As mentioned above, an essential feature of the FIA program is the confidentiality of the data. Because data are collected from all land ownerships and because the data would be biased if landowners or others knew the location of the plots and treated them differently than areas outside the plots, these locations and much of the data from them are not available directly to agencies. Instead, the agencies must craft specific questions for the FIA program, and then FIA responds with answers to the data queries.

We believe existing FIA sampling schemes for all three phases provide adequate data to meet the proposed delisting criteria. Owl-relevant FIA variables should be used to monitor trends in owl habitat, providing a range-wide habitat sampling scheme. Phase 1 data provide a comprehensive coverage of changes amount and type of forest habitat. Phase 2 provides information on changes in forest-stand structure. Phase 3 provides information on additional habitat variables important to owls, such as down woody debris

For purposes of Mexican spotted owl recovery planning, the FIA plots would be aggregated into strata that would be based on 1) EMU, 2) elevation, and 3) forest type. Stratification is important because it distributes samples throughout an EMU and improves precision of the habitat estimates.

5. Relating Habitat and Owl Occupancy Modeling

For purposes of understanding progress towards recovery of the Mexican spotted owl, monitoring should document the changes in the owl population and its habitat when, in fact, such changes are occurring. Thus, an effective monitoring program requires measuring changes in both habitat quantity and owl occurrence across the landscape. To link the monitoring of owl occupancy in forest habitat with the habitat conditions, analysis of occupancy monitoring data should incorporate FIA data.

Linking occupancy monitoring to FIA monitoring is recommended for three reasons. First, the FIA inventory (both Phase 2 and Phase 3) provides microhabitat measurements that can be used to improve the occupancy monitoring scheme, providing predictor variables that will improve the estimation of the probability of occupancy and detection for the plots sampled.

Second, important microhabitat variables that are correlated with owl occupancy will be determined that can then be used to evaluate temporal trends in microhabitat. A strength of this approach is that FIA data collected prior to occupancy monitoring can also be analyzed to determine long-term trends in these variables. In summary, linking FIA data with the occupancy monitoring sampling plots will provide: 1) the opportunity to identify microhabitat variables that relate to owl occupancy and detection rates, and 2) the ability to evaluate trends in these microhabitat variables through time.

Third, FIA is a well-funded, ongoing effort. Thus, it provides a unique opportunity to collect data potentially useful in monitoring trend in owl habitat, without requiring a separate and prohibitively expensive sampling effort.

6. Conclusions

The technology and expertise are available to monitor trends in Mexican spotted owl habitat and population size. Clearly, the objectives and design of the monitoring program must be defined explicitly, and they must be attainable. To implement the process, knowledgeable, dedicated people must be assigned the task. Adequate training and constant feedback mechanisms are critical aspects to a successful monitoring program, as tenable conclusions can be based only on reliable data.

APPENDIX F - LAWS, REGULATIONS, AND AUTHORITIES FOR RECOVERY PLAN IMPLEMENTATION

This Recovery Plan, First Revision is based or predicated upon laws that designate specific legal authority and responsibility to government agencies for managing public resources, including wildlife and wildlife habitat. The following summarizes relevant laws and authorities applicable to implementation of this Recovery Plan.

1. Endangered Species Act

Section 2(c)(2) of the ESA expresses the policy of Congress that "...all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of [the] Act." Section 7(a)(1) of the ESA requires Federal agencies to "...utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of endangered species and threatened species...." Thus, Congress clearly intended conservation of endangered and threatened species to be considered in implementation of Federal programs and actions. In addition, other Federal laws and regulations require consideration of endangered and threatened species in program implementation, including the National Forest Management Act (NFMA) and the NEPA.

Implementation of the ESA is the responsibility of the Secretary of the Interior (Secretary) for listed terrestrial species. The Secretary generally delegates implementation authority to the FWS. The following sections of the ESA are relevant to implementation of species recovery efforts:

A. Section 4

Section 4 includes the listing and recovery provisions of the ESA. Section 4(b) of the ESA provides for designation of critical habitat for endangered and threatened species. Regulations governing listing and critical habitat designation are codified at 50 CFR 424. Protection of critical habitat is administered under section 7 of the ESA (discussed below). Critical habitat is defined under section 3(5)(A) of the ESA as:

> "(i) the specific areas within the geographical area occupied by the species...on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and,
> "(ii) specific areas outside the geographical area occupied by the species...upon a determination by the Secretary that such areas are essential for the conservation of the species."

Section 4(d) of the ESA provides for promulgation of special rules for threatened species only. This allows the Secretary to issue regulations as deemed necessary and advisable for the conservation of such species. Special rules can be useful in enacting regulatory provisions

uniquely applicable to the species at hand and can be promulgated to avoid unnecessary regulatory burden.

B. Section 5

Section 5 directs the Secretary to utilize funds and authorities of other laws in acquisition of lands, as deemed appropriate for conservation of endangered and threatened species.

C. Section 6

This section authorizes cooperation with the states in conservation of threatened and endangered species. Among its provisions is the authority to enter into management agreements and cooperative agreements and to allocate funds to the states that have entered into such agreements.

D. Section 7

Section 7 and its implementing regulations at 50 CFR 402 govern cooperation between Federal agencies. Federal agencies must, in consultation with and with the assistance of the Secretary, ensure that any action they fund, authorize, or carry out is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of a listed species' designated critical habitat. Regulations at 50 CFR 402 provide the following definitions:

> "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species."
>
> "Destruction or adverse modification' means a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species." This regulatory definition has been legally challenged and is no longer used by FWS; no new regulatory definition has been promulgated to date.

Section 7 requires action agencies to assess the effects of proposed actions on listed species and their critical habitat. If, as a result of that assessment, the agency determines that an action may affect a listed species or its critical habitat, the agency must enter into consultation with FWS. That consultation may result in a biological opinion from FWS, in which a determination is made as to whether jeopardy to the species and/or destruction or adverse modification of its critical habitat are likely to result from the agency action.

If a biological opinion concludes that jeopardy to the species and/or adverse modification of its critical habitat are not likely to result from a proposed action, the action may proceed. The FWS may provide conservation recommendations to the agency on ways to minimize or avoid potential adverse effects on the listed species and/or critical habitat. Implementation of the conservation recommendations are at the action agencies' discretion. In cases where the action is likely to result in the incidental taking of a species, FWS may provide reasonable and prudent

measures to minimize the amount or extent of the take. The terms and conditions that accompany and implement any reasonable and prudent measures are nondiscretionary and must be implemented. However, reasonable and prudent measures and their implementing terms and conditions cannot alter the basic design, location, scope, duration, or timing of the action; and they may involve only minor changes.

If a biological opinion determines that jeopardy and/or adverse modification is likely to result from the proposed action, the FWS and the action agency develop reasonable and prudent alternatives, if any, to the proposed action. Reasonable and prudent alternatives refer to alternative actions that are consistent with the intended purpose of the proposed action, that can be implemented within an action agency's legal authority, that are economically and technologically feasible, and that FWS believes will not result in jeopardy to the listed species or destruction or adverse modification of critical habitat. If no reasonable or prudent alternatives can be identified, the action agency may apply to the Endangered Species Committee for an exemption to prohibition of jeopardy and/or destruction or adverse modification of critical habitat.

E. Section 8

Section 8 authorizes international cooperation in conservation and endangered and threatened species. Included under this section is the authority to provide financial assistance to foreign countries to assist in their conservation efforts.

F. Section 9

Section 9 covers prohibited acts in regard to listed species. Of relevance to the Mexican spotted owl is the prohibition of taking individuals. "Taking" is defined as "…to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Permits for direct taking of threatened species may be issued for scientific purposes, to enhance propagation or survival, in cases of economic hardship, for zoological exhibition, or for educational purposes (50 CFR 17.32).

Taking of spotted owls is most likely to occur through "incidental take." "Incidental take" is defined as the taking that results from, but is not the purpose of, carrying out an otherwise lawful activity. Incidental taking of spotted owls may result from activities such as timber harvest, if that activity results in habitat loss to an extent that an individual spotted owl's normal behavior patterns are impaired. In cases where incidental taking will not result in jeopardy to a listed species, the FWS may issue an incidental take statement in a biological opinion on a proposed Federal action, thereby exempting the action agency from the take prohibition. Relief from taking prohibition for non-Federal activities is discussed under "Section 10" below.

G. Section 10

Section 10 authorizes the FWS to issue permits for takings otherwise prohibited under section 9. Permits for purposeful taking may be issued under 10(a)(1)(A) of the ESA for research purposes and to implement recovery actions. In addition, 10(a)(1)(B) of the ESA allows permits for

incidental takings that may result from an activity provided an applicant submits a conservation plan that specifies:

> "(i) the impact which will likely result from such taking;
>
> "(ii) what steps the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps;
>
> "(iii) what alternative actions to such taking the applicants considered and the reasons why such alternatives are not being utilized; and
>
> "(iv) such other measures that the [FWS] may require as being necessary or appropriate for purposes of the plan."

2. National Forest Management Act

The NFMA governs FS Management on NFS lands. The first planning regulations (rule) articulating implementing language were provided in 1979 and then revised in 1982. In 1997, the Secretary of Agriculture convened a committee of scientists to provide recommendations on how to better implement NFMA. This led to a series of planning rule revisions (2000, 2002, 2005, 2008) that have yet to gain final approval. In 2009 the FS issued a Notice of Intent to prepare an environmental impact statement (EIS) for a new planning rule, starting a new planning-rule-revision effort. A draft EIS was distributed in 2011 and a proposed final programmatic EIS was published in 2012 (79 CFR 30.8480). At this time, that PEIS pending approval by the Secretary of Agriculture.

USDA republished the 2000 rule as amended in the Federal Register in order to make it available to the public in the Code of Federal Regulations (36 CFR Part 219; Federal Register 2009). This interim rule is currently in effect. Below are relevant parts of the interim rule relevant to recovery planning.

Section 219.20 (Species Diversity) states:

"(a)(2)(ii) *Evaluations of species diversity.* Evaluations of species diversity must include, as appropriate, assessments of the risks to species viability and the identification of ecological conditions needed to maintain species viability over time based on the following:

"(A) The viability of each species listed under the Endangered Species Act as threatened, endangered, candidate, and proposed species must be assessed. Individual species assessments must be used for these species.

"(D) In analyzing viability, the extent of information available about species, their habitats, the dynamic nature of ecosystems, and the ecological conditions needed to support them must be identified. Species assessments may rely on general conservation principles and expert opinion. When detailed information on species habitat relationships, demographics, genetics, and risk factors is available, that information should be considered."

Section 219.20 further provides guidance pertaining to forest plan decisions related to species diversity:

"(b)(2) *Species diversity.* (i) Plan decisions affecting species diversity must provide for ecological conditions that the responsible official determines provide a high likelihood that those conditions are capable of supporting over time the viability of native and desired non-native species well distributed throughout their ranges within the plan area, except as provided in paragraphs (b)(2)(ii) through (iv) of this section. Methods described in paragraph (a)(2)(ii) of this section may be used to make the determinations of ecological conditions needed to maintain viability. A species is well distributed when individuals can interact with each other in the portion of the species range that occurs within the plan area. When a plan area occupies the entire range of a species, these decisions must provide for ecological conditions capable of supporting viability of the species and its component populations throughout that range. When a plan area encompasses one or more naturally disjunct and self-sustaining populations of a species, these decisions must provide ecological conditions capable of supporting over time viability of each population. When a plan area encompasses only a part of a population, these decisions must provide ecological conditions capable of supporting viability of that population well distributed throughout its range within the plan area.

"(b)(3)(i) *Federally listed threatened and endangered species.* Plan decisions must provide for implementing actions in conservation agreements with the FWS or the NMFS that provide a basis for not needing to list a species. In some situations, conditions or events beyond the control or authority of the agency may limit the FS's ability to prevent the need for Federal listing. Plan decisions should reflect the unique opportunities that NFS lands provide to contribute to recovery of listed species.

"(b)(3)(ii) Plan decisions involving species listed under the ESA must include, at the scale determined by the responsible official to be appropriate to the plan decision, reasonable and prudent measures and associated terms and conditions contained in final biological opinions issued under 50 CFR part 402. The plan decision documents must provide a rationale for adoption or rejection of discretionary conservation recommendations contained in final biological opinions."

3. National Environmental Policy Act

The NEPA requires Federal agencies to prepare Environmental Impacts Statements (EIS) or Environmental Assessments (EA) for implementation of agency actions and issuance or modification of agency policies and guidance. Impacts of the proposed action or policy amendment on endangered and threatened species must be evaluated, including a range of alternatives. If a deciding official determines that no significant impact will result from an action or policy amendment, a "Finding of No Significant Impact" (FONSI) is issued. If an agency determines that a significant impact will result from the proposed action or policy amendment, an EIS must be prepared. It is released for public review and comment, after which an alternative is selected and a Record of Decision (ROD) is signed by the deciding official.

4. Migratory Bird Treaty Act (MBTA)

Prior to listing the Mexican spotted owl as threatened, the MBTA provided the only Federal protection for the subspecies other than that afforded by land-management agencies. Under the provisions of the MBTA, it is unlawful to pursue, hunt, take, capture, or kill in any manner any migratory bird unless permitted by regulations. The MBTA applies in both the U.S. and Mexico. Because the Mexican spotted owl exhibits migratory behavior in some areas, it is included on the list of birds protected under the MBTA.

5. Tribal Lands

The FWS recognizes that tribes have management jurisdiction over tribal lands and supports tribal efforts to implement the provisions of this Recovery Plan to achieve management consistency throughout the Mexican spotted owl's range. In accordance with Secretarial Order 3206 entitled "American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the ESA, signed by the Secretaries of the Department of the Interior and the Department of Commerce in 1997, the FWS is required to formally consult with tribes for any ESA actions that may impact tribal lands and culturally significant resources.

6. State and Private Lands

Although relatively few Mexican spotted owls are known on state and private lands in the U.S., the FWS encourages states to continue and/or begin a program to inventory forests and canyons for the presence of Mexican spotted owls. As discussed in Part II.H.3.d (Inadequacy of existing regulatory mechanisms), all states within the U.S. range of the owl have protections in place to prohibit the direct taking of Mexican spotted owls. However, we are unaware of any provisions under state law to regulate the loss of Mexican spotted owl habitat. In addition, the FWS should evaluate the importance of state and private lands to the Mexican spotted owl, and consider promulgating a special rule under 4(d) of the ESA that specifies habitat-altering activities that can be allowed on private lands without violating the prohibition of incidentally taking Mexican spotted owls.

7. Mexico

In Mexico there are various legal mechanisms aimed at the regulation of conservation and sustainable uses of wildlife and its habitat, as well as conservation and protection of endangered species. These are found in a suite of laws, official Mexican standards (Normas Oficiales Mexicanas), and international agreements, among others, and provide the basis for the development of actions for conservation, protection, and recovery of the populations of species listed under some risk category, such as the spotted owl.

A. <u>General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente)</u>

This is the primary law dealing with environmental matters in Mexico, and it integrally regulates the general terms of environmental protection. This law defines the basic principles of Mexican

environmental law and the instruments for its implementation, as well as the mechanisms for the conservation of ecological equilibrium, environmental protection, and the establishment and administration of natural protected areas, among other matters.

Chapter III of this law is directly focused on conservation and sustainable use of wildlife (fauna and flora). Section III of article 79 states that the conservation of species in the endemic, threatened, endangered, or special protection categories should be one of the criteria to be taken into account when granting concessions, permits, and authorizations for use, possession, administration, conservation, repopulation, propagation, and development of wildlife.

B. General Wildlife Law and its Regulations (Ley General de Vida Silvestre y su Reglamento)

This law is part of the national environmental policies and it seeks to balance wildlife conservation with its use. It fosters the implementation of activities oriented to protect wildlife while creating new opportunities that allow the use of natural resources for social benefit. It creates support for conservation by engaging the population in conservation actions that generate income.

This law regulates extractive and non-extractive uses of wildlife specimens, parts, and derivatives, including those species listed in a risk category in the NOM-059-SEMARNAT-2010, and priority species, seeking at all times the viability and permanence of wildlife in nature.

The most important conservation tools promoted by this law are Management Units for the Conservation of Wildlife (UMAs, Unidades de Manejo para la Conservación de Vida Silvestre). These are collective or private land holdings where the following activities take place: conservation, restoration, protection, maintenance, recovery, reproduction, repopulation, reintroduction, research, rescue, shelter, rehabilitation, exhibition, recreation, environmental education, and sustainable use of wildlife and its habitat.

C. General Law of Sustainable Forest Development and its Regulations (Ley General de Desarrollo Forestal Sustentable y su Reglamento)

This legal body regulates the forestry policy of Mexico with the objective of contributing to social, economic, and ecological development through conservation, protection, restoration, production, zoning, cultivation, management, and use of the forest resources and forested ecosystems of the country.

This law is entrusted with: 1) regulating all matters relative to conservation, management, and use of forest resources; 2) establishing measures for forest conservation, as well as control, surveillance, and sanctions; and, 3) encouraging social participation. It is of particular importance in the conservation of forested areas, including the forests in which the spotted owl is found.

D. Official Mexican Standard NOM-059-SEMARNAT-2010 (Norma Oficial Mexicana NOM-059-SEMARNAT-2010)

This identifies and lists within an at-risk category all those species that are at risk and groups them in four categories: P-endangered, A-threatened, Pr-subject to special protection, and E-probably extinct in the wild.

Even though this standard in itself does not constitute an instrument that fosters species conservation, it is a tool that assists in prioritizing projects related to these species. Based on this, the Secretary of the Environment and Natural Resources is mandated to promote and foster the conservation of species and populations at risk through the development of conservation projects.

E. *In situ* conservation strategies

The implementation of the Recovery Plan in Mexico would be carried out through *in situ* conservation instruments included in the environmental legal framework. The following section describes the available plans and implementation mechanisms for the conservation of the spotted owl and associated species.

i. Natural Protected Areas (Áreas Naturales Protegidas)

Natural Protected Areas have been the main instrument for natural habitat and biodiversity conservation in Mexico's environmental policies. CONANP (National Commission of Natural Protected Areas) is responsible for implementing actions focused on conservation, recovery, restoration, and management, including attention to species at risk found within protected areas as well as in their influence zones. NPAs (Natural Protected Areas) have Management Programs that outline the activities that will be implemented, including species monitoring. Currently, there are 174 NPAs that are managed by CONANP, including those where the spotted owl is present, as mentioned in previous sections.

ii. Certified Conservation Areas (Áreas Certificadas para la Conservación)

This is a tool designed for landowners (communities, ejidos, or private lands) that are interested in the conservation of their land to voluntarily access conservation schemes. Once owners join this program they have access to funding and other benefits through programs of the government or civil society organizations. Under this scheme owners commit to manage their land as if it was a private natural protected area, which allows for conservation of the natural habitat, thus complementing the objectives of natural protected areas.

iii. Management Units for the Conservation of Wildlife (UMAs, Unidades de Manejo para la Conservación de Vida Silvestre)

These are mostly private properties registered to undertake wildlife management, generally associated to economic interests; they also usually undertake activities for conservation of the natural habitat, populations, and wildlife. They are managed by the owners themselves, and

represent a source of income derived from the sustainable use of wildlife. Thus, owners become the most interested party in guaranteeing the viability of wild populations and their natural habitat, undertaking surveillance, monitoring, and management of habitat and populations.

iv. Program of Conservation of Species at Risk (PROCER) (Programa de Conservación de Especies en Riesgo--PROCER)

This program is carried out by CONANP, the National Commission of Natural Protected Areas, and its objective is to recover 30 species at risk. Its main tool is the elaboration and execution of Action Programs for the Conservation of Species (PACE), which establish conservation strategies for each priority species, as well as specific actions aimed at conserving, protecting and recovering their populations and habitat.

This program is tightly linked to the work that is conducted inside Natural Protected Areas; however, its action scope is beyond the limits of the NPAs and considers the execution of other forms of conservation activities as well as activities for other species.

F. Other development programs associated with biodiversity conservation

i. Program for Payment for Environmental Services (Programa de Pago por Servicios Ambientales)

These programs are operated by the National Forestry Comission (CONAFOR), and its resources provide support to communities, ejidos, Regional Forestry Associations, and private owners of forested lands, who receive a payment in exchange for biodiversity conservation. Supported categories include projects related to biodiversity conservation, agroforestry systems, and carbon capture, among others. Currently, CONANP and CONAFOR have worked jointly to define priority areas for conservation of species at risk.

ii. Program for Conservation for Sustainable Development (Programa de Conservación para el Desarrollo Sostenible)

This subsidy program is operated by the CONANP and promotes the conservation of ecosystems and their biodiversity through the active participation of the population in actions and projects that encompass conservation of natural resources, as well as alternative production projects that decrease pressure on natural resources. In this way communities and regional stakeholders view sustainable development as a form through which they can improve their quality of life while conserving natural resources, and converts them into important allies in the conservation of biodiversity.

APPENDIX G - CONSERVATION MEASURES AND MANAGEMENT IN THE UNITED STATES AND MEXICO

1. United States

a. Federal agencies

i. Fish and Wildlife Service

The FWS has only one record of Mexican spotted owls on its lands (in Brown Canyon on Buenos Aries National Wildlife Refuge), so the FWS's main management responsibility involves conducting the processes associated with listed species under the ESA, such as Section 7 consultation on Federal actions that may affect the species and/or its critical habitat, issuance of research permits under Section 10, and recovery planning under Section 4. Over 200 formal Section 7 consultations have been conducted on actions proposed by numerous Federal agencies, and several hundred informal consultations have occurred as well. The FWS designated critical habitat for the owl in 2004. In addition, the FWS has reviewed two petitions to delist the species. In both cases, delisting was determined to be "not warranted" because the petitions failed to present substantial scientific and commercial information to support their assertion that the species should be delisted. Notices of those findings, including discussions of the issues raised in the petitions, were published in the Federal Register on 23 September 1993 (58 FR 49467) and 1 April 1994 (59 FR 15361). The FWS findings were upheld in legal challenges.

ii. Forest Service

The primary administrator of lands supporting Mexican spotted owls in the U.S. is the FS. Most spotted owls have been found within FS Region 3 (including 11 National Forests in Arizona and New Mexico). The Rocky Mountain (Region 2, including two National Forests in Colorado) and Intermountain Regions (Region 4, including three National Forests in Utah) support fewer spotted owls.

<u>Forest Service Southwestern Region (Region 3)</u>

On 5 June 1996, Regional Forester Charles W. Cartwright signed a ROD to implement Alternative G of the Final EIS for Amendment of Forest Plans (FEIS; USDA FS 1996). That decision directs individual National Forests to incorporate Recovery Plan recommendations, as well as those of the Management Guidelines for Northern Goshawk in Southwestern U.S., into their forest plans. The FS then consulted with the FWS under Section 7 of the ESA on the forest plan amendments. The FWS issued a biological opinion finding that implementation of the forest plan amendments would not likely jeopardize the continued existence of the Mexican spotted owl or other listed species. In addition, the Mexican spotted owl Recovery Team reviewed the forest plan amendments and concluded that the direction detailed in the FEIS was generally compatible with the original Recovery Plan recommendations, although some disparities and management concerns were recognized. In addition, on January 17, 2003, the FWS completed a reinitiation of the 1996 Forest Plan Amendments non-jeopardy biological opinion, and again reached a non-jeopardy conclusion. Consultation on individual actions under

these biological opinions anticipated incidental take in the form of harm and/or harassment of owls associated with 243 PACs on FS Region 3 lands. The FS Region 3 reinitiated consultation on the Land and Resource Management Plans (LRMPs) on April 8, 2004. On June 10, 2005, the FWS issued a revised non-jeopardy biological opinion on the amended LRMPs. Following a legal challenge to the 2005 biological opinion, the FWS issued revised biological opinions for each Region 3 forest in spring 2012.

Region 3 of the FS continues to manage under the 1996 ROD, but deviates from some Recovery Plan recommendations when overriding resource, social, or economic considerations (e.g., fuels-reduction projects for the purpose of reducing the risk of high-severity fire in the WUI) require the agency to deviate from those recommendations. Deviations from the direction in the ROD and FEIS require Section 7 consultation with FWS to ensure that FS programs and individual projects will not jeopardize the continued existence of the Mexican spotted owl or adversely modify its critical habitat.

The Southwestern Region of the FS has conducted spotted owl inventories since 1988. In 1994, the FS reported 846 owl "sites" reported between 1984 and 1993 (Fletcher and Hollis 1994). Prior to the listing of the Mexican spotted owl, Region 3 issued guidelines for its management. Those guidelines were issued as Interim Directive Number 1 in June 1989, then revised and reissued as Interim Directive Number 2 approximately one year later. Interim Directive Number 2 guidelines required establishing management territories around all nesting and roosting spotted owls and around territorial owls that were detected at night for which daytime locations were not recorded. All management territories (except those on the Lincoln and Gila National Forests) consisted of approximately 800 ha (2,000 ac) of habitat per territory. Since that time, the FS's Region 3 has incorporated the recommendation of the original Recovery Plan (USDI FWS 1995) and established approximately 1,061 240-ha (600-ac) PACs at all Mexican spotted owl sites known from 1989 to present (Table II.1). All Southwestern forests have more than one PAC, and the relative percentage of known sites by National Forest has not changed significantly.

Forest Service Rocky Mountain Region (Region 2)

Region 2 of the FS continues to manage under the original Recovery Plan (USDI FWS 1995) recommendations. Most projects occurring in Mexican spotted owl habitat consist of fuels-reduction treatments that have been able to meet the Protected and Restricted Habitat Guidelines in the original recovery plan. Projects rarely occur within PACs.

Since 1990, the Rocky Mountain Region of the FS has conducted spotted owl inventories in most of the National Forests in Colorado. Currently occupied Mexican spotted owl sites are present on the Pike/San Isabel and San Juan National Forests. The FS's Region 2 has established PACs of at least 240-ha (600-ac) in size at all Mexican spotted owl sites where owls have shown some level of occupancy (i.e., not believed to be transitory owls) since 1990. Several owl sites are being further evaluated for potential establishment of PACs.

Forest Service Intermountain Region (Region 4)

Potential Mexican spotted owl habitat in the FS's Intermountain Region is limited to small portions of the Dixie, Fishlake, and Manti LaSal National Forests in southern Utah. Employees of the Intermountain Region have collected site-specific Mexican spotted owl data since 1990. Survey efforts covered approximately 335,930 ha (830,100 ac) of habitat statewide on FS-administered lands. Few Mexican spotted owl breeding pairs have been documented on these National Forests. The inventories in southern Utah encompassed a wide range of habitat types, but all owls detected were found in steep-walled sandstone canyons, some of which contained intermittent streams and stringers of mixed conifer and/or deciduous multi-layered vegetation. In southern Utah, owls were found nesting only on ledges or small caves in these steep-walled canyons. As a result of these extensive survey efforts, spotted owl inventories were discontinued in rolling forested landscapes of the Intermountain Region and were focused on steep-walled canyon areas consistent with where owls were documented. Broad-scale survey efforts were replaced with forest-level surveys, as needed to determine owl presence in proposed project areas. In 2003, approximately 2,400 ha (6,000 ac) were surveyed on the Teasdale and Escalante Ranger Districts with two detections. As a result of these refocused survey efforts, an additional owl site was located in 2008 and the Dixie National Forest designated three PACs.

The FS has regulatory mechanisms and management direction in place to protect and recover the Mexican spotted owl. The Forest Service Manual (FSM) requires review of all FS planned, funded, executed, or permitted programs and activities for possible effects on the owl (FSM 2672.4). Additionally, each National Forest is required to complete consultation with the FWS for all agency programs or activities that may affect the species (FSM 2671.45c). Existing forest plans for the Dixie, Fishlake, and Manti LaSal National Forests require that spotted owl habitat be protected, maintained, or improved. Additionally, these forests' plans are currently under revision, and owl habitat and recovery are being addressed in the revision process. The existing Recovery Plan guidance is also implemented as appropriate on these three southern Utah forests.

iii. National Park Service (NPS)

In the range of the Mexican spotted owl, the NPS has 57 administrative units. However, most of these park units are very small in acreage and/or have no spotted owl habitat. Other parks with apparent spotted owl habitat characteristics have been surveyed and no owls have been found (Arches NP, Rocky Mountain NP, Great Sand Dunes NP and Preserve, Black Canyon NP, and Curecanti NRA). As a result, 21 parks are known or expected to have spotted owls or owl habitat. Some of the 21 parks have not been surveyed for spotted owls, so the actual presence of owls has not been confirmed at this time. Designation of PACs has been inconsistent in national park units in part because much of the acreage in the 21 parks is wilderness, proposed wilderness, or backcountry land designations. These land-management categories greatly reduce the potential for most management impacts to owls and owl habitat. As a consequence, there is less need for park managers to conduct surveys and identify the specific acreage to be managed for owls through PAC designations. Increases in human recreation in the parks is heightening concern for spotted owls in these less-developed portions of parks, and may stimulate designation of more PACs to focus protection of the owls. This is true particularly where owls are using canyon habitats and may have less ability to retreat from human disturbances. In two

national park units with Mexican spotted owls there is shared management responsibility with the Navajo Nation (Canyon de Chelly and Navajo National Monuments). Consistent with the Navajo Nation's desire to keep owl sites confidential, the owl sites described paragraphs below are not displayed in the Recovery Plan maps of owl distribution.

Generally, the most pressing issue of managing owl habitat in national parks is the need to reduce fuels and reintroduce natural fire regimes, while maintaining or improving owl habitat. Fire Management Plans commonly include owl habitat management as a focus issue in decisions for planned and unplanned fire management.

The following summaries provide detail on owl populations in the 21 parks that are known or expected to have owls or owl habitat.

Arches National Park, Utah

Repeated spotted owl surveys have not detected owls at this park unit. The habitat appears suitable and survey efforts will continue.

Bandelier National Monument, New Mexico

Mexican spotted owls were first reported at Bandelier National Monument in 1910 and owl surveys began in 1985. The spotted owls in Bandelier nest in canyons walls with cool, moist, mixed-conifer forests; the majority of this habitat is in the Bandelier Wilderness. From the 1990s into the 2000s, the park managed all potential habitat within canyon as nesting and roosting habitat. During the 1990s, breeding was documented at three locations. From 2003 to 2011, spotted owls seemed to have disappeared from these sites. In 2011, a wildland fire burned at high and moderate intensities with nearly complete tree mortality through much of the owl's habitat. As of fall 2011, the park is uncertain whether owls could successfully occupy the park. Habitat evaluations and owl surveys will be conducted. For the time being, three breeding locations will be kept on record.

Big Bend National Park, Texas

There is one record of a Mexican spotted owl being heard from the Chisos Basin campground and lodging development in Big Bend National Park during the breeding season by a visiting bird-watcher familiar with owl calls. The conditions of the observation meet the definition of an "owl site" used in the Recovery Plan. No formal surveys have been performed in Big Bend National Park. To date, no confirmed visual sightings or photographs have been made of Mexican spotted owls in the park. Additional, anecdotal information leads the NPS to consider the possibility of spotted owls here. That information includes: the confirmed presence of owls in the Davis Mountains and in a Mexican mountain range south of the Rio Grande; several records of unidentified *Strix* species (either barred or spotted owls) near this park; two predictive habitat models that identified probable habitat in the park; and the professional judgment of Recovery Team members who visited the park and found the habitat to be potentially suitable. The single unconfirmed detection is reflected in the Recovery Plan map of owl distribution.

The park will attempt to conduct owl surveys to determine if spotted owls regularly occupy the park and whether a PAC is warranted. At this time there are no PACs delineated at Big Bend NP.

Bryce Canyon National Park, Utah

There are no documented owl territories within Bryce Canyon National Park. Surveys have been performed throughout the park in areas predicted to be suitable habitat (1993-1995) and in connection to proposed projects (2003, 2008, 2009). No surveys detected spotted owls. Most of the potential spotted owl habitat occurs in proposed wilderness areas where it is protected from development. No prescribed fire treatments are currently planned for the potential owl habitat in the park. Unplanned fire and recreation impacts are currently the greatest threat to the possibility of owls occurring at Bryce Canyon. A lightning-caused event in July 2009 burned several hundred acres in potential spotted owl habitat. Owl surveys in that area prior to the fire had not located spotted owls. Surveys for Mexican spotted owls will continue, generally related to proposed activities within or adjacent to potential habitat.

Canyon de Chelly National Monument, Arizona

Canyon de Chelly's primary mission is to protect the prehistoric ruins and other features of scientific or historical interest. The monument encompasses approximately 34,000 ha (84,000 ac) within the Navajo Nation. The Navajo Nation holds management responsibility for wildlife resources in the monument. Mexican spotted owls and their habitat are managed under the Navajo Nation Management Plan for the Mexican Spotted Owl (2000). Records show the species has occupied parts of the monument since the mid-1980s. Surveys since 2005 have found that owls are widely, but patchily distributed throughout the monument, resulting in designation of five PACs. Both the NPS and Navajo Nation recognize the potential for more owl sites to be located in the monument due to the abundance of steep, north-facing canyon walls, perennial streams, and patches of Douglas-fir that have not yet been surveyed.

Canyonlands National Park, Utah

The first study of Mexican spotted owls in Canyonlands was in 1977. A series of owl studies were conducted in the 1990s (Van Riper and Willey 1992, Willey 1995, 1996, 1998; Swarthout and Steidl 2000, 2001, 2003; Willey and Van Riper 2000). These studies investigated demographics, owl sensitivity to recreational disturbance, prey base, home range size, habitat use, and natal dispersal of the birds. In 1996, PACs were designated around all 22 known owl territories [about 9,300 ha (23,000 ac)], and a GIS layer was developed to manage activities occurring in this owl habitat. Although monitoring has been sporadic, owls have consistently been located in these PACs. In 2002 and 2003, a comprehensive re-survey of the entire park was undertaken to determine the status of the owl population (Schelz et al. 2004). Most of the 22 PACs were surveyed, as were other areas. The resulting 47 Mexican spotted owls (10 pairs and 27 individuals) led to a current estimate of 29 PACs in the park. The top issues threatening the owls in Canyonlands are increased human activity in the remote backcountry and the loss and degradation of riparian habitat.

There are approximately 77,000 ha (190,000 ac) of potential owl habitat in the park, of which about 49,000 ha (120,000 ac) have been surveyed to protocol. Owl nesting habitat in the park is rugged, steep-canyon topography with vertical cliffs and numerous caves with small patches of woodland vegetation (pinyon-juniper being the most common type). As owl habitat in the park is not fire-dependent, prescribed fires are not used as a management tool, and no acres of owl habitat have been lost to canopy fire.

Capitol Reef National Park, Utah

Capitol Reef National Park has nine owl sites designated as PACs. Breeding was confirmed at all nine sites during the 1990s (Willey 1998b). The most recent surveys have occurred during 2008-2010 and all nine PACs were visited; a pair was observed at one site, single males were observed at three others, and no owls were detected at the remaining five sites. The park does not have an estimate of amount of potential owl habitat or of the acreage surveyed. Fires are rare in the park, and large fires would be unlikely to occur near owl territories due to vegetation patterns. No owl habitat in the park has been lost to fire or treated with fuels-management methods. Potential impacts to owls could arise from increased human recreation in areas occupied by owls. Research was conducted in Capitol Reef, Canyonlands, and Zion NPs examining owl response to human activity (Swarthout and Steidl 2001, 2003). Results concluded that the cumulative effects of high levels of short-duration recreational hiking near nests may be detrimental to Mexican Spotted Owls and that buffer zones should be established around nest sites to protect breeding owls (Swarthout and Steidl 2001, 2003).

Carlsbad Caverns National Park, New Mexico

Carlsbad Caverns National Park has 23 detection records of Mexican spotted owls. Formal surveys in 2010, covering half of the wilderness area of the park, documented 16 of those records, which likely represented 4 male individuals and 1 pair. While most of these early records suggest that the owls were dispersing or wintering individuals, the most recent observations (since 2005) indicate that this species is a resident in some of the narrow, steep-sided canyons with floors above 1,525 m (5,000 ft) in elevation. Four sites can be designated as PACs given the recent records. The park is characterized by steep-walled canyons with caves and ledges, with limited areas of scattered ponderosa pine and maple-oak ravine woodlands. The woodlands are less than four percent of the park acreage and tend to occur on north-facing slopes above 1,500 m (4,900 ft) or in canyon bottoms. Although breeding has yet to be documented, the narrow canyons at higher elevations in the park most likely provide nesting habitat for Mexican spotted owls.

The park backcountry receives little human use, and there are no special management restrictions for owls. The Fire Management Plan guides the most prevalent vegetation management in the park. The western half of the park, with rugged canyons and the majority of woodland patch habitats, is slated for management as a wildland fire use study area under the plan. Several large fires since the 1970s, including those in 2010 and 2011, have burned most of the park. However, many of the narrow canyons likely to be used by Mexican spotted owls have not been greatly impacted. However, the influence of these fires may limit woodland regeneration and favor montane shrublands where the owls may forage.

Chiricahua National Monument, Arizona

There are two sites with spotted owl occupancy that are managed as PACs. Management of this acreage is addressed in the Fire Management Plan. In 2011, a wildfire burned over the entire Monument. Owl surveys will be conducted to determine if the PACs are still occupied.

Coronado National Memorial, Arizona

Coronado National Memorial has surveyed for Mexican spotted owls in most years since 1997 and has found a pair using one site consistently. As part of a study of the population biology of Mexican spotted owls in sub-Mogollon Arizona (Duncan and Spiech 2002), the adult owls and their young from 1997 and 1999 were captured, marked with color bands and aluminum bands, and monitored through 2000. The purpose of this study was to determine survivorship, reproductive success, environmental variation, and population trends. Research has also been done on rodent populations in the PAC. In 2011, a wildfire burned over the entire Monument; the PAC burned with a light severity. Owl surveys will be conducted to determine if the PAC is still occupied.

Dinosaur National Monument, Colorado

There is one known owl territory in Dinosaur National Monument where a single bird was observed in two consecutive years in the late 1990s. The territory is located within an extremely remote area of the park that receives little human use. The site has not been designated as a PAC due to the remote location and lack of management action there. There are no known threats to this territory. In 2009, biologists were unsuccessful in their attempt to access the site and determine if owls were present.

Gila Cliff Dwellings National Monument, New Mexico

The Gila Cliff Dwellings National Monument consists of 216 ha (533 ac) and does not have any spotted owl records from within the unit. However, it is surrounded by Gila National Forest acreage, and the park acreage may contribute to owl home ranges that are centered on FS-administered lands.

Glen Canyon National Recreation Area, Arizona and Utah

Glen Canyon National Recreation Area has ten spotted owl detections that are managed as PACs. No surveys have been conducted since the late 1990s except for a survey in Miller Canyon, where a pair was observed in 2009.

Grand Canyon National Park, Arizona

There are 40 known Mexican spotted owl territories within Grand Canyon National Park, all of which have been mapped as PACs. Due to restricted access to many PACs, annual monitoring of all PACs is not practible. However, a minimum of 18 PACs were occupied in 2001, 20 PACs in 2002, 13 PACs in 2003, and 10 PACs in 2004. One owl in each of seven PACs was radio-

tracked in 2004 (Bowden 2008). Systematic surveys continue to be implemented yearly on the North and South Rim prior to undertaking fire-related activities.

In Grand Canyon National Park, Mexican spotted owls have been located primarily in canyon habitat; however, one owl was confirmed on the plateau at the rim's edge on the South Rim, and one owl was detected in several locations on the North Rim plateau <0.8 km (0.5 mi) from the rim (Bowden 2008). All other owl locations and all roost and nest sites have been confirmed below the rim in canyon habitat. Radio-tracking data and home-range analyses from 2004-2007 (Bowden 2008) showed that owls at Grand Canyon roosted and nested in canyon habitat and occasionally foraged on the high plateau within 1 km (0.6 mi) of the rim in ponderosa pine and mixed-conifer forests. All mixed-conifer forest on the North Rim has been surveyed at least twice since 1991, with one owl detected in 2007 (D. Willey pers. obs.). Approximately 16,000 ha (40,000 ac) of predicted canyon habitat occurs in the park and approximately 50% of it has been surveyed. Until further information is available, the Park continues to survey for owls in mixed conifer habitat on the North Rim and in canyon habitat throughout the park.

Guadalupe Mountains National Park, Texas

There are eleven Mexican spotted owl detections in Guadalupe Mountains National Park that have been identified as PACs. Several other detections of single male owls have been located in the park. The owls are found in areas of steep-walled canyons with wooded bottoms consisting of a well-developed overstory and open understory. Owls may not occupy some survey areas due to an overly dense understory that may limit the owls' ability to forage. Spotted owl observations over the past 30 years cluster the birds' activity areas in about six locations in the park, and some areas remain unsurveyed. Production of young has been documented intermittently since 1994. Most owl habitat is located in remote areas of the park and is not routinely subject to disturbance from human activity. The park has restricted potentially impacting activities (e.g., helicopter use and blasting activity for trail improvements) near known territories during the breeding season. The greatest threat to the owl is habitat loss from stand-replacing wildfire, and the park has initiated fuels treatments to reduce this threat.

Mesa Verde National Park, Colorado

There are three sites documented as owl territories within Mesa Verde National Park and other areas where owls have been heard. Breeding has not been documented since the 1990s. The lack of owl detections recently is a concern and suggests the need for continued surveys. Owl habitat is in sandstone canyons and side canyons with Gambel oak thickets and stands of pinyon-juniper and Douglas-fir. Areas used by spotted owls are managed as de facto PACs but designation is still pending. Recent severe wildfires have burned thousands of acres of pinyon-juniper, Douglas-fir, and woodlands on the mesas adjacent to the canyons, which may provide foraging habitat for the canyon-dwelling owls. Stand-replacing fires continue to be a threat to owls and owl habitat in the park. A unique management issue at Mesa Verde National Park is the Mexican spotted owl's use of Ancestral Puebloan architecture (ruins) for nesting and roosting. This creates a potential conflict with modern human use of these sites by visitors and archeologists.

Navajo National Monument, Arizona

Land within the Navajo National Monument is owned by the Navajo Nation, but is under NPS management for administrative care of culturally significant structures and recreation control. The Monument is approximately 243 ha (600 ac) in size and receives approximately 66,000 visitors per year. The Monument contains canyon habitat for the Mexican spotted owl. Mexican spotted owls were initially identified within the Monument in 1986 and the Navajo Nation established a PAC in Betatakin Canyon in 1997. A majority of the PAC area is outside the Monument on Navajo Nation lands. However, the head of Betatakin Canyon, which is within the Monument, contains spotted owl nesting habitat and there are several records of spotted owl detections in this area. That portion of the PAC on the Monument is subject to the Navajo Nation Management Plan for the Mexican Spotted Owl, but the National Park Service is still required to consult under Section 7 of the Act for any projects that may affect the owl.

Saguaro National Park, Arizona

Resident Mexican spotted owls were first detected in Saguaro National Park in 1992. The park currently supports five owl sites in the Rincon Mountain District of the park, each with a designated PAC and core area (1,200 ha [3,000 ac] total). Radio telemetry studies from 1996-1998 confirmed the number and territories of breeding pairs, their reproductive success, roosting and foraging habitat, and diet, and documented owl behavioral responses to local prescribed burns (Willey 1998a). The owls have been monitored intermittently since that time in relation to fire-management activities. At least one adult (usually a male) has been located in each PAC every year that surveys have been conducted. For management purposes, all vegetated acreage above 2,000 m (6,000 ft) elevation is considered potential spotted owl habitat. Habitat loss from wildland fire and human disturbances related to fire management are probably the greatest potential threats to the park's owls.

Mexican spotted owl breeding habitat is limited to the upper elevations of the Rincon Mountains in the park, usually on north facing slopes; most of this habitat is now in PACs. Prescribed burns have been conducted in about 800 ha (2,000 ac) of such habitat, and wildland fires have occurred in PAC acreage. Approximately 200 ha (500 ac) have been affected by canopy fire (mostly from wildfire) in the past 10 years.

Tonto National Monument, Arizona

In February 2010, a spotted owl was photographed with a night-time camera trap near the center of this National Monument. Until that time, spotted owls had not been confirmed. No surveys had been done because the habitat was not considered suitable. With this new detection, the park will attempt to conduct surveys to determine if a PAC is warranted. At this time there are no PACs delineated at Tonto NM.

Walnut Canyon National Monument, Arizona

The earliest record of Mexican spotted owl activity at Walnut Canyon National Monument dates to 1980, when a roost site was reported. A pair of owls was observed near this location again in

1986, but no nest was found. There are approximately 730 ha (1,800 ac) of owl habitat in the park, all of which has been surveyed to protocol at least once. Informal and protocol surveys occurred in nine breeding seasons between 1987 and 1999. Surveys between 2000 and 2003 did not result in owl detections, though an owl was incidentally observed in 2003. The area in the east canyon that was added to the park in 1996 has not been formally inventoried. Three PACs were established within the monument. No areas within owl habitat have been treated with prescribed fire or mechanical thinning, nor have any areas of habitat been lost to canopy fire in the past 10 years. The Fire Management Plan includes some site-specific mechanical thinning to protect natural and cultural sites at risk, but it does not propose prescribed fire in PACs due to topography. Greatest threats to owls at Walnut Canyon National Monument include growth and development of nearby human communities, drought and insect-related conifer mortality, risk of crown fire, changes in riparian vegetation, and increases in outdoor recreational use.

The three PACs encompass most of the Douglas-fir-Gambel oak, ponderosa pine-Gambel oak, pinyon-juniper-shrub-succulent vegetation on steep slopes, and much of the riparian corridor along the bottom of Walnut Canyon National Monument within and adjacent to the monument. All three PACs include acreage outside of the monument boundary on the surrounding Coconino National Forest. A fourth PAC is centered on the National Forest and includes some acreage of the Monument.

Zion National Park, Utah

There are 29 known Mexican spotted owl territories within Zion National Park, which are mapped into 20 PACs (8,757 ha [21,639ac]). In 2009, owls were detected in 81% of 27 territories monitored. The oldest record for owls in the park, a single juvenile, is from 1928. There were no subsequent owl observations until 1963 and 1974, with formal owl surveys beginning in the 1970s. Research on the owls in Zion occurred between 1987 and 2000; studies included owl distribution, habitat characteristics, home ranges and juvenile dispersal, and habitat disturbance effects on owls. Zion has been monitoring Mexican spotted owl territory occupancy and nesting activity on a regular basis since 1995. Prescribed burning has been used as a management tool on approximately 1,700 ha (4,200 ac) of owl habitat with no loss of the forest canopy.

The greatest threat to spotted owls in Zion comes from increased visitor use, especially visitation to canyons containing owl habitat. Some of the nesting sites are in heavy human-use areas. All of the canyons requiring technical climbing ability and equipment require access permits and have use limits. A three-year study on the effects of recreation in canyons on owl occupancy and reproduction was initiated in 2008. Another concern is high severity fires burning in foraging habitat as a result of increased fuel loads resulting from years of fire suppression. Reintroducing fire is a priority.

Spotted owl nesting habitat in Zion is found in canyons and adjoining areas are used for foraging. The habitat in these landscapes is described as vertical and overhanging cliffs; parallel-walled canyons with cool, north-facing aspects; complex side canyons; and a mosaic of vegetation types. The rock walls include caves, ledges, and fractured zones that provide protected nesting sites. The canyons also include patchy areas of vegetation along canyon

bottoms, on flat benches, or on plateaus or mesa tops above the canyon rim. Canyon habitat in the park is estimated at roughly 25,000 ha (62,000 ac). For this estimate, mesa tops between the canyons were included because the owls may use these areas for foraging. However, this does not imply the mesa tops are considered nesting habitat.

iv. Bureau of Land Management (BLM)

Arizona

Most BLM-administered spotted owl habitat in Arizona is in the Arizona Strip area of the CP EMU. Protection and recovery considerations are oriented toward the vicinity of steep-walled rocky canyons that meet criteria as potential nest/roost habitat. The BLM is implementing the original Recovery Plan (USDI FWS 1995) in this area by avoiding habitat-altering projects such as timber harvest within 1.6 km (1 mi) of canyons that could support breeding or roosting owls. No mixed-conifer forest occurs on public land in the Arizona Strip. The BLM continues to periodically survey for Mexican spotted owls in a few accessible areas. No birds have been found. The BLM in the Arizona Strip addresses Mexican spotted owl recovery opportunities in its Resource Management Plan.

The Hualapai Mountains, administered by the Kingman Field Office (FO), support one historical breeding location for spotted owls. Much of the 1,750 ha (4,300 ac) of ponderosa pine and mixed conifer forest in the Hualapais is shared by the owl and the endangered Hualapai Mexican vole, which also has a recovery plan under implementation. Since the most recent record of Mexican spotted owl breeding activity dates from 1979, no PAC has been designated. As on the Arizona Strip, the BLM continues to periodically survey for Mexican spotted owls in a few accessible areas thought to contain spotted owl habitat, yet no birds have been found. The BLM's activities are oriented to maintaining the existing ponderosa-pine forest and a very small amount of mixed-conifer forest in the Hualapai Mountains. Activities in historical spotted owl habitat are compatible with the original Recovery Plan and those identified in the Hualapai Mexican Vole Recovery Plan (T. Cordery, USDI BLM, pers. comm.).

New Mexico

Of the 849,840 ha (2.1 million ac) designated as Mexican spotted owl critical habitat in New Mexico, only 879 ha (2,171 ac) are located on BLM-administered lands. Furthermore, there are no protected owl habitats, as defined in the original Recovery Plan, or known extant Mexican spotted owl populations on BLM-administered lands in New Mexico. Historically, BLM lands in New Mexico likely contained forest stands suitable for the owl. However, from as early as the 1800s, homesteaders, owners of land grants, and private logging companies removed most of the large commercial timber, and few dense, older forests exist today. Of the six BLM FOs in New Mexico, four have implemented management actions for the Mexican spotted owl: Farmington FO, Taos FO, Rio Puerco FO, and Socorro FO (M. Ramsey, USDI BLM New Mexico State Office, pers. comm.). Of these four FOs, the Farmington FO is the only one to administer lands with critical habitat and has the greatest potential for supporting owls. However, Mexican spotted owl surveys were conducted from 1992 through 2009 and no owls were reported. A single owl was heard in 2002, but it was determined that it was a "floater" moving through the area (USDI BLM 2002). Only limited areas of BLM lands within the Taos FO have the potential

to meet the habitat criteria to support the owl and there has only been a single confirmed owl sighting within the FO; on 26 June 1991, an "inferred Mexican spotted owl" was detected in a Douglas-fir tree on BLM lands on the east side of Archuleta Mesa (UNM 1995). A BLM protocol survey for the owl was conducted in 1993 along the same transects where the owl was recorded in 1991, but no responses from spotted owls were elicited (USDI BLM 1993). Mexican spotted owl surveys were conducted by the Rio Puerco FO in 1992, but no responses from spotted owls were elicited and no suitable habitat was identified (M. Ramsey, USDI BLM New Mexico State Office, pers. comm.). The Rio Puerco FO has not subsequently conducted any surveys for the owl. Although owls are known to occur in mountains in west- and south-central New Mexico, including Mogollon and Tularosa mountains in Catron County, and the San Mateo Mountains in Socorro County, no owls or suitable habitats were documented during owl surveys conducted by the Socorro FO in 1992, 1993, and 1998 (M. Ramsey, USDI BLM New Mexico State Office, pers. comm.).

Considering the most current information on the limited distribution of the Mexican spotted owl and its required habitats on BLM-administered land in New Mexico, ongoing programs within FOs have very little potential to create disturbances to the Mexican spotted owl. Nonetheless, in any areas where Mexican spotted owls or their habitat are identified on BLM-administered lands or where BLM-administered lands are adjacent to other lands that have been identified as Mexican spotted owl habitat, the BLM will follow guidelines in the Recovery Plan in managing its timber and fuelwood programs, oil and gas development, coal leasing and development activities, and off highway vehicle activity.

Utah

Five separate critical habitat units were designated for the owl in Utah totaling some 912,000 ha (2,252,857 ac) (69 FR 53181). Of that total, approximately 147,000 ha (362,135 ac) are located on public lands administered by BLM. The administrative units with designated critical habitat are the Price, Moab, Monticello, Richfield, Kanab, Cedar City, and St. George FOs and the Grand Staircase-Escalante National Monument.

Much of the Utah habitat has been inventoried and monitored by Utah Division of Wildlife Resources (UDWR) personnel with funding from the Utah State BLM Office. As a result of these studies, over 100 protected activity centers (PACs) in Utah have been identified, of which approximately 20% occur on BLM-administered lands. These studies are continuing, and Utah BLM also continues to work collaboratively with UDWR to develop habitat models to guide survey efforts and to assist in project evaluations. Predictive habitat models developed in 1997, 2000, and 2007 (e.g., Willey 2007) are currently being used in determining habitat and potential impacts to the owl and its habitat from actions authorized by BLM.

In 2008, Utah BLM completed work on six land use plans. This effort included major plan revisions for the Vernal, Price, Moab, Monticello, Richfield, and Kanab FOs. Section 7 consultation was a major aspect of plan preparation and appropriate conservation measures were incorporated into the plans. The St. George FO and Grand Staircase-Escalante National Monument also are current in their land management plan Section 7 consultations for the owl.

Colorado

The BLM in Colorado has been managing under the 1995 Recovery Plan recommendations. Most owl habitat occurs in narrow, rocky canyons with difficult access. Few projects occur in these sites, but those that do include grazing permits, transmission line rights-of-way, and a rock quarry. Projects rarely occur within PACs. These projects are generally managed consistent with the guidelines in the 1995 Recovery Plan.

Since 1990, the BLM conducted spotted owl inventories on BLM lands throughout Colorado. Currently occupied owl sites on BLM land in Colorado are located along the Front Range in the Canon City area. The BLM has established PACs of at least 240-ha (600-ac) in size at all Mexican spotted owl sites where owls have shown some level of occupancy (i.e., not believed to be transitory owls) since 1990 (Table B.1). Several owl sites are being further evaluated for potential establishment of PACs. The number of occupied owl sites on BLM lands in Colorado has generally remained steady since 1992, with several of the sites showing strong site fidelity by resident birds. One such site has been occupied by the same male banded for the past 17 years.

v. Department of Defense (DOD)

Fort Huachuca Military Reservation, Arizona

The Fort Huachuca Military Reservation (Post) in southeastern Arizona is known to support nesting Mexican spotted owls. Fort Huachuca manages owls, habitat, and the activities that may affect owls under the terms of a programmatic biological opinion issued by FWS (14 June 2007). Activities in spotted owl habitat generally are confined to various foot maneuvers and driving wheeled vehicles on dirt roads through canyon bottoms, although law-enforcement activities to interdict illegal immigration and smuggling are frequent and widespread in some owl habitat.

Public recreation accounts for the greatest amount and frequency of human activity in spotted owl habitat. One spotted owl site has been popular with birders for over three decades, but the effect of this activity on owls is unknown. Unauthorized off-trail walking has proliferated at this and at least one other site, and these side trails in the canyon bottoms where owls tend to be found have increased forest-floor disturbance and erosion. Undocumented immigrant passage increased dramatically in 2002 and has been significant and frequent through all canyons and spotted owl habitat. Extensive new trail networks have appeared throughout spotted owl habitat. Law enforcement interdiction efforts day and night have similarly increased in scope and frequency.

Whereas unregulated recreation is considered the mostly likely source of impacts on individual owls, the Army considers wildland fire to be the greatest potential threat at the population level. The Army assesses the possibility of wildland fire ignition and spread when planning, designing, and authorizing military activities on the Post (S. Stone, DOD, Fort Huachuca, pers. comm.).

Camp Navajo Garrison Training Center, Arizona

Camp Navajo Garrison Training Center is located in northern Arizona, west of the City of Flagstaff. The installation contains protected, recovery, and designated critical habitat. The Volunteer Canyon PAC was designated in 1988 on the southern end of the installation, in portions of Volunteer Canyon, extending into the Coconino National Forest. Mexican spotted owl surveys of Camp Navajo have been conducted since 1997, primarily within the southern and western portions of the installation. Adult Mexican spotted owls and potential juveniles were heard within the PAC on Camp Navajo during the summer of 2000 and a pair of owls was found in this same location in 2010. Mexican spotted owls were located primarily along the rim and side drainages of Volunteer Canyon near the installation's southern boundary with the Coconino National Forest.

Recovery habitat also occurs along the western portion of the installation. A telemetry study in the fall of 1995 found that a dispersing juvenile Mexican spotted owl spent approximately two weeks in the immediate vicinity of Volunteer Mountain before dispersing onto the Kaibab National Forest (J. Ganey, USDA FS, pers. comm.). The 2008 surveys conducted by the Arizona Game and Fish Department (AGFD) detected an owl in the Volunteer Mountain area; however, no responses were noted during subsequent visits to the site or adjacent sites during the 2008 field season. Therefore, the recovery habitat within the Camp Navajo facility could serve as an important corridor for dispersing owls. Designated critical habitat for the MSO is located along the southern portion of the installation and includes the majority of Volunteer Canyon.

U.S. Naval Observatory Flagstaff Station, Arizona

The U.S. Naval Observatory Flagstaff Station (NOFS) is located in northern Arizona, just outside the City of Flagstaff. The NOFS has joint management of the Dry Lake PAC with the Arizona State Land Department and the Coconino National Forest. Surveys for Mexican spotted owls at NOFS and the Dry Lake Crater Caldera began in 1994 when Arizona State Land Department personnel first detected an owl either immediately adjacent to or on the NOFS property. Since 1994, surveys have been conducted by the Arizona State Land Department, FS, and U.S. Geological Survey/Southwest Biological Science Center/Colorado Plateau Research Station. The owls associated with the Dry Lake PAC are usually located on NFS lands, but the NOFS has been managing its portion of the PAC and recovery habitat per the 1995 Recovery Plan recommendations.

Kirtland Air Force Base, New Mexico

On 20 March 2009, Kirtland Air Force Base (KAFB) personnel detected a male Mexican spotted owl of unknown age incidental to general avian point count surveys (Envirological Services, Inc. 2009). KAFB personnel were not successful in their attempts to relocate the owl on 2 April 2009. In response to this first confirmed detection of a spotted owl on KAFB, standardized FWS owl surveys were completed on base from 4 May to 11 July 2009. No spotted owls were detected during the surveys, but some suitable habitat was delineated. Suitable spotted owl habitat on KAFB is patchily distributed and is interspersed with large tracts of open or arid and unusable habitat. Suitable habitat includes stands of ponderosa pine with Gambel oak understory, some drainage bottoms with deciduous components, and some cliff bands. On

KAFB, ponderosa pine is generally distributed at higher elevations or in drainage bottoms. Most canyons with a northern exposure on KAFB are wide, with cliffs occurring in bands usually toward the top of the canyon. As these canyons are broad, these bands receive a high degree of solar radiation and, therefore, are less suitable for breeding spotted owls. Because KAFB contains only pockets of habitat for owls and no mixed-conifer habitat, spotted owls likely do not breed on the base. However, KAFB might provide adequate habitat for dispersing or wintering birds. KAFB does not allow recreational activities in the area where the owl was detected, though unregulated recreational activity (e.g., mountain biking) does occur. Activity in KAFB owl habitat can include occasional law-enforcement activities, hiking by official personnel, biologists conducting wildlife surveys, helicopter activity, and various foot maneuvers.

Other U.S. Military Involvement

Low-level military air operations have been identified through Section 7 consultations as actions that may affect Mexican spotted owls. Low-level flights from air-rescue and attack model helicopters along with jet aircraft have flown over PACs in UGM and BRE EMUs. Emergency training missions of attack helicopters based out of Holloman Air Force Base occurred over several PACs in the Sacramento Mountains as recently as 2009 (J. P. Ward, Mexican Spotted Owl Recovery Team, pers. comm.). It is currently unknown if these types of training missions will continue in the future. Additionally, Fort Bliss near El Paso, Texas, is increasing its troop capacity and future training missions may include helicopter flights over owl sites in nearby mountain ranges of the BRE EMU. Holloman Air Force Base has funded studies to assess the effects of low-level flights but we are not aware that those results have been published.

vi. Department of Energy

Los Alamos National Laboratory, New Mexico

Mexican spotted owls were first reported at Los Alamos National Laboratory (LANL) in 1995 when management-related owl surveys located a nesting pair. At LANL, owls nest in canyons with cool, moist, mixed-conifer forests. The majority of owl habitat is within the central to western portions of LANL. The owls at LANL have been found to nest in cliff cavities rather than trees. Instead of PAC delineation, Areas of Environmental Interest (AEIs) were mapped as part of LANL's 2000 Habitat Management Plan. An AEI consists of a core boundary around suitable nesting habitat with an accompanying buffer habitat extending 420 m (0.25 mi) beyond this boundary. These alternative methods of delineating owl habitat areas were used instead of known nesting areas. The AEIs are surveyed annually and access, noise, and habitat modification restrictions are in place each year until occupancy is determined.

Owl surveys have been conducted on LANL property annually since 1994. In 1995, a pair of Mexican spotted owls was located and the AEI has been occupied each year since. In 2004, 2005, and 2006, a second AEI was found to be occupied by at least one Mexican spotted owl. In 2007, a pair of spotted owls was located in a third canyon and this AEI has been occupied each year since. The two AEIs with active pairs have successfully bred in most years.

b. States

i. Arizona

All of Arizona's native wildlife, including threatened and endangered species, is protected under the general provisions of Arizona Revised Statutes, Title 17. It is illegal to "take" wildlife unless authorized by the Arizona Game and Fish Commission. "Take" is specifically defined under A.R.S. § 17-101 to mean "pursuing, shooting, hunting, fishing, trapping, killing, capturing, snaring or netting wildlife or the placing or using of any net or other device or trap in a manner that may result in the capturing or killing of wildlife." Further, the Mexican spotted owl is protected under A.R.S. § 17-236 which makes it "unlawful to take or injure any bird or harass any bird upon its nest, or remove the nests or eggs of any bird, except as …authorized by commission order." There is no commission order in Arizona allowing for the "take" of Mexican spotted owl as defined in Title 17.

Currently, in Arizona's State Wildlife Action Plan, the owl is a Species of Greatest Conservation Need. It is listed as a Tier 1a species because it is federally listed as threatened. Species identified in the State Wildlife Action Plan have the highest priority for conservation management and are eligible for congressionally appropriated funds.

Management actions taken by the AGFD for the spotted owl have included: (1) participation in the original FS-sponsored Mexican Spotted Owl Task Force; (2) member of the FWS-sponsored Mexican Spotted Owl Status Review Team; (3) member of the Mexican Spotted Owl Recovery Team; (4) member of three Mexican Spotted Owl EMU Working Teams; (5) funding research and surveys to determine the status of the Mexican spotted owl in Arizona; and (6) continued review and technical guidance on projects that might impact Mexican spotted owl occupied or potential habitat.

Only one Mexican spotted owl nest has been located on Arizona State land, although approximately seven primary activity centers are on state or private lands located within Coconino, Santa Cruz, and Cochise counties. However, more Mexican spotted owls may occur on state lands than what is known because no standardized surveys have been completed on these lands in over a decade.

ii. Colorado

The Mexican spotted owl was state-listed as threatened by the Colorado Division of Wildlife (CDOW) in 1993. "Threatened" wildlife is defined as "...any species or subspecies of wildlife which, as determined by the Colorado Wildlife Commission, is not in immediate jeopardy of extinction but is vulnerable because it exists in such small numbers or is so extremely restricted throughout all or a significant portion of its range that it may become endangered." Threatened status protects wildlife species by making it unlawful "...for any person to take, possess, transport, export, process, sell or offer for sale...any species or subspecies of [threatened] wildlife...." In addition, the CDOW is legislatively mandated to "...establish such programs including acquisition of land...as are deemed necessary for management of...threatened species."

iii. New Mexico

Although the Mexican spotted owl is not state-listed under the New Mexico Wildlife Conservation Act (17-2-37 New Mexico Statutes Annotated [NMSA 1978]), it and other owls are protected by Statute 17-2-14 (NMSA 1978), which states that it is unlawful for any person to take, attempt to take, possess, trap, ensnare, or in any manner injure, maim, or destroy owls. Under this statute, it is also unlawful to purchase, sell, trade, or possess for the purpose of selling or trading any owl parts. The owl is also listed as a Species of Greatest Conservation Need in the Comprehensive Wildlife Conservation Strategy of New Mexico (NMDGF 2006), which is New Mexico's strategic action plan for conserving the state's biodiversity and, thereby, precluding the necessity of listing more species as threatened and endangered.

Management actions taken by the New Mexico Department of Game and Fish (NMDGF) for the spotted owl include: 1) participation in the original FS-sponsored Mexican Spotted Owl Task Force; 2) serving as a member of the FWS-sponsored Mexican Spotted Owl Status Review Team; 3) serving as a consultant to the Mexican Spotted Owl Recovery Team; 4) serving as a member of Mexican Spotted Owl EMU Working Teams; 5) funding research to determine the status of the Mexican spotted owl in New Mexico; 6) funding surveys in Mexico and on non-Federal lands in New Mexico; 7) oversight of the creation of the first Mexican spotted owl statewide database; and, 8) continued review and technical guidance on projects that might impact Mexican spotted owl occupied or potential habitat, as authorized by Statute 17-1-5.1 (NMSA 1978; M. Watson, NMDGF, pers. comm.).

Mexican spotted owls or their required habitats are not known to occur on any state-administered lands, but much of New Mexico's State lands have not been surveyed. Although spotted owls and their required habitats might occur on state park lands and New Mexico Department of Game and Fish Wildlife Management Areas, no standardized surveys have ever been completed on these lands (S. Cary, New Mexico State Parks Department, pers. comm., J. Hirsch, NMDGF, pers. comm.). However, spotted owls have been detected within 1.6 km (1 mile) of State Park and New Mexico Department of Game and Fish co-managed land near Fenton Lake (Sandoval County) during spotted owl surveys completed by the FS (J. Hirsch, NMDGF, pers. comm.). Similar to other state lands, New Mexico State Trust Lands (Trust Lands) are not known to support Mexican spotted owls (S. Knox, New Mexico State Land Office, pers. comm.). Still, it is possible that spotted owls occur on Trust Lands as potential spotted owl habitat has been identified on Trust Lands in southern Colfax County, southern Lincoln County, northwestern Union County, eastern Catron County, and northern Otero County. Surveys have been conducted only when forest-thinning projects were proposed within potential spotted owl habitat on Trust lands near Black Lake (Colfax County), Valley of the Utes (Colfax County), and Moon Mountain (Lincoln County). Thus, spotted owl occupancy of potential habitat cannot be determined until other Trust Lands are surveyed. Funding options are currently being explored for surveying other potential habitat on Trust Lands (S. Knox, New Mexico State Land Office, pers. comm.).

iv. Texas

Few Mexican spotted owls are documented for Texas, and most of the location records are in Guadalupe National Park (see section on Guadalupe Mountains National Park, Texas, above). However, there are four known spotted owl locations in the Davis Mountains of Jeff Davis County based on owl detections since the mid-1990s. These locations are in the Davis Mountains preserve, owned by The Nature Conservancy. Given the size of the Davis Mountains, the extensive amount of canyon and mesic pine-oak habitat, and recent results from predictive habitat models (Chihuahuan Desert Network, USDI NPS, unpublished data), it is likely that there are a number of undiscovered owls in that area. There is also one visual observation of a Mexican spotted owl in Big Bend National Park.

The State of Texas has listed the species as threatened. In addition, Chapters 67 and 68 of the Texas Parks and Wildlife Code, and Sections 65.171-65.176 of the Texas Administrative Code, prohibit the taking, possession, transportation, or sale of any animal species designated by state law as endangered or threatened without issuance of a permit. Destruction of eggs and nests of nongame birds is also prohibited (http://www.tpwd.stste.tx.us/huntwild/wild/species/ending/regulations/texas/index.phtml).

v. Utah

The Mexican spotted owl is included on the Utah State Sensitive Species list and the Utah Wildlife Action Plan as a federally Threatened Species and Tier I Species of Greatest Conservation Need, respectively. Threatened species receive protected status under Utah wildlife code. For species under protected status, "...[A] person may not take...protected wildlife or their parts; an occupied nest of protected wildlife; or an egg of protected wildlife." Nor may a person "...transport,...sell or purchase...or possess protected wildlife or their parts."

The Utah Division of Wildlife Resources (UDWR) has been collaborating with Federal agencies in implementing recommendations from the 1995 Recovery Plan. The three primary thrusts of this work have been to fill gaps in data on spotted owl distribution and status, to develop multivariate models of spotted owl canyon habitat in Utah, and to test occupancy sampling as a monitoring tool. The UDWR also works closely with the FWS and other Federal and state agencies in providing information for formal and informal consultations.

c. Tribes

Tribal beliefs and philosophies guide resource management on tribal lands. Included within this cultural context, many tribes employ the federally accepted survey methodology and management techniques consistent with those contained in this Recovery Plan. Several tribes consider owls a bad omen or a warning of danger or neglect, so owls play an important cultural role. Tribal beliefs also dictate that all living creatures are essential parts of nature and, as such, they are revered and protected. For example, the Elders Council of San Carlos Apache Tribe expressed the traditional view that owls and their homes should not be disturbed.

Tribes are sovereign governments with management authority over wildlife and other natural and cultural resources on their lands. Many tribes maintain professionally staffed wildlife and natural resources management programs to ensure prudent management and protection of tribal resources, including threatened and endangered species.

Most tribes consider their wildlife information to be proprietary and therefore we only discuss below information for which disclosure has been authorized by the individual tribes. Mexican spotted owl habitat or potential habitat exists on at least 10 Indian reservations in the United States. At least nine tribes have conducted spotted owl surveys, and at least six Tribes have located spotted owls on their lands. Two other tribes have historical spotted owl records. We discuss below spotted owl conservation efforts on seven Indian Reservations/Pueblos: the Mescalero Apache, San Carlos Apache, Jicarilla Apache, Navajo Nation, Southern Ute, and Northern and Southern Pueblos Agencies.

i. Mescalero Apache Tribe (New Mexico)

The Mescalero Apache Tribe began conducting surveys for the Mexican spotted owl in 1988, five years prior to its listing as a threatened species under the ESA. Since that time, more than 48,500 ha (120,000 ac) of forested reservation lands have been surveyed for the owl. The first draft of the Mescalero's Mexican Spotted Owl Management Plan was completed in 1995 and, after six years of discussions and revisions, the plan was accepted by the FWS in 2001.

Forest management on the Mescalero Apache Reservation emphasizes uneven-aged silvicultural techniques, specifically single-tree and group-selection cutting methods. Uneven-aged management results in a relatively unfragmented forest with stand-level conditions exhibiting vertical and horizontal structural diversity and moderate to thick canopy cover. As in many areas of the southwestern United States, stand-replacing fires are the primary threat to preserving Mexican spotted owl habitat. The Mescalero Apache Tribe maintains an active resource-management program that includes forest stand improvement, fuels reduction in the WUI, and watershed restoration treatments.

ii. San Carlos Apache Tribe (Arizona)

Traditional Apache culture and a deep abiding respect and love for the land, the water and all species inform the Tribe's management of the San Carlos Apache Reservation (Reservation), management of the land, and associated natural resources and environmental protection of all plant and animal species. Traditional Tribal ecological knowledge (TEK) is a key and fundamental principle of species conservation and land management on the Reservation. TEK incorporates concepts of an ecosystem-based approach to land and species management and conservation. It incorporates concepts of adaptive management by the Tribal government, the Tribal leaders and elders, and the Apache people in land and species management and preservation.

Consistent with TEK, the Tribe adopted a Strategic Plan in September of 2004. The Strategic Plan was developed with the Tribe's vision, goals, and objectives, to serve as an action plan for all resources on the Reservation. In February 2004, the Tribe adopted its Mexican

Spotted Owl Conservation Plan for the San Carlos Apache Reservation (Conservation Plan). The Tribe's Conservation Plan was designed and drafted with the assistance, among others, of the FWS. TEK was a paramount consideration and guiding principle in the drafting of the Conservation Plan. The Conservation Plan has been actively implemented on the Reservation since its adoption.

The Conservation Plan delineated PACs around known owl sites in all forested habitat of the Reservation. The Conservation Plan ensures that Tribal land-management activities and policies do not jeopardize the continued existence of Mexican spotted owls on the Reservation. Jeopardizing the existence of any species would be counter to the Apache cultural belief that all things were created for a purpose and have value. Mexican spotted owl habitat has been identified and delineated throughout the Reservation. Approximately 90% of tribally identified nesting, roosting, and foraging habitats are on lands inoperable for timber harvest and therefore are not in the commercial timber base.

In October of 2003, the Tribe adopted the San Carlos Apache Tribe Forest Management Plan (FMP) for the planning period 2004 to 2015. The FMP was also drafted with consideration of TEK. Indeed, the FMP addressed significant sections of the plan to wildlife, threatened and endangered species and fisheries, including addressing the specific needs of the Mexican spotted owl. The FMP has been actively implemented on the reservation since January of 2004. The FMP was available and considered by the team which drafted the Conservation Plan.

Since the adoption of the Conservation Plan, the Tribe and its responsible departments have interfaced and worked with FWS staff in the implementation of the plan. Similarly, departments within the Tribe have worked to implement the Conservation Plan. For instance, consideration is given to spotted owl habitat, including designated PACs, prior to any commercial timber sales on the Reservation. Consultation is undertaken with FWS staff prior to the implementation of commercial timber sales so as to minimize, if not eliminate, impacts to owls.

Furthermore as called for under the Conservation Plan and the FMP, wildland fire management actions are implemented throughout the Reservation as funding allows. These actions include forest thinning and prescribed burns. Mexican spotted owl habitat has benefitted from the management of Tribal forest resources. Indeed, the forest management practices employed on the Reservation are believed to have been a significant factor in reducing and minimizing the effects of the 2011 Wallow Fire, the largest forest fire in recorded Arizona history.

iii. Jicarilla Apache Tribe (New Mexico)

The Jicarilla Apache Nation has developed a Mexican spotted owl conservation plan, approved by the Jicarilla Legislative Council and accepted by the FWS. No resident spotted owls have been detected on the reservation; however, in the event resident owls are detected, the Jicarilla Apache Tribe has proposed to designate a 405 ha (1,000 ac) management territory. Uneven-aged timber management will be allowed to continue in all but 40 ha (100 ac) of the territory. In the absence of confirmed resident owls, all mixed-conifer stands ≥10 ha (25 ac) are treated as roosting/nesting sites and timber harvest is not allowed. A seasonal restriction is also proposed around any located active nest sites.

iv. Navajo Nation (Arizona, New Mexico, Utah)

The Navajo Nation occupies over 69,930 km^2 (27,000 mi^2) on the Colorado Plateau within Arizona, New Mexico, and Utah. The Navajo Nation's Department of Fish and Wildlife (Department), under the oversight of the Navajo Nation Council's Resources Committee, is the entity within the Navajo Nation Government that is responsible for management and protection of the Mexican spotted owl on Navajo lands. The Department developed the "Navajo Nation Management Plan for the Mexican Spotted Owl," which was approved by the Resources Committee of the Navajo Nation Council in 2000. Threats to the owl identified in that management plan include abandoned mine reclamation, commercial timber harvest, wildland fire and fire management, fuelwood harvest, livestock grazing, home-site development, large-scale coal mining, recreation, road building and reconstruction, and other human developments and activities.

Although no comprehensive surveys for spotted owls have been performed across the Navajo Nation, this species has been found during pre-project, clearance-type surveys and other biological surveys. This survey information, along with knowledge about the distribution of habitat, gives the Department a relatively good understanding of spotted owl distribution on Navajo lands. The owls occupy three habitat types on the Navajo Nation including the traditional, steep-sloped, mixed-conifer forests; cool, mesic canyons; and a unique habitat referred to as Black Mesa. The latter is restricted to the Black Mesa region near the center of the Navajo Nation, and it is unique because it consists of low- to moderately-sloped drainages containing small patches of Douglas-fir within a matrix of pinyon-juniper woodlands. There is no federally designated critical habitat for the spotted owl on the Navajo Nation.

The Navajo Nation Management Plan for the Mexican Spotted Owl (Management Plan) outlines the various components by which the owl is managed and protected. The owl is protected from "take" under Navajo Nation Code due to its status on the Navajo Endangered Species List; this adds an additional layer of regulation beyond the Federal ESA and Migratory Bird Treaty Act. Their Management Plan provides protection to the owl through: 1) the Tribal project-approval process; 2) mandatory pre-action surveys using the accepted Mexican Spotted Owl Inventory Protocol; 3) establishment of PACs around all recent and historical owl sites consistent with the 1995 Recovery Plan; and, 4) Federal agency consultations with the FWS for Federal actions. In addition, the Department has been a member of the Colorado Plateau Mexican Spotted Owl Recovery Implementation Working Team since its inception.

v. Southern Ute (Colorado)

Both the Southern Ute Tribe and the U.S. Bureau of Indian Affairs, Southern Ute Agency, have shown a strong willingness to work with the FWS in all aspects of Mexican spotted owl conservation, including extensive survey work and implementation of appropriate mitigation measures for planned projects. More than 12,150 ha (30,000 ac) of forested reservation lands have been surveyed for the owl since 1990. Management guidelines have been developed for areas of Tribal land proposed for fuels-reduction projects. These guidelines generally coincide with those set forth in the 1995 Recovery Plan for Restricted and Protected Steep Slope Habitats. Also, fuels-reduction treatments on mesa tops emphasize stand-level conditions with vertical and

horizontal structural diversity and the retention of large, downed logs and snags, where possible, while still meeting the fuels reduction goal.

vi. Northern and Southern Pueblos Agencies (New Mexico)

Twenty-three federally recognized and two Self-Governance Tribes have land within New Mexico's boundaries. The U.S. Bureau of Indian Affairs Southwest Regional Office has a Federal trust responsibility to provide intergovernmental assistance to all of New Mexico's tribes through nine agencies: Jicarilla, Laguna, Mescalero, Northern Pueblos, Ramah Navajo, Southern Pueblos, Southern Ute, Ute Mountain, and Zuni. The agencies can provide technical guidance and support for various forest and wildlife programs, such as completing Mexican spotted owl surveys in areas targeted for forest thinning. Tribes served by the Northern Pueblos Agency – the Pueblos of Nambe, Picuris, Pojoaque, San Ildefonso, Ohkay Owingeh, Santa Clara, Taos, and Tesuque – and tribes served by the Southern Pueblos Agency – the Pueblos of Acoma, Cochiti, Isleta, Jemez, Sandia, San Felipe, Santa Ana, Santo Domingo, Ysleta del Sur Pueblo, and Zia – are considered to not support spotted owl habitat or to only support a limited amount of habitat (L. Abeita, Southern Pueblos Agency, pers. comm.; N. Jojola, Northern Pueblos Agency, pers. comm.). Information on extent of spotted owl habitat on other Tribal lands within New Mexico is not available. Nonetheless, when Tribal projects are funded with Federal dollars, Mexican spotted owl surveys are completed on Tribal land in compliance with requirements of the National Environmental Policy Act. In addition, some tribes complete spotted owl surveys on their lands, e.g., when completing forest thinning projects or evaluating the effects of wildland fire. Two of the 10 tribes served by the Southern Pueblo Agency have completed spotted owl surveys, which were done in association with federally funded forest management projects, and no owls were located (L. Abieta, Southern Pueblos Agency, pers. comm.). Lands within the vicinity of the Pueblos of Santa Clara and San Ildefonso were surveyed for owls after the 2000 Cerro Grande Fire. Since then, only one of the eight tribes served by the Northern Pueblos Agency has completed spotted owl surveys, which were done in association with a non-federally funded forest management project (N. Jojola, Northern Pueblos Agency, pers. comm.).

Table G.1. Cumulative range-wide number of sites occupied by one or more Mexican spotted owls on non-Tribal lands in the U.S. at least once during the breeding season since 1989 according to land ownership.

Land Owner	No. Sites	(%)
USDA Forest Service	1,077	81.3%
USDI National Park Service	173	13.1%
USDI Bureau of Land Management	55	4.2%
Private	7	0.53%
US Department of Defense	11	0.8%
State Lands	1	0.07%
Total:	**1,324**	**100%**

2. Mexico

a. Protection Status

In Mexico, the Norma Oficial Mexicana 059 (NOM-059-SEMARNAT-2001) is the official list for endangered species. Proposed species are assigned to several threat categories following a review by several Mexican specialists. The Mexican spotted owl is listed as a Threatened species on this list (SEMARNAT 2002). Under the international treaty Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), *Strix occidentalis lucida* is listed on Appendix II (UNEP-WCMC, 2010). The UICN Red List of Threatened Species includes this bird in the category Near Threatened-NT, mentioning declining populations (BirdLife International 2008).

b. Records from Natural Protected Areas (NPAs)

Several Natural Protected Areas (Áreas Naturales Protegidas) in Mexico have records of this species (see Tables G.3 and G.4). The Zona Sujeta a Conservación Ecológica "Sierra Fría" in Aguascalientes is a state-protected area where pairs of owls have been documented in six different localities: Barranca El Tiznado, Cueva Prieta, El Carrizal, El Pinal, El Tejamanil, and La Angostura. Since nests have not been found, it is unclear if the species nests in the area (Márquez-Olivas et al. 2002). It is important to mention that in Sierra Fría logging is prohibited and security guards inspect every vehicle driving through the area to stop illegal timber harvest as part of the protected area management (Tarango et al. 2001). There are also records of *Strix occidentalis lucida* in the Reserva de la Biosfera de la Michilía, a Federal protected area in southeastern Durango.

c. Binational Conservation Efforts

Wildlife agencies from Canada, the United States, and Mexico signed a memorandum of understanding in 1996 for the official collaboration among the three countries to protect the wildlife and ecosystems of North America through the establishment of the Trilateral Committee for Wildlife and Ecosystem Conservation and Management. At annual meetings, the Committee addresses a broad array of biodiversity issues, including key strategies for conservation in currently active working groups. One of their working groups, the Species of Common Concern, facilitates dialogue with government wildlife managers to determine species with shared interest and the implementation of protection and recovery actions.

Likewise the CONANP is currently implementing Endangered Species Recovery Plans (Programa de Conservación de Especies en Riesgo [PROCER]) and developing Species Conservation Action Plans (Programas de Acción para la Conservación de Especies [PACE]) to influence protection and recovery of species. Although PROCER is starting with 35 taxa, it is not limited to them because the objective is to pay attention to threatened and priority species in and out of NPAs in Mexico. Based on that premise, *Strix occidentalis lucida*, a listed threatened species by the NOM-059-SEMARNAT-200I, is not excluded from PROCER. It is worth mentioning that although conservation actions focused directly on this species have not been implemented yet, habitat protection has been started for species sharing the owl habitat and protection needs since 2008.

Table G.2. Amount of area within each EMU in the U.S. in different land jurisdictions/ownerships.

Landowner Area by Ecological Management Unit in the United States for the Mexican Spotted Owl										
	BRE		BRW		CP		SRM		UGM	
LAND STATUS	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares
Federal Lands										
BLM	7,175,282.5	2,903,745.4	3,659,160.0	1,480,815.5	24,785,929.3	10,030,549.8	4,255,136.0	1,721,999.3	322,758.8	130,616.4
FS	1,431,950.2	579,492.0	5,580,168.5	2,258,223.1	8,213,268.5	3,323,805.1	15,366,720.6	6,218,716.1	8,699,145.4	3,520,433.3
NPS	277,713.8	112,387.2	79,014.9	31,976.3	4,462,160.5	1,805,779.5	421,809.6	170,701.0	42,427.4	17,169.8
Total Federal	8,884,946.5	3,595,624.7	9,318,343.5	3,771,014.9	37,461,358.3	15,160,134.5	20,043,666.2	8,111,416.4	9,064,331.5	3,668,219.5
State Lands										
AZ	0.0	0.0	5,241,674.7	2,121,239.0	2,407,042.0	974,099.2	0.0	0.0	47,039.7	19,036.4
CO	0.0	0.0	0.0	0.0	60,664.5	24,550.1	758,348.2	306,893.9	0.0	0.0
NM	3,239,860.6	1,311,130.3	550,383.4	222,733.1	736,495.1	298,050.2	690,189.9	279,311.1	503,160.6	203,622.7
UT	0.0	0.0	0.0	0.0	2,554,154.6	1,033,633.8	0.0	0.0	0.0	0.0
Total State	3,239,860.6	1,311,130.3	5,792,058.1	2,343,972.1	5,758,356.3	2,330,333.4	1,448,538.1	586,204.9	550,200.3	222,659.1
Tribal Lands	995,042.8	402,681.1	1,613,903.4	653,126.2	21,620,638.1	8,749,596.8	1,404,034.5	568,194.9	2,321,911.6	939,648.0
Private Lands	9,596,716.6	3,883,668.9	6,429,327.4	2,601,866.9	15,733,238.6	6,367,041.2	16,453,866.3	6,658,670.1	1,569,133.5	635,008.4
Other	2,909,784.5	1,177,552.7	239,686.5	96,998.1	336,922.0	136,348.0	552,410.7	223,553.6	29,283.8	11,850.8
TOTAL	25,626,350.9	10,370,657.8	23,393,318.9	9,466,978.1	80,910,513.4	32,743,454.0	39,902,515.9	16,148,039.9	13,534,860.7	5,477,385.7
(in thousands)	25,626.4	10,370.7	23,393.3	9,467.0	80,910.5	32,743.5	39,902.5	16,148.0	13,534.9	5,477.4

Table G.3. Federal and State Protected Areas in Mexico with records of Mexican spotted owls.			
Name	**Area (ha)**	**Location**	**Type**
Reserva Forestal Nacional y Refugio de Fauna Silvestre Sierras de Ajos Bavispe	200,000	Sonora	Federal
Reserva de la Biosfera de Janos	526,482	Chihuahua	Federal
Reserva de la Biosfera Montes Azules	331,200	Chiapas	Federal
Reserva de la Biosfera Sierra de Manantlán	139,577	Jalisco and Colima	Federal
Reserva de Biosfera "La Michilía"	9,325	Durango	Federal
Parque Nacional Cumbres de Monterrey	177,396	Nuevo León	Federal
Parque Nacional Sierra de San Pedro Mártir	72,911	Baja California	Federal
Área de Protección de Flora y Fauna Sierra de Arteaga*	120,428	Nuevo León	Federal
Área de Protección de Flora y Fauna Sierra de Álamos-Río Chucujaqui	92,890	Sonora	Federal
Área de Protección de Flora y Fauna Cerro Mohinora*	9,126	Chihuahua	Federal
Zona Sujeta a Conservación Ecológica "Cerro el Potosí"	989.38	Municipio de Galeana, Nuevo León	State
Zona Sujeta a Conservación Ecológica Sierra Fría	112,090	San José de Gracia, Rincón de Romos, Pabellón de Arteaga, Jesús María y Calvillo, Estado de Aguascalientes	State
Zona Sujeta a Conservación Ecológica "Cerro El Peñón"	103.39	Municipio de Dr. González, Nuevo León	State

*In process to become Protected Area.
Source: Gobierno del Estado de Aguascalientes, 1998; Gobierno del Estado de Nuevo León, 2000, INE-SEMARNAP, 2000; INE-SEMARNAT, 2000; CONANP, 2005; CONANP, 2006; Gobierno Federal, 2009; CONANP, 2010.

Even though there are currently no records of this species in other National Protected Areas (NPAs), it will most likely be found in several of the other NPAs because of its wide distribution. This would increase the distribution of the species within protected areas. This is highly probable in the Transvolcanic Range area, where it would be important to verify several sightings of this species.

Table G.4. Protected Areas in Mexico with potential distribution of Mexcian spotted owls.			
Name	**Area (ha)**	**Location**	**Type**
Reserva de la Biosfera Mariposa Monarca	56,259	Michoacán and México	Federal
Parque Nacional Iztaccihuatl-Popocatepetl	90,284	México, Puebla and Morelos	Federal
Parque Nacional Nevado de Toluca	46,784	México	Federal
Parque Nacional Malinche o Matlalcueyatl	45,711	Tlaxcala and Puebla	Federal
Parque Nacional El Tepozteco	23,259	Morelos and D.F.	Federal
Parque Nacional Bosencheve	10,432	México and Michoacán	Federal
Parque Nacional Lagunas de Zempoala	4,790	Morelos and México	Federal
Parque Nacional Insurgente Maria Morelos	4,325	Michoacán	Federal
Parque Nacional Insurgente Miguel Hidalgo y Costilla	1,580	D.F.	Federal
Parque Nacional Desierto de los Leones	1,529	D.F.	Federal
Parque Nacional Cumbres del Ajusco	920	D.F.	Federal
Área de Protección de Flora y Fauna Tutuaca	444,489	Sonora and Chihuahua	Federal
Área de Protección de Flora y Fauna Papigochi	222,274	Chihuahua	Federal
Área de Protección de Flora y Fauna Campo Verde	108,069	Sonora and Chihuahua	Federal
Área de Protección de Flora y Fauna La Primavera	30,500	Jalisco	Federal
Área de Protección de Flora y Fauna Pico de Tancítaro	23,406	Michoacán	Federal
Área de Protección de los Recursos Naturales Cuenca Alimentadora del distrito de riego 043 Estado de Nayarit	2,328,975	Nayarit, Jalisco, and Zacatecas	Federal
Área de Protección de los Recursos Naturales Cuenca Alimentadora del Distrito Nacional de Riego 004 Don Martín	1,519,920	Coahuila	Federal
Área de Protección de los Recursos Naturales Cuenca Alimentadora del Distrito Nacional de Riego 001 Pabellón	97,699	Zacatecas and Aguascalientes	Federal

Source: CONANP 2010

APPENDIX H - ACRONYMS USED IN THE RECOVERY PLAN

AEI	Areas of Environmental Interest
AGFD	Arizona Game and Fish Department
AOU	American Ornithologists' Union
BA	Basal area
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BRE	Basin and Range-East
BRW	Basin and Range-West
CDC	Center for Disease Control
CDOW	Colorado Division of Wildlife
CFR	Code of Federal Regulations
CP	Colorado Plateau
DBH	Diameter at breast height
DC	Desired Condition
DoD	United States Department of Defense
DPS	Distinct Population Segment
DRC	Diameter at root collar
EMU	Ecological Management Unit
ESA	Endangered Species Act
ESR	Emergency stabilization and rehabilitation
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FIA	Forest Inventory and Analysis
FLRA	Forest Landscape and Restoration Act
ForestERA	Forest Ecosystem Restoration Analysis
FO	Field office
FS	United States Forest Service
FSM	Forest Service Manual
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
GPS	Global Positioning System
HFRA	Healthy Forests Restoration Act
IDT	Interdisciplinary Team
KAFB	Kirtland Air Force Base
LANL	Los Alamos National Laboratory
NEPA	National Environmental Policy Act
NFS	National Forest System
NMDGF	New Mexico Department of Game and Fish
NMSA	New Mexico Statutes Annotated
NOFS	Naval Observatory Flagstaff Station
NPS	National Park Service
NRZs	Nesting-roosting Zones
OHV	Off-highway vehicle
PAC	Protected Activity Center
PFC	Proper functioning condition

PNVT	Potential natural vegetation type
QMD	Quadratic Mean Diameter
RMRS	Rocky Mountain Reasearch Station
RMSTAND	Stand-exam analysis routines
ROD	Record of Decision
RU	Recovery Units
SDI	Stand Density Index
SMR	Soil moisture
SRM	Southern Rocky Mountain
STR	Soil temperature
SWWP	Southwestern white pine
TIN	Triangulated irregular network
UDWR	Utah Division of Wildlife Resources
UGM	Upper Gila Mountain
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
UTM	Universal Transverse Mercator
SGCNA	Species of Greatest Conservation Need in Arizona
WNV	West Nile Virus
WSCA	Wildlife of Special Concern in Arizona
WUI	Wildland-urban interface

APPENDIX I - LATIN NAMES FOR COMMON NAMES USED IN THE TEXT

Names appear in taxonomic order.

Common Name	Scientific Name
BIRDS	
Golden eagle	*Aquila chrysaetos*
Northern goshawks	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*
Thick-billed parrot	*Rhynchopsitta pachyrhyncha*
Great horned owl	*Bubo virginianus*
Northern spotted owl	*Strix occidentalis caurina*
Mexican spotted owl	*Strix occidentalis lucida*
California spotted owl	*Strix occidentalis occidentalis*
Barred owl	*Strix varia*
Barred owl subspecies	*Strix varia helveda*
Barred owl sunspecies	*Strix varia georgieo*
Great gray owl	*Strix nebulosa*
Flammulated owl	*Otus flammeolus*
Fulvous owl	*Strix fulvescens*
Imperial woodpecker	*Campephilus imperialis*
Common raven	*Corvus corax*
MAMMALS	
Bat species	*Vespertilionidae spp.*
Rabbits	*Sylvilagus* spp.
Pocket gopher species	*Thomomys spp*.
Deer mice	*Peromyscus maniculatus*
Brush mouse	*Peromyscus boylii*
Woodrat species	*Neotoma spp.*
Mexican woodrat	*Neotoma mexicana*
Vole species	*Microtus spp.*
Mogollon vole	*Microtus mogollonensis*
Long-tailed vole	*Microtus longicaudus*
Mexican vole	*Microtus mexicanus*
Coyote	*Canis latrans*
Gray-fox	*Urocyon cinereoargenteus*
Coati	*Nasua nasua*
Ring-tailed cat	*Bassariscus astutus*
Bobcat	*Lynx rufus*
Elk	*Cervus canadensis*

INSECTS

Spruce beetle	*Dendroctonus rufipennis*
Western balsam bark beetle	*Dryocoetes confuses*
Spruce aphid	*Elatobium abietinum*
Janet's looper	*Nepytia janetae*

PLANTS

Maple species	*Acer* spp.
Rocky Mountain maple	*Acer glabrum* Torr.
Big-toothed maple	*Acer grandidentatum* Nutt.
Arizona boxelder	*Acer negundo var. arizonicum* Sarg.
Alder species	*Alnus* spp.
Western hop-hornbeam	*Ostrya knowltonii* Sarg.
Juniper species	*Juniperus spp.*
Arizona cypress	*Cupressus arizonica* Greene
Texas madrone	*Arbutus xalapensis* Kunth.
Chihuahua oak	*Quercus chihuahuenses* Trel.
Red oak	*Quercus coccolobifolia* Trel.
Mexican red oak	*Quercus eduardii* Trel.
Gambel oak	*Quercus gambelii* Nutt.
Gentry's oak	*Quercus gentryi* C.H. Mull
Gray oak	*Quercus grisea* Liebm.
Silverleaf oak	*Quercus hypoleucoides* A. Camus
Chinkapin oak	*Quercus muehlenbergii* Engelm.
Mexican white oak tree	*Quercus polymorpha* Schlecht. & Cham.
Mexican white oak	*Quercus potosina* Trel./*Quercus laeta* Liebm.
No common name	*Quercus resinosa* Liebm.
New Mexcio locust	*Robinia neomexicana* Gray
True fir species	*Abies* spp.
White fir	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.
Corkbark fir	*Abies lasiocarpa var. arizonica* (Merriam) Lemmon
Subalpine fir	*Abies lasiocarpa var. lasiocarpa* (Hook.) Nutt.
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
Blue spruce	*Picea pungens* Engelm.
Bristlecone pine	*Pinus aristata* Engelm.
Arizona pine	*Pinus arizonica* Engelm.
Mexican white pine	*Pinus ayacahuite* Ehrenb. ex Schltdl.
Nut pine	*Pinus cembroides* Zucc.
Durango pine	*Pinus durangensis* Martínez.
Piñon pine	*Pinus edulis* Engelm.
Apache pine	*Pinus engelmannii* Carr.
Limber pine	*Pinus flexilis* James
Chihuahuan pine	*Pinus leiophylla* Schiede & Deppe
Michoacán pine	*Pinus michoacana* Martínez.

Weeping pine	*Pinus patula* Schiede ex Schltdl. & Cham.
Ponderosa pine	*Pinus ponderosa var. scopulorum* Engelm.
Ocote pine	*Pinus oocarpa* Schiede ex Schltdl.
Southwestern white pine	*Pinus strobiformis* Engelm.
Aztec pine	*Pinus teocote* Schiede & Deppe
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Rocky Mountain Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco
Sycamore species	*Platanus* spp.
Cottonwood species	*Populus* spp.
Narrowleaf cottonwood	*Populus angustifolia* James
Quaking aspen	*Populus tremuloides* Michx.
Willow species	*Salix* spp.
Dwarf mistletoe	*Arceuthobium* spp.
Douglas fir dwarf mistletoe	*Arceuthobium douglasii* Engelm.

APPENDIX J - GLOSSARY

- A -

adaptive kernel (AK) – Refers to a method of estimating home-range size. This method involves estimating a bivariate probability distribution from the observed animal locations, and it can be used to compute the area containing a specified proportion of those locations. A 75% AK was used to calculate the minimize size of PACs in this plan.

adaptive management – A deliberate and iterative process to optimize management strategies. The process entails formation of a management model, management implementation, monitoring and interpretation of system responses, and ultimately refinement of management model given lessons learned.

adult – A spotted owl >27 months old

- B -

basal area – The cross-sectional area of a tree stem (including bark) near its base, generally measured at breast height (approximately 1.5m above ground level).

before-after-control-impact (BACI) – A specific type of manipulative quasi-experiment. Under the BACI design, potential responses are examined before and after proposed manipulations at control (or reference) sites and at impact sites. Differs from an experiment because treatments are not randomly assigned to experimental units and treatments may not be replicated.

biomass – With respect to individuals, this refers to the weight (mass) of a plant or an animal. With respect to areas or communities, this refers to the total mass of living organisms in that area or community at any given time. With respect to owl diet, this refers to the relative contribution of one species (or group) of prey animals to the overall diet.

biotic disturbance – Disturbance resulting from insects,disease, and pathogens that alters forest/woodland structure and composition.

bosque – A discrete grove or thicket of trees, particularly in lowland or riparian areas of the Southwestern United States and Mexico; for example a cottonwood bosque or a mesquite bosque.

breeding dispersal – Movement of an adult spotted owl from home range to another where they establish a territory and attempt to breed.

burned area emergency response (BAER- USDA) – While many wildfires cause little damage to the land and pose few threats to fish, wildlife and people downstream, some fires create situations that require special efforts to prevent further problems after the fire. Loss of vegetation exposes soil to erosion; runoff may increase and cause flooding, sediments may move downstream and damage houses or fill reservoirs, and put endangered species and community

water supplies at risk. The BAER program addresses these situations with the goal of protecting life, property, water quality, and deteriorated ecosystems from further damage after the fire is out.

burned area rehabilitation (BAR- DOI) – Efforts (non-emergency) undertaken within three years of a wildfire to repair or improve fire-damaged lands which are unlikely to recover to management approved conditions; or to repair or replace minor facilities damaged by fire.

- C -

canopy – A layer of foliage, generally the uppermost layer, in a forest stand. Can be used to refer to midstory or ***understory*** vegetation in multi-layered stands.

canopy closure – An estimate of the percentage of ground covered by overhead vegetation (also canopy cover).

co-dominant tree – The condition of having two equally ***dominant tree*** species in a ***forest type***. The crowns of these trees help to form the main canopy in even-aged stands. In uneven-aged stands, the crowns of these trees are above the crowns of the tree's immediate neighbors and receive full light from above and partial light from the sides.

commercial forest land – Forested land deemed tentatively suitable for the production of timber that has not been withdrawn administratively from timber production (see ***reserved land***).

competition – Occurs when a certain resource (e.g.,food) is in limited supply and is used by 2 or more species. Can be exploitative (both species use the same resource) or interference (use by one speciesprecludes use by another).

confidence interval – An interval constructed around a parameter estimate in which that estimate should occur with a specified probability, such as 95% of the time. Bounds of the confidence interval are usually defined by the magnitude of dispersion around a mean value.

connectivity – An estimate of the extent to which intervening habitats connect otherwise disjunct subpopulations of spotted owls.

cover type – Refers to a forest or woodland type,such as ponderosa pine,pine-oak, or mixed-conifer. See also ***forest type*** and ***vegetation type***.

- D -

delist – The process of removing a species from the list of threatened and endangered species.

demography – Demography includes various population parameters such age structure, fecundity, survival rates, and the like. Data from these parameters allows for the quantitative analysis of population structure and trend.

desired conditions – Quantitative and qualitative descriptions of forest and woodland conditions used by spotted owls for nesting, roosting, foraging, and other needs.

diameter at breast height (dbh) – A standard measure of tree diameter measured approximately 1.5 m (4.5 ft) above the ground.

dispersal – The movement of organisms from their one location to another location where they produce offspring. See also ***breeding dispersal*** and ***natal dispersal***.

disturbance – Significant alteration of conditions for owls. Disturbance my alter habitat structure or composition through natural (e.g., fire) or human-caused (e.g., timber harvest) events. Disturbance may also be caused by noise or human activity (e.g., recreation) is close proximity to owls.

dominant tree – The overstory tree species which contributes the most cover or basal area to the ***stand***, compared to other tree species. Dominant trees are those whose crown extends above the general level of the main canopy (Helms 1998).

- *E* -

early seral stage – An area that is in the early stages of ecological succession.

ecological management unit (EMU) – An updated term for what was previously referred to in the 1995 Recovery Plan as a ***recovery unit*** (RU). A specific geographic area, identified mainly from physiographic provinces, used to evaluate the status of the Mexican spotted owl and within which to develop specific management guidelines.

ecological restoration – Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Society for Ecological Restoration International Science & Policy Working Group 2004). An intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity, and sustainability.

ecological succession – The orderly progression of an area through time from one vegetative community to another in the absence of disturbance. For example, an area may proceed from grass-forb through aspen forest to mixed-conifer forest.

ecosystem – An interacting biophysical system of organisms and their environment.

emergency stabilization (ES-DOI) – Planned actions to stabilize and prevent unacceptable degradation to natural and cultural resource, to minimize threats to life or property resulting from the effects of a fire, or to repair/replace/construct physical improvements necessary to prevent degradation of land or resources.

emigration – Permanent movement of individuals away from a population.

encinal – Of or relating to oaks, particularly plant communities dominated by live oaks.

environmental stochasticity – Random variation in environmental attributes, such as weather patterns or fire regimes.

even-aged forest/stands – Refers to forests composed of trees with a time span of <20 years between oldest and youngest individuals.

even-aged management – The application of a combination of actions that result in the creation of stands in which trees are essentially all of the same age. Cutting methods that produce even-aged stands include clearcuts, seed-tree cuts, and shelterwood cuts.

- F -

fire regime – A description of the frequency, severity, and extent of fires that typically occur in an area or vegetation type.

floater – A member of a spotted owl population that does not hold, maintain, or defend a territory (see Franklin 1992).

forb – A broadleaved, herbaceous plant (e.g., columbine).

forest restoration treatments – Treatments that help recover forest ecosystem resilience and the adaptive capacity of forest ecosystems that have been degraded, or are otherwise outside the natural range of variation that would preclude sustainability through time.

forest type – A means of classifying forests based upon the similarity of species composition and structure. The primary forest types used by the owl in the American southwest are mixed-conifer and pine-oak forests.

fragmentation – The process of reducing the size and connectivity of habitat patches.

fuel loads – The amount of combustible material present per unit area.

fuels – Combustible materials.

fuels-reduction treatments – Reduction of surface and understory fuels, increasing the height to live crown, decreasing crown density, and retaining the majority of large trees of fire-resistant species through thinning and/or the use of fire.

fuelwood – Wood, either green or dead, harvested for purposes of cooking or space heating, and usually measured in cords (1 cord = 128 cubic feet.).

- G -

gene flow – The movement of genetic material among populations.

Geographical Information System (GIS) – A computer system capable of storing and working with spatial data.

graminoids – Any plants of the grass family in particular and also those plants in other families that have a grass-like form or appearance (e.g., sedges).

grazing intensity – A measure of pressure imposed on growing vegetation by feeding herbivorous animals. The number of feeding animals and length and season of use are the main factors that affect vegetation and differentiate grazing intensity.

group-selection cutting – Uneven-aged silvicultural system that entails removing small groups of trees within a restricted area, usually no greaters than twice the height of the tallest tree in the group.

- H -

habitat – Suite of existing environmental conditions required by an organism for survival and reproduction. The place where an organism typically lives.

habitat fragmentation – See ***fragmentation***.

habitat type – See ***vegetation type***.

hanging canyon – A side canyon, the mouth of which lies above the floor of a larger canyon to which the side canyon is tributary.

home range – The area used by an animal in its day-to-day activities.

hybridization – Iinterbreeding among species resulting in offspring that shares genes from both species. Hybridization has been reported between barred and spotted owls.

- I -

immigration – The movement of individuals from other areas into a given area.

intermediate/suppressed tree position – Trees that are shorter than the dominant and co-dominant, larger trees, yet taller than understory shrubs and herbaceous vegetation.

Intermountain Region – An administrative region of the FS, lying between the Pacific Coastal and Rocky Mountain Ranges and including Utah, Nevada, southern Idaho, and parts of Wyoming and Montana.

J-

juvenile – A spotted owl <5 months old.

- K -

key grazing areas – Primarily riparian areas, meadows (natural), and created openings that receive disproportionate grazing by ungulates due to their location, the quantity and quality of forage they produce, and their grazing or browsing value (Holechek et al. 2001).

- L –

landscape scale – A spatial scale and extent expressed in geographic terms within which to target action, e.g., projects aimed at forest landscape restoration. Landscapes may be defined by watersheds or other topographic or administrative units. Our definition of landscape scale is determined by the particular research or management issue being addressed. The appropriate scale may therefore vary from a particular watershed to a national forest boundary or a specific forested region (such as all ponderosa pine forest on the Mogollon Rim).

large tree – In this Recovery Plan, large trees are defined as trees ≥46-cm (18-inches) dbh.

ladder fuel – Dead or living fuels that connect fuels on the forest floor to the canopy and promote the spread of surface fires to tree crowns.

Land Resource Management Plan (LRMP) – A plan written for the management of a National Forest. These plans were mandated by the National Forest Management Act of 1976.

late seral stage forest – A forest in the latter stages of development, usually dominated by large, old trees.

- M -

macrohabitat – Landscape-scale features that are correlated with the distribution of a species; often used to describe seral stages or discrete arrays of specific vegetation types.

madrean – Pertaining to Mexico's Sierra Madre cordillera, or to plant species or communities whose primary affinity is to that region (see also ***Petran***).

madrean pine-oak forest – Forests in which any of several pines characterize the overstory and in which midstory oaks are mostly evergreen species. Many of the dominant species are ***Madrean*** in affinity. See Marshall (1957) for descriptions. This habitat type was included as pine-oak by Fletcher and Hollis (1994).

majority – For purposes of this plan in regards to our definitions for ***forest types***, we use this term to refer to the situation where a single tree species contributes >50% of the basal area (Eyre 1980).

management experiment – A manipulative experiment conducted through partnership of professional managers and scientists to quantify the effects of one or more management activities.

mechanical treatments – Any activity (e.g., silvicultural thinning, biomass removal) performed by human-controlled tools (e.g., chainsaw, feller-buncher) that results in the removal or alteration of wood fiber. Does not include the use of fire.

mesic – Of or relating to conditions between hydric and ***xeric*** or the specific quality of being adapted to conditions between wet and dry.

metapopulation – Systems of local populations connected by dispersing individuals.

microhabitat – Habitat features at a fine scale; often identifies a unique set of local habitat features to describe those associated with specific owl activities such as nesting,roosting and foraging.

microtine – For the purposes this plan, any vole of the genus *Microtus*.

midstory – Intermediate tree position in a forested stand. These trees are shorter than the dominant and co-dominant, larger trees, yet taller than understory shrubs and herbaceous vegetation.

migration – The seasonal movement from one area to another and back.

mixed-conifer forest type – Overstory species in these forests include Rocky Mountain Douglas-fir, white fir, Rocky Mountain ponderosa pine, quaking aspen, southwestern white pine, limber pine, and blue spruce. Refer to Appendix C.2.b.iii for a more precise discussion and definition of mixed-conifer forest type.

model – A representation of reality, based on a set of assumptions, that is developed and used to describe, analyze, and understand the behavior of a system of interest.

monitoring – The process of collecting information to track changes of selected parameters over time.

mousing – A technique used to assess reproductive status of a pair of spotted owls. Entails feeding mice to adult owls and observing the owls' subsequent behavior.

multi-layered (or multi-storied) stands – Forest stands with >2 distinct canopy layers. Applied to forest stands that contain trees of various heights and diameters and therefore support foliage at various heights in the vertical profile of the stand.

- *N* -

natal dispersal – Occurs after the fledging period when juveniles leave their nest site to settle and establish a breeding territory.

nest/roost recovery habitat – Areas managed to replace nest/roost habitat lost to disturbance or senescence and toprovide new nest/roost habitat for a recoverying owl population.

null hypothesis – A hypothesis stating that there is no difference between units being compared.

- *O* -

occupany – Use of and presence within a specific area by one or more owls.

old growth – An old forest stand, typically dominated by large, old trees, with relatively high canopy closure and a high incidence of snags, as well as logs and other woody debris.

opening – A break in overstory and understory plant canopy as created by the natural absence or physical removal of trees and shrubs. Quantitative descriptions may be based on overhead canopy closure (e.g., an area of defined size with <10% cover) or on density of trees (e.g., an area of relevant size with fewer than five trees ≥11 inches in diameter). The size of area will depend on the ecological objective being considered. Relevant to habitat use by spotted owls, a small opening would be 0.10 ha (0.25 ac), and a large opening would by > 0.81 ha (>2 ac).

other forest and woodland types – Vegetation types that are neither ***restricted*** or within ***PACs*** as to management recommendations provided in this Recovery Plan.

O***ther Riparian Habitat*** – Those forested riparian areas that currently are not used by spotted owls for nesting and breeding season roosting but may provide habitat for dispersing and wintering spotted owls.

overstory – The highest limbs and foliage of a tree, and consequently extending and relating to the upper layers of a forest canopy.

- *P* -

pellet – A compact mass of undigested material remaining after preliminary digestion and eliminated by regurgitation rather than by defecation.

peromyscid – Any mouse in the genus *Peromyscus* of the family Muridae (formerly Cricetidae).

petran – Pertaining to the Rocky Mountain area. Used to identify plant associations or species that have their primary affinity to the Rocky Mountain area (see also ***madrean***).

physiognomy – The characteristic features or appearance of a plant community or vegetation.

physiographic province – A geographic region in which climate and geology have given rise to a distinct array of land forms and habitats.

pilot study – A preliminary study conducted to evaluate the efficacy of study design components, including sampling design, field methods, and sample size.

pine-oak forest type – Stands within the *Pinus ponderosa* and *Pinus leiophylla* series that exhibit a pine overstory and oak understory. Refer to Appendix C.2.b.ii for these criteria and a more precise discussion and definition.

plurality – The situation where a species (or group of species of interest) comprises the largest proportion, but not a ***majority***, of a mixed-species stand (Eyre 1980).

ponderosa pine forest type – Any forested stand of the *Pinus ponderosa* Series not included in the pine-oak forest type definition, or any stand that qualifies as pure (i.e., any stand where a single species contributes >80% of the basal area of dominant and codominant trees) ponderosa pine, regardless of the series or habitat (see also Eyre 1980). Refer to Appendix C.2.b.i for a more precise discussion and definition.

population – A collection of individuals that share a common gene pool.

population density – The number of individuals per unit area.

population viability – The probability that a population will persist for a specific period of time, despite demographic and environmental stochasticity.

power – With respect to statistical comparisons, refers to the probability of not making a Type-II error.

pre-commercial thinning – The practice of removing some of the smaller trees in a stand so that remaining trees will grow faster.

prescribed fire – A wildland fire burning with planned ignitions under specified conditions.

prey – The collection of species taken by spotted owls as food. These are typically small-medium sized mammals and birds.

protected activity center (PAC) – An area established around an owl nest (or sometimes roost) site, for the purpose of protecting that area. Management of these areas is largely restricted to managing for forest-health objectives.

protected habitat – See ***protected activity center*** (PAC).

pure stand – A plant community in which a single species is predominant. For purposes of this plan, we use this term to refer to any stand where a single species contributes >80% of the basal area of ***dominant*** and ***co-dominant trees***.

- *R* -

recovery – As provided by the Endangered Species Act and its implementing regulations, the process of returning a threatened or endangered species to the point at which protection under the Endangered Species Act is no longer necessary.

recovery habitat – As used within this Recovery Plan, areas outside of PACS managed as nest/roost, foraging dispersal, and wintering habitat. Recovery habitat includes pine-oak, mixed-conifer, and riparian forests well as rocky canyons.

recovery plan – As provided by the Endangered Species Act, a plan for management of a threatened or endangered species that lays out the steps necessary to recover a species (see ***recovery***).

recovery team – A team of experts appointed by the Fish and Wildlife Service whose charge is development of a ***Recovery Plan***.

recovery unit (RU) – A specific geographic area, identified mainly from physiographic provinces, used to evaluate the status of the Mexican spotted owl and within which to develop specific management guidelines. This term has been replaced by ***ecological management unit*** (EMU) in the first revision (2012) of this plan.

recruitment – The addition of individuals to a population from birth and immigration.

reserved lands – Lands that have been administratively withdrawn from commercial activities, such as wilderness areas or research natural areas.

riparian forests – Riparian forests are plant communities affected by surface and subsurface hydrologic features of perennial or intermittent water bodies (e.g., rivers, streams, lakes). Riparian forests have one or both of these principle characteristics: (1) distinctively different tree and shrub species than the adjacent areas and/or (2) tree species similar to adjacent areas but exhibiting more vigorous or robust growth forms (FWS 2009).

riparian recovery habitat – Consists of riparian forests outside of PACs that could frequently be used by owls for foraging, roosting, daily movements, dispersal, and potentially for nesting. See also, ***other riparian habitat***.

Rocky Mountain Region – An administrative region of the FS, including Colorado, Nebraska, South Dakota, and parts of Wyoming.

rotation – The planned number of years between regeneration of a forest stand and final harvest of that stand.

- *S* -

salvage – Removal of dead, damaged, or unhealthy trees following fire or insect epidemic to recover economic value from the trees.

sanitation salvage – Removal of dead, damaged, or susceptible trees primarily to prevent the spread of pests or pathogens and to promote forest health.

seral species – Any plant or animal that is typical of a seral community (stage).

seral stage – Any plant community whose plant composition is changing in a predictable way; for example, an aspen community changing to a coniferous forest community.

shelterwood cut – An even-aged regeneration cutting in which new tree seedlings are established under the partial shade of remnant seed trees.

silviculture – The practice of controlling the establishment, composition, and growth of forests.

single-tree selection cutting – A cutting method based on removal of individual trees, rather than groups of trees (see also ***group selection cutting***).

sink – In a population sense, refers to a population where death rate exceeds birth rate. Such a population can result in a decline (see also ***source***).

snag – A standing dead tree.

source - In a population sense, refers to a population where birth rate exceeds death rate. Such a population produces an excess of juveniles that can disperse to other populations (see also ***sink***).

Southwestern Region – An administrative unit of the FS, including Arizona, New Mexico, and grasslands in the Oklahoma and Texas panhandle; and, an administrative unit of the FWS, including Arizona, New Mexico, Texas and Oklahoma.

spruce-fir forest type – High-elevation forests occurring on cold sites with short growing seasons, heavy snow accumulations, and strong ecological and floristic affinities to cold forests of higher latitudes. In general, dominant trees include Englemann spruce, subalpine and/or corkbark fir, or sometimes bristlecone pine. Refer to Appendix C.2 for a more precise discussion and definition.

stand – Any homogeneous area of vegetation with more or less uniform soils, landform, and vegetation. Typically used to refer to forested areas.

stochastic – Random or uncertain.

stringers – Narrow bands of trees that extend into confined areas of suitable habitat such as in ravines.

sub-adult – A spotted owl between 5-26 months old.

subpopulation – A well-defined set of individuals that comprises a subset of a larger, interbreeding population (see also ***metapopulation***).

survivorship – The proportion individuals that survive from one time period to the next. Usually measured from year to year in terms of annual survival.

- T -

target population – The group of subjects for which a scientific conclusion can be applied. The target population is established at the onset of a scientific investigation and helps to shape sampling procedures.

team – The Mexican Spotted Owl Recovery Team.

territory – The area that an animal defends against intruders of its own species. Not synonymous with ***home range***, as parts of the home range are typically shared with other individuals.

transient owl – Any Mexican spotted owl that is away from a territory whether a floater, wintering bird, migrant, disperser, etc.

type-I error – The error made when a null hypothesis that is true is inappropriately rejected, as when concluding that two samples from a single population come from two different populations.

type-II error – The error that is made when a null hypothesis that is false is not rejected, as when concluding that two samples from different populations came from a single population.

- U -

understory – Any vegetation whose canopy (foliage) is below, or closer to the ground than, canopies of other plants. The opposite of ***overstory***.

uneven-aged management – The application of a combination of actions needed to simultaneously maintain continuous tall forest cover, recurring regeneration of desirable species, and the orderly growth and development of trees through a range of diameter or age classes. Cutting methods that develop and maintain uneven-aged stands are single-tree selection and group selection.

- V -

vegetation types – A land classification system based upon the concept of distinct plant associations. Vegetation or habitat types (plant associations) have been documented for western forests, and keys to their identification are available. The primary vegetation (or habitat) types used by Mexican spotted owls are discussed in Appendix C.

viability – Ability of a population to persist through time (see ***population viability***).

vital rates – Collective term for age- or stagespecific demographic rates, such as birth and death rates, of a population.

vole – Any small rodent in the genus *Microtus*, *Clethrionomys*, or *Phenacomys*, all in the family Muridae.

-W-

wildland fire – A term describing any non-structure fire that ocurrs in the wildland. Wildland fires are categorized into two distinct types: *Wildfires* (includes both unplanned ignitions and planned ignitions that are declared wildfires. The wildfire term is to be applied to all unplanned ignitions including those events formally termed wildland fire use) and *Prescribed Fires* (planned ignitions).

- X -

xeric – Of or relating to perennially dry conditions or the specific quality of being adapted to dry conditions.

APPENDIX K – MOUNTAIN-PRAIRIE REGION (REGION 6) CONCURRENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mountain-Prairie Region

IN REPLY REFER TO:
FWS/R6
ES

MAILING ADDRESS:
P.O. BOX 25486, DFC
Denver, Colorado 80225-0486

STREET LOCATION:
134 Union Boulevard
Lakewood, Colorado 80228-1807

SEP 5 2012

Memorandum

To: Regional Director, Region 2
Attention: Wendy Brown

From: Deputy Regional Director, Region 6

Subject: Concurrence on the Final Mexican Spotted Owl Recovery Plan, First Revision

Thank you for the opportunity to participate in the development of the subject recovery plan. Our Colorado Field Office and Utah Field Office contributed to this ambitious undertaking. We concur with the final plan and look forward to working with the Southwest Region and all of our partners as we work toward recovery and eventual delisting.