PROJECT GUIDELINES

ABOUT

The New Mexico Department of Game and Fish (Department) Project Guidelines provide conservation measures to minimize impacts of land use and development projects on wildlife and wildlife habitats. These Project Guidelines were developed cooperatively between Mark Watson, Department Terrestrial Habitat Specialist, and Dr. Zander Evans, Executive Director of Forest Stewards Guild, and his Santa Fe office staff.

ERT for NM

The Environmental Review Tool (ERT) for New Mexico is a web-based system that quickly screens land use and development projects for potential impacts to wildlife and wildlife habitats. The ERT provides best management practices and guidance to mitigate these impacts. Evaluate your project with the ERT at: https://nmert.org.

EEP SECTION

The Ecological and Environmental Planning Section's Technical Guidance Team coordinates the Department's environmental review process, and works with community, private sector, state and federal government, nongovernmental organizations, and other project proponents to protect and enhance wildlife habitats. The Section implements the Share with Wildlife program and maintains BISON-M, a database of New Mexico's wildlife species. It also participates in the development and application of wildlife-related information management and planning tools.

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PONDEROSA PINE RESTORATION GUIDELINES TO BENEFIT WILDLIFE

Unlogged old growth ponderosa pine, Valles Caldera National Monument. Photo: Mark Watson.

PONDEROSA FOREST HISTORY AND RESTORATION NEED

Historically, southwestern ponderosa pine (*Pinus ponderosa*) forests were open stands with many large and old, fire-resistant trees that experienced frequent, low-intensity fire, every 2 to 5 years on average (Covington and Moore 1994, Covington et al. 1997, Bailey and Covington 2002). These less dense, more open ponderosa pine forests defined the evolutionary environment that wildlife adapted to for thousands of years (Dahms and Geils 1997, Hunter 1999, Kalies et al. 2011). Since the late 19th century, the density and structure of southwestern ponderosa pine forests have been significantly altered by the combined effects of livestock overgrazing, commercial logging, fire suppression, and climatic events, all of which favored dense conifer regeneration (Covington and Moore 1994, Covington et al. 1997, Dahms and Geils 1997). For many species of wildlife, the habitat value of ponderosa pine forests declined as forests became dominated by small trees and as large trees, forest openings, and snags were reduced (Dahms and Geils 1997, Reynolds et al. 2013). Dense stands block sunlight from reaching the forest floor, reducing understory plant diversity and abundance and food sources for wildlife (Moore et al. 2006, Bakker et al. 2010).

Twentieth century fire suppression tactics that prevented the spread of almost all fires further densified ponderosa pine forests with smaller trees that create ladder fuels, carrying fire from the forest floor into the canopy (Smith et al. 2000, Allen et al. 2002, Covington 2003). Wildfires in southwestern U.S. forests now burn with uncharacteristically high severity, frequency, and extent (Westerling et al. 2006, Allen et al. 2010, Crockett and Westerling 2017, Lydersen et al. 2017, Prichard et al. 2017, Singleton et al. 2018, Parks and Abatzoglou 2020). High severity wildfires kill wildlife and destroy wildlife habitat and can result in habitat conversion from forest to shrub or grassland habitats (vegetative type conversions) that may no longer provide the climatic conditions necessary to support forest regrowth (Guiterman et al. 2017, Parks and Abatzoglou 2020, Prichard et al. 2021, Guiterman et al. 2022) or provide seed sources for tree regeneration (Korb et al. 2019). However, restoration treatments can reduce wildfire severity, even under extreme weather conditions (Lydersen et al. 2017, Walker et al. 2018, Evans et al. 2019, Prichard et al. 2021), though studies that consider future climate conditions and landscape-level effects are needed (Jain et al. 2021, McKinney et al. 2022). Treatments that restore the composition, structure, and spatial patterns that wildlife evolved with historically can benefit most wildlife species that use these forests (Beier and Maschinski 2003, Kalies et al. 2010, Kalies and Kent 2016).

The restoration of these unnaturally dense forests is one of the most important land management issues in the western U.S. (Noss et al. 2006). There is wide recognition of the need to restore ponderosa pine forests and return fire as the key disturbance driver for ecosystem structure and function (Allen et al. 2002, Prichard et al. 2021). The New Mexico Forest Restoration Principles (Principles) presented by Bradley (2009) capture the points of agreement among agencies, conservation organizations, and industry about how most treatments should be implemented in ponderosa pine forests. The Department strongly recommends that all treatments in ponderosa pine forests follow the Principles (see pp. 2-3 below) that benefit wildlife, including and especially, the protection of large and old trees.

NEW MEXICO FOREST RESTORATION PRINCIPLES: KEY CONCEPTS BENEFITTING WILDLIFE*

Reduce the threat of unnatural crown fire. A key restoration priority must be reducing the risk of unnatural crown fires both within stands and across landscapes. Specific restoration strategies should vary based upon forest vegetation type, fire regime, local conditions (including slope and aspect), and local management objectives. Forests and woodlands characterized by infrequent and mixed-severity fire should be managed toward a stand structure consistent with their historical ranges of variation. Discontinuous stand structure may be appropriate to meet community protection objectives in areas such as the wildland-urban interface (WUI) for these forest and woodland types.

Preserve old or large trees. Large and old trees, especially those established before ecosystem disruption by Euro-American settlement, are important forest components and critical to ecosystem function. Their size and structural complexity provide important wildlife habitat by contributing crown cover, influencing understory vegetation patterns, and providing future snags. Ecological restoration efforts should ensure the continuing presence of large and old trees, both at the stand and landscape levels. This includes preserving the largest and oldest trees from cutting and crown fires and focusing treatments on excess numbers of small young trees. Develop "desired" forest condition objectives that favor both an abundance of large-diameter trees and an appropriate distribution of age classes on the landscape, with retention of a high percentage of older trees. It is generally advisable to maintain ponderosa pines larger than 16 in (41 cm) diameter at breast height (dbh) and other trees with old-growth morphology regardless of size (e.g. yellow-barked ponderosa pine or any species with large drooping limbs, twisted trunks, or flattened tops).

Utilize existing forest structure. Restoration efforts should incorporate and build upon valuable existing forest structures such as large trees and groups of trees of any size with interlocking crowns (excluding aspen). These features are important for some wildlife species, such as Abert's squirrels (*Sciurus aberti*) and northern goshawks (*Accipiter gentilis*). Maximizing use of existing forest structure can restore historical conditions more quickly. Leaving some relatively dense, within-stand patches of trees need not compromise efforts to reduce landscape-scale crown fire risk. The underlying successional processes of natural tree regeneration and mortality should be incorporated into restoration design. Southwestern conifer regeneration occurs in episodic, often region-wide pulses, linked to wet and warm climate conditions and reduced fire occurrence. Periods with major regeneration pulses in the Southwest occurred in the 1910s to 1920 and from 1978 to 1998. Some of this regeneration would be expected to survive under natural conditions. Restoration efforts should retain a proportion of these cohorts.

Restore ecosystem composition. A robust vegetative understory restrains tree regeneration and is essential for carrying lower intensity, surface fires. Soil organisms, such as mycorrhizal fungi, are vital elements that can influence community composition and dynamics. The establishment and maintenance of natural patterns of understory vegetation diversity and abundance are integral to ecological restoration. Restoration planning should include the conservation of habitats for declining or extirpated wildlife species. Comprehensive forest ecosystem restoration requires balancing fire risk reduction with retention of forest structures necessary for canopy-dependent species. Recovery and conservation plans for threatened, endangered, and sensitive species should be incorporated to the fullest extent possible in planning for comprehensive forest restoration. Treatments should also focus on achievement of spatial forest [structural] diversity by managing for variable densities. Overall, forest densities should be managed to maintain tree vigor and stand resiliency to natural disturbances. Disease conditions are managed to retain some presence of native forest pathogens on the landscape but constrained so that forest sustainability is not jeopardized. Treatment plans must provide opportunities to apply differing, site-specific management strategies to achieve best outcomes and recognize that multiple treatments may be needed.

Restore historic tree species composition where appropriate. Forest density levels and the presence of fire in the ecosystem are key regulators of tree species composition. Where fire suppression has allowed fire-sensitive trees like junipers or shade-tolerant white fir or spruce to become abundant in historical ponderosa pine forests, treatments should restore dominance of more fire-resistant ponderosa pines. However, fire-intolerant species sometimes make up the only remaining large tree component in a stand. Retention of these large trees is important to canopy-dependent wildlife species.

Left: Overly dense ponderosa pine stand near Banco Bonito, Valles Caldera National Preserve. Right: High severity burn in dense ponderosa pine stand, Lake Fork Fire, Jemez Mountains. Photos: Mark Watson

*Principles on pages 2 and 3 derived from Bradley (2009); substantive modifications noted with []'s.

Implement regional heterogeneity. Biological communities vary at local, landscape, and regional scales, and so should restoration efforts. Ecological restoration should also incorporate the natural variability of disturbance regimes across heterogeneous landscapes. Heterogeneity should be fostered in planning and implementing ecological restoration at all spatial scales, including within and between stands and across landscape and regional scales.

Protect sensitive biological communities. Certain ecological communities embedded within ponderosa pine or other types of forests and some riparian areas could be adversely affected by on-site prescribed burning or mechanical thinning. Restoration efforts should protect these and other rare or sensitive habitats, which are often hotspots of biological diversity, particularly those that are declining in abundance or quality in the region.

Integrate process and structure. Ecological sustainability requires the restoration of process as well as structure. Natural disturbances, including fire, insect outbreaks, and droughts, are irreplaceable shapers of forests [e.g., Baker et al. 2023]. Fire regimes and stand structures interact and must be restored in an integrated way; mechanical thinning alone will not reestablish necessary, natural disturbance regimes. Similarly, fire alone may be too imprecise or unsafe in a particular location, so a combination of treatments may constitute the safest and most certain restoration approach. The single best indicator of whether a proposed approach should be considered as "ecological restoration" is to evaluate if the treatment would help successfully restore the fire regime that is natural for that forest type. Approaches that do not restore natural fire regimes will not achieve full ecological restoration.

Prioritize and strategically target treatment areas. Key considerations for prioritizing restoration treatment areas include: degree of unnatural crown fire risk; proximity to human developments and important watersheds; protection of old-growth forests and habitats of species federally-listed as threatened, endangered, or sensitive; and strategic positioning to break up landscape-scale continuity of hazardous fuels. Treatments should be done at a landscape scale to decrease forest vulnerability to unnatural stand-replacing fire. This priority setting should take place during fire management, land management, and community wildfire protection planning.

Use low-impact techniques. Restoration treatments should strive to use the least disruptive techniques and balance intensity and extensiveness of treatments. In many areas, conservative initial treatments would be the minimum necessary to adequately reduce the threat of unnatural crown fire. Wildland fire use or management of ignited fires may be sufficient to reestablish natural conditions in many locations. In the extensive areas where fire alone cannot safely reduce tree densities and hazardous ladder fuels, mechanical thinning of trees may be needed before the introduction of prescribed fire. Patient, effective treatments will typically provide more options for the future than aggressive attempts to undo 120 years of change at once. However, some WUIs may require application of rapid, heavy thinning of mostly small-diameter trees to mitigate the imminent threat of crown fire.

Develop site-specific reference conditions. Site-specific, historical ecological data can provide information on the natural range of variability for key forest attributes, such as tree age structure and fire regimes that furnish local "reference conditions" for restoration design. When historical data are not available for a planned treatment area, the focus should be on restoring ecological integrity and function.

Manage livestock grazing. Grass, forb, and shrub understories are essential to plant and animal diversity and soil stability. Robust understories are also necessary to restore natural fire regimes and to limit excessive tree seedling establishment. Where possible, defer livestock grazing after treatment until the herbaceous layer has established its current potential structure, composition, and function.

[Furthermore, the Department strongly encourages avoiding significant adverse effects to federal and state threatened and endangered species, U.S. Forest Service species of conservation concern, and Species of Greatest Conservation Need (NMDGF 2016) by leaving some stands within the broader project area untreated to serve as habitat refugia during periods of significant disturbance from treatments (i.e., use of masticators, chainsaws, heavy equipment), until treatment area conditions provide suitable habitat (Allen et al. 2002).]

Left: Treated and Right: untreated stands of ponderosa pine, Collaborative Forest Restoration Program project area near Las Conchas Campground, Jemez Mountains. Ladder fuels in the untreated stand may carry ground fire into the canopy. Photos: Mark Watson

PONDEROSA PINE FOREST RESTORATION GUIDELINES TO BENEFIT WILDLIFE

More than a century of research in western North American, dry forests documents a persistent and substantial fire deficit and resulting widespread alterations to ecological structure and function (Hagmann et al. 2021). Ponderosa pine forest restoration treatments should be designed to adapt fire-excluded forests to a changing climate by fostering ecosystem resilience and conserving native biodiversity (Prichard et al. 2021). Managing forests to re-establish pre-settlement fire regime conditions (i.e., high frequency, low severity) restores the environment to be within the natural range of variability that ponderosa pine forest wildlife evolved with (Moore et al. 1999, Kalies et al. 2010), enhancing the capacity of wildlife to adapt to stressors such as fire, insects, disease, and climatic variability and change (Reynolds et al. 2013). Restoration efforts can also enhance ecosystem function by increasing decomposition rates and nutrient cycling, water availability, carbon storage, and plant biodiversity in the understory (Allen et al. 2002, Finkral and Evans 2008, Boerner et al. 2009, Kalies and Rosenstock 2013).

Forest elements that affect wildlife use include individual tree sizes and age classes, overstory structure (vertical layering [i.e., single or multiple canopy layers] and total canopy cover within a stand), stand size and shape (i.e., horizontal patchiness or clumpiness), snags, coarse woody debris such as downed logs, and presence of other key vegetation such as Gambel oak (*Quercus gambelii*; Moir et al. 1997, Block and Finch 1997). Overstory structure influences understory plant diversity and abundance, which significantly influences wildlife species diversity and abundance. Dense stands block sunlight from reaching the forest floor, reducing understory plant diversity and abundance and food sources for wildlife. Reducing canopy cover in some patches increases sunlight reaching the forest floor, which increases understory plant and wildlife diversity and abundance (Dahms and Geils 1997, Bogan et al. 1998, Bakker et al. 2010, Abella and Springer 2014).

There is no standardized prescription for forest restoration and climate adaptation, as local site conditions and history are important considerations (Prichard et al 2021). Additionally, implementing the same prescription everywhere would not be optimal for wildlife; incorporating treatment heterogeneity is crucial (Allen et al. 2002). At the landscape scale, a diversity of forest structure and age classes, including forest openings and areas with dense cover (i.e., “clumpiness”), supports more species than does a homogeneous landscape (Horncastle et al. 2013, Evans et al. 2019). To maximize benefits for native wildlife species, ponderosa pine forest restoration treatments should focus on removing small-diameter trees, creating a clumpy or mosaic pattern of uneven age, multi-canopy layer, leave-tree groups that includes the largest and oldest remaining trees, snags. and downed logs. Tree groupings and interspaces between tree groups should have irregular borders. Stand-level prescriptions should maintain or create important wildlife habitat elements such as snags, coarse woody debris, mistletoe-infected trees, and large, old trees. Treatments should be designed to create composition and structure for key species such as northern goshawk and Abert’s squirrel by maintaining interlocking crowns among groups of trees within the treatment area (Lehmkuhl et al. 2007; see Abert’s squirrel recommendations p. 10).

Old growth ponderosa pine forest with robust herbaceous understory, Gila Wilderness. Gila and Aldo Leopold Wilderness managers have allowed wildfire to play a more natural role in maintaining a high frequency, low intensity fire regime, which shapes more open stand forest structure. Photo: Mark Watson

PONDEROSA PINE FOREST RESTORATION GUIDELINES TO BENEFIT WILDLIFE

Ponderosa pine treatments (e.g., restoration, fuels reduction, WUI protection) alter the availability of food and cover for wildlife. As a result, some species are benefited, while others are adversely affected (Ffolliott 1997, Lehmkuhl et al. 2007). Factors that affect wildlife responses to treatments include the scale at which treatments are applied, the mobility of an organism, animal home range size and degree of habitat specialization (Chambers and Germaine 2003), and the ability of dislocated populations to recolonize a site after treatment. Treatments may have negative, short-term effects on wildlife species that do not tolerate disturbance well or that depend on removed trees for nesting or foraging (Chambers and Germaine 2003, Kalies et al. 2010). Over the long term, treatments should create forest stands with reduced tree densities and a more open but patchy, mosaic structure of mostly mature trees with robust herbaceous ground cover maintained by frequent, low intensity fires. The increased spatial heterogeneity will diversify vegetative structures available for use by wildlife, allowing for the restoration of a diverse assemblage of native wildlife species (Kalies et al. 2010).

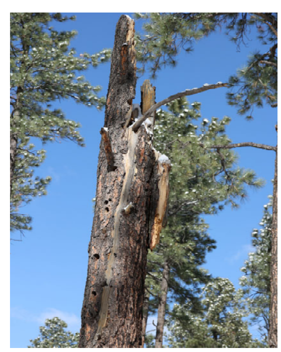
To maximize wildlife diversity and abundance, large-diameter trees, snags, and downed logs are very important habitat elements to conserve during treatments. Treatments that emphasize the retention of large-diameter trees and snags, coarse woody debris, and untreated stands in a mosaic pattern increase habitat heterogeneity and complexity and will benefit the greatest number of species over time (Allen et al. 2002, Pilliod et al. 2006). At a minimum, treatment areas should retain at least 2, large-diameter snags and downed logs per acre, all of which should be the largest diameter possible. In some cases, it may be necessary to increase the number of snags and downed logs to better benefit wildlife (Chambers et al. 2005, Marcot et al. 2010). Before prescribed burns, heavy fuels should be manually removed from around the base of large and old trees and snags to reduce mortality of these important habitat components (Horton and Mannan 1988, Covington and Moore 1994, Bagne et al. 2008, ERI 2011).

Although the New Mexico Forest Restoration Principles in Bradley (2009) suggest retaining trees 16 in (40.6 cm) dbh or greater, Kalies and Rosenstock (2013) recommend retaining trees 18 in (45.7 cm) dbh or greater to benefit nesting migratory songbirds. They found that the commonly-proposed diameter minimum of retaining trees 16 in dbh or greater was unlikely to benefit nesting songbirds, as resulting tree densities would remain too large. However, if larger diameter trees are rare or unavailable in the treatment area, some 16 in dbh trees should be retained to facilitate future old growth conditions. Retain older pinyon and juniper trees in ecotones for habitat complexity and to provide wildlife food resources.

After reducing ladder fuels and creating clumpiness, returning fire as a regular source of natural disturbance is key to successfully restoring ponderosa pine forests (Prichard et al. 2017, 2021). There exists widespread agreement in the scientific literature that the combined effects of thinning and prescribed burning consistently reduce the potential for severe wildfire across a broad range of forest types and conditions (Fule et al. 2012, Kalies and Yocum-Kent 2016, Prichard et al. 2021). Across seasonally dry forests, such as ponderosa pine, treatments that involve follow-up prescribed fire or effectively-managed wildfires generally mitigate the spread and severity of subsequent wildfires for 5 to 20 years, depending on treatment intensity, site productivity, vegetation, and climate (Korb et al. 2020). Mechanical fuel reduction treatments that are not followed by fire are generally not as effective at restoring fire-adapted ecosystems (Prichard et al. 2021).

Management of surface fuels created by the thinning process is necessary to increase the likelihood that the treated stand will survive a wildfire (Agee and Skinner 2005). Broadcast or pile burning after thinning is needed to eliminate fuels generated by a forest treatment (Evans et al. 2019). Managers should be aware of the potential for wildlife to populate piles of woody vegetation and conduct fires in winter or when some species may be belowground. In a meta-analysis of the effects of fuel reduction treatment effects on fire severity, Martinson and Omi (2013) found that treatments that include surface fuel reduction, particularly by prescribed burning, reduce the potential for high severity fire in both long-needle pine and mixed-conifer forests. These treatments remain effective at reducing high severity fire for up to 10 years. If fuels generated by a treatment are not disposed of, they largely offset the hazard reduction benefit from opening the canopy (Martinson and Omi 2013). Where crown fire hazard is high due to heavy fuel loads and hazardous ladder fuels, mechanical thinning will be necessary before fire can be safely reintroduced (Allen et al. 2002, Martinson and Omi 2013). Restored ponderosa pine stands will require continued maintenance to meet resilience and adaptation goals (Agee and Skinner 2005, Prichard et al. 2021).





Left: Red-breasted nuthatch (*Sitta canadensis*) forages on a ponderosa pine. Middle: Large decaying log provides habitat for rodents and invertebrates. Right: Large ponderosa pine snag with broken top provides important habitat for cavity nesting birds and tree-roosting bats. Photos: Mark Watson

IMPORTANCE OF PONDEROSA PINE FORESTS TO WILDLIFE

Ponderosa pine is a major forest type in the southwestern U.S., covering over 3 million hectares (Block and Finch 1997). Southwestern ponderosa pine forests support a high diversity of bird, mammal, reptile, and amphibian species (Chambers and Germaine 2003). A search of the Biota Information System of New Mexico (BISON-M; accessed 29 September 2022) indicates almost 300 vertebrate taxa in New Mexico use ponderosa pine forests during some stage of their life history. These species include approximately 200 bird, 77 mammal, 10 reptile, and 6 amphibian species.

Ponderosa pine forests support mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) as the primary grazers (Dahms and Geils 1997). In the southwestern U.S., they provide roosting and foraging habitat for at least 16 species of bats (Bernardos et al. 2004, Johnson and Chambers 2017). Block and Finch (1997) identify more than 150 species of songbirds that use ponderosa pine forests in New Mexico. Some species, like Grace's warbler (*Setophaga graciae*), Virginia's warbler (*Leiothlypis virginiae*), olive warbler (*Peucedramus taeniatus*), and pygmy nuthatch (*Sitta pygmaea*), are considered pine or pine/oak forest obligates. Ffolliott (1983) found that at least 49 bird and 10 mammal species, and numerous species of herpetofauna and insects used tree cavities in southwestern ponderosa pine forests.

Within ponderosa pine forests, snags and downed logs are very important habitat components for many species of wildlife. They provide nesting, roosting, feeding, loafing, and storage sites for over 75 species of birds, mammals, reptiles, and amphibians, as well as numerous invertebrate species (Chambers 1999, Chambers and Germain 2003, Chambers and Mast 2005; see Table 1). Large snags, either burned or unburned, are important habitat for cavity-nesting birds and bats (Rabe et al. 1998, Pilliod et al. 2006). In northern Arizona, Rabe et al. (1998) documented 8 bat species using ponderosa pine snags as maternity roosts. In New Mexico and Arizona, Scott (1978) documented the frequent use of cavities in dead or partially dead ponderosa pine trees by American kestrel (*Falco sparverius*), elegant trogan (*Trogon elegans*), 7 species of owls, 11 species of woodpeckers, 2 flycatchers, 3 swallows, 5 chickadees and titmice, 3 nuthatches, the brown creeper (*Certhia americana*), 4 wrens, and 3 bluebirds. Snags and coarse woody debris, such as stumps and downed logs, create cover for small mammals, including mice and voles, which are important prey species for raptors such as Mexican spotted owls (*Strix occidentalis lucida*; USFWS 1995) and mammalian carnivores. Black bears (*Ursus americanus*) and other mammalian carnivores use large logs and snags as dens (Rudis and Tansey 1995, Pilliod et al. 2006), so removing these components can reduce their population (Cunningham et al. 2003).

Decaying live trees and trees with mistletoe brooms are also important habitat components for many species of wildlife. Decaying trees have a higher probability of surviving fire than snags, are important to cavity nesters such as woodpeckers, and are used by other mammal and bird species as resting, nesting, or foraging sites (Chambers and Germain 2003). Some wildlife species use mistletoe as a food source (Block and Finch 1997). Mistletoe causes witch's brooms, which are important nesting substrate for many species of birds, and mistletoe broom trees are used by Abert's squirrels as cache sites (Garnett et al. 2006). Dwarf mistletoe (*Arceuthobium* spp.) is a native, natural source of disturbance in ponderosa pine forests. Dwarf mistletoe infections of individual ponderosa pine trees should be viewed as presence of a native ecological disturbance organism that changes the structure and function of some ponderosa pine trees, positively influencing wildlife use (Bennetts et al. 1996).


Left: Black bear (*Ursus americanus*), Burro Mountains, and Right: Western tanager (*Piranga ludoviciana*) male, Jemez Mountains. Photos: Mark Watson

IMPORTANCE OF GAMBEL OAK WITHIN PONDEROSA PINE FORESTS TO WILDLIFE

In the southwestern U.S., Gambel oak occurs within ponderosa pine forests in multiple, age-related growth forms, from small shrubs to large-diameter, old trees (Rosenstock 1998). Where Gambel oak is present within ponderosa pine stands, it dramatically changes the structure of the stand (Rosenstock 1998). In some pine-oak stands, Gambel oak may comprise up to 30% of total tree basal area (Reynolds et al. 1970). In New Mexico, Gambel oak is a very important wildlife habitat component of ponderosa pine forests, providing food, cover, and nesting structure for many species of wildlife (Patton 1995, Moir et al. 1997). All stages of Gambel oak, but especially large tree-form oaks, are important to wildlife (Kruse 1992). Gambel oak trunks, brush, and sprouts provide thermal and hiding cover for deer, elk, rabbits, rodents, and birds (Moir et al. 1997) and important fawning cover for deer (Kruse 1992). Although Gambel oak often represents less than 25 percent of the canopy cover in ponderosa pine-oak stands, it is important to many vertebrate species, including a large number of threatened, endangered, and sensitive species, and its presence is associated with increased bird and bat abundance and diversity (Clary and Tiedemann 1992, Rosenstock 1998, Bernardos 2001, Ffolliott 2002, Chambers and Germaine 2003). Older Gambel oak trees provide valuable alternative cavity nesting sites when ponderosa pine snags are limiting (Rosenstock 1996).

Gambel oak acorn crops may influence the number of species within ponderosa pine forests with a Gambel oak component. Species such as elk, mule deer, whitetail deer (*Odocoileus virginianus*), black bear, javelina (*Peccari tajacu*), Abert's squirrel, wild turkey (*Meleagris gallopavo*), blue grouse (*Dendragapus obscurus*), acorn woodpecker (*Melanerpes formicivorus*), band-tailed pigeon (*Columa fasciata*), Montezuma quail (*Cyrtonyx montezumae*), and many songbirds rely on Gambel oak for part of their diet (Reynolds et al. 1970, Clary and Tiedemann 1992, McShea and Healy 2002, Chambers and Germain 2003). Both mule and whitetail deer feed on Gambel oak leaves and acorns (Reynolds et al. 1970). Clonal oak and mature trees produce acorns that feed 21 species of mammals and 20 species of birds such as corvids and woodpeckers (Patton 1995). Acorns are the preferred food of Abert's squirrels, band-tailed pigeons, turkeys, deer, elk, and acorn woodpeckers. Merriam's turkeys (*Meleagris gallopavo merriami*) feed extensively on Gambel oak acorns, and acorns are an important food source for band-tailed pigeons during fall and winter months (Reynolds et al. 1970).

In north-central Arizona, Gambel oaks with diameters of 12 to 14 in (30-36 cm) were the most reliable acorn producers (Clary and Tiedemann 1992). As the trees age and become less vigorous, acorn production drops, but hollow boles and limbs offer cavities sheltering owls, woodpeckers, other passerine birds, bats, squirrels, and racoons (Moir et al. 1997).

In New Mexico and Arizona, ponderosa pine forests with Gambel oak have been documented to support higher bird diversity and abundance than ponderosa pine forests without Gambel oak (Rosenstock 1998, Jentsch et al. 2008). In Arizona, Rosenstock (1998) found 10 migratory bird species that were largely restricted to, or only found in, Gambel oak/ponderosa pine stands, whereas only 5 species were unique to pure ponderosa pine stands. Bird species diversity was significantly higher in pine-oak stands, which provide habitat for more species of Neotropical migrants, ground nesters, primary cavity excavators, and secondary cavity users than pure pine stands. Some migratory songbirds in New Mexico that use Gambel oak include pinyon jay (*Gymnorhinus cyanocephalus*), Woodhouse's scrub jay (*Aphelocoma woodhouseii*), Stellar's jay (*Cyanocitta stelleri*), green-tailed towhee (*Pipilo chlorurus*), spotted towhee (*Pipilo maculatus*), dusky flycatcher (*Empidonax oberholseri*), blue-gray gnatcatcher (*Polioptila caerulea*), black-headed grosbeak (*Pheucticus melanocephalus*), and pygmy nuthatch.

Left: Warbling vireo (*Vireo gilvus*) and Right: orange-crowned warbler (*Leiothlypis celata*) forage in Gambel oak trees, Tusas Mountains. Photos: Mark Watson

MANAGEMENT RECOMMENDATIONS FOR GAMBEL OAK WITHIN PONDEROSA PINE FORESTS TO BENEFIT WILDLIFE

Game and non-game birds have been shown to benefit from increased densities of Gambel oak in the 12 to 14 in (30-36 cm) diameter class (Reynolds et al. 1970), and non-game Species of Greatest Conservation Need (NMDGF 2016) bird populations have been shown to benefit from increased densities of Gambel oak poles in the 3 to 6 in (8-15 cm) diameter range (Jentsch et al. 2008). Virginia's warblers, a New Mexico Avian Conservation Partners level 1 species of conservation concern in New Mexico due to a rapidly declining population, have shown preference for young, brushy thickets of Gambel oak for foraging and nesting habitat (Lesh 1999). Many other wildlife species, such as deer and elk, also rely on Gambel oak for food and cover. Therefore, the Department recommends leaving Gambel oak and other native shrubs untreated, unless removal is necessary in the WUI. If Gambel oak needs to be removed, we recommend the following specific guidelines:

Retain a mosaic of all sizes and age classes of Gambel oak across treated areas. Maximize retention of tree-form Gambel oak in the 12 to 14 in (30-36 cm) diameter range to maximize acorn production for game and non-game species (Clary and Tiedemann 1992) and larger diameter Gambel oak to provide nesting and roosting habitat for turkey and other bird species. Maximize retention of patches of pole-sized Gambel oak in the 3 to 6 in (8-15 cm) diameter range to increase migratory bird diversity (Jentsch et al. 2008).

Mexican spotted owl (*Strix occidentalis lucida*) fledglings perched on Gambel oak tree, Gila National Forest. Photo: Ron Kellermueller

Abert's Squirrel

Some species of small mammals, such as Abert's squirrels, prefer high canopy closure and denser, untreated patches of ponderosa pine forests. To avoid adverse effects to Abert's squirrels that may cause population declines, restoration treatments should include clumps/groups of larger, older, uneven age trees with interlocking canopies (Dodd et al. 2003, Loberger et al. 2011, Yarborough et al. 2015).

Abert's squirrels are highly dependent on ponderosa pine trees, living and nesting in them and feeding on ponderosa pine seeds, flowers, needles, and the inner bark of terminal buds (Hoffmeister 1986) and plants and fungi closely associated with this species (Yarborough et al. 2015). Abert's squirrels typically build both winter and non-winter nests in the upper branches of large (15 to 23 in [37.5-57.5 cm] dbh) ponderosa pines (Halloran and Bekoff 1994, Snyder and Linhart 1994, Loberger et al. 2011). Abert's squirrels play a key role in facilitating symbiotic interactions of ponderosa pine and mycorrhizal fungi through the consumption of fruiting bodies and dispersal of spores (States and Gaud 1997, States and Wettstein 1998, Dodd et al. 2003). Abert's squirrels are an important prey species for the northern goshawk (Reynolds et al. 1992).

Research has documented that ponderosa pine stands with higher basal area and canopy cover support higher densities of Abert's squirrels (Trowbridge and Lawson 1942, Patton et al. 1985, Dodd et al. 2006, Loberger et al. 2011). In ponderosa pine forests of north-central Arizona, Abert's squirrels selected areas with higher canopy cover, and squirrel recruitment was strongly related to the local number of interlocking crowns of trees (Dodd 2003). Patton (1975) reported that 92% of squirrel nests were found in trees growing inside a group of pine trees, with 75% of nest trees having 3 or more interlocking canopy trees in the group of pines. Loberger et al. (2011) found that although Abert's squirrels preferentially selected untreated patches of ponderosa pine forest in summer and winter seasons, this pattern was strongest during winter when squirrels selected untreated forest patches as core use areas. Previous studies have suggested that winter survival is the limiting factor for Abert's squirrel populations (Loberger et al. 2011). Although squirrels depend upon ponderosa pines throughout the year, habitat quality is especially critical in winter when their primary food source is the inner bark of terminal twigs of chemically-unique ponderosa pine "feed trees" (Keith 1965, Hall 1981). Although not visually distinct to humans, feed trees differ in mineral and terpene concentrations from trees not selected for food (Farentinos et al. 1981, Zhang and States 1991, Snyder 1992). Abert's squirrels consistently use these chemically-unique pine trees from year to year as winter food sources (Keith 1965, Hall 1981). Feed trees are typically found in clumps that are distributed throughout a forest patch (States et al. 1988, Linhart 1989, Loberger et al. 2011).

Loberger et al. (2011) hypothesized that groups of trees with interlocking canopies and higher canopy cover and crown bulk density provide nest locations with structural and thermal conditions necessary to moderate temperatures during the critical winter survival period. In winter, heavy snowfall may impede ground movements, so interlocking canopies may become more important as pathways for squirrels to access feed trees and as escape routes from predators (Stephenson and Brown 1980).

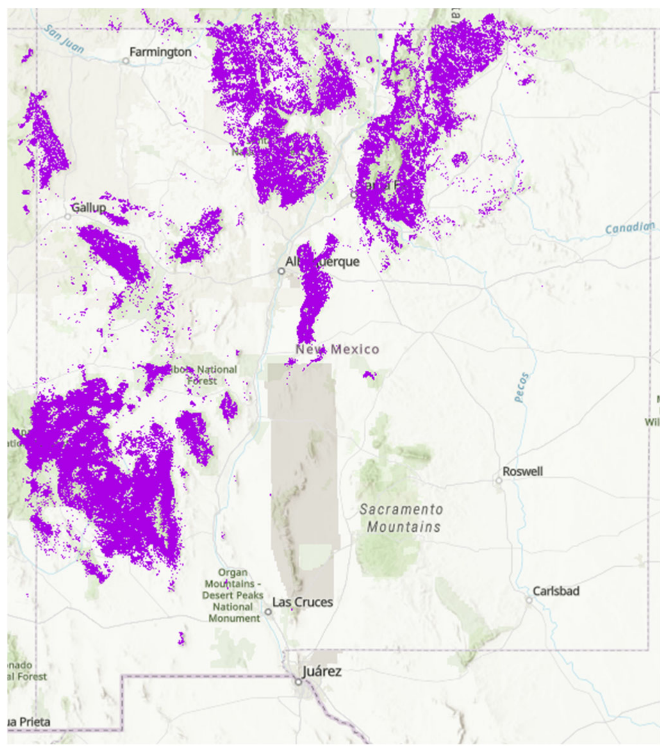
Although some studies have documented that forest restoration activities result in a decline in Abert's squirrel abundance, more recent research results suggest that restoration treatments that provide smaller winter core areas made up of groups of older, larger diameter trees with interlocking crowns (i.e., high basal area and canopy cover) can provide winter habitat while still reducing the risk of stand-replacing wildfire (Yarborough et al. 2015).

Abert's squirrels (*Sciurus aberti*), Sandia Mountains. Photos: Mark Watson (left) and James N. Stuart (right).

MANAGEMENT RECOMMENDATIONS

The preference of Abert's squirrel for denser patches/groups of older ponderosa pine trees with interlocking crowns demonstrates the need for heterogeneity within restoration treatments (Loberger et al. 2011). Retaining groups of older, larger trees with interlocking canopies will benefit Abert's squirrel populations (Dodd et al. 2003, Lobeger et al. 2011) and many other species of wildlife (e.g., northern goshawk). Therefore, the Department recommends that all ponderosa pine restoration treatments within forests occupied by Abert's squirrels incorporate the following, research-based prescriptions:

- Winter core area forest patches for Abert's squirrels should have canopy closure ranging from 55% to 72% to maximize squirrel density and recruitment (Yarborough et al. 2015).
- Winter core area forest patches should have basal areas of greater than 35 square meters per hectare and tree densities of greater than 20 trees per hectare of vegetation structural stage Class 5 diameter trees, with a minimum of 22 patches per hectare with 5 or more trees per group with interlocking canopies (Dodd et al. 2003).
- Ladder fuels and coarse woody debris around the perimeter of and within clumps should be cut and piled or scattered outside of the clumps to reduce the potential for torching of interlocking tree canopies.



Left: Northern goshawk (*Accipiter gentilis*) juvenile, Curry County. Photo: Deb Whitecotton. Right: Abert's squirrel (*Sciurus aberti*) range map; distribution of potential suitable habitat shown in purple (BISON-M 2024).

PONDEROSA PINE TREATMENT GUIDELINES TO BENEFIT BATS

Ponderosa pine forests in the Southwest support at least 16 species of bats (Johnson and Chambers 2017). Pilliod et al. (2006) found that little information is available on the direct effects of fuel reduction treatments on bats, although some inferences can be made based on known bat habitat associations. Some tree-roosting bat species select ponderosa pine stands with abundant prey and tall, large-diameter trees and snags or cavities in Gambel oak trees as primary roost sites (Rabe et al. 1998, Bernardos 2001, Pilliod et al. 2006). Long-legged myotis (*Myotis volans*), silver-haired bats (*Lasionycteris noctivagans*), and other tree-roosting bat species are known to preferentially roost under the bark of large-diameter snags with exfoliating bark, which provides insulation necessary to support maternity colonies (Rabe et al. 1998, Chambers et al. 2002, Johnson and Chambers 2017). Wildfire and prescribed fire are known to destroy snags preferentially used by bats for roosting (Horton and Mannan 1988, Chambers et al. 2002, Chambers and Mast 2005, Bagne et al. 2008). Snags created by wildfire and prescribed fire are generally smaller in diameter and do not have exfoliating bark, thus, they are not effective replacements for the large snags preferred by bats for roosting (Rabe et al. 1998, Chambers et al. 2002, ERI 2011). If large-diameter snags and trees are protected during treatments, thinning or prescribed fire may have minimal or even positive effects on bat populations. However, loss of these habitat features is likely to be detrimental to forest bat species (Chambers et al. 2002, Johnson and Chambers 2017; see Table 1 for bats associated with snags).

The following restoration treatment guidelines to benefit bats were adapted from the Ecological Restoration Institute (2007):

- Leave as many tall, large-diameter snags as possible. In general, the larger the snag the better, although a variety of decay classes should be kept to accommodate different bat species. Protect all large-diameter snags with exfoliating bark by removing fine and medium fuels around the base.
- Optimum, minimum size for ponderosa pine roost snags is 26 in (66 cm) dbh and 70 ft (21 m) tall.
- For Gambel oak, snags should have internal cavities and be at least 10 in (25 cm) in diameter (Bernardos et al. 2004).
- Preserve clumps of large-diameter ponderosa pine snags or groups of large oaks.
- Snags along draws that lead to water or near bodies of water should be considered a high priority because bats tend to select roosts that are close to water features, which are excellent foraging habitat.
- Preserve water features including lakes, streams, wildlife drinkers, springs, livestock tanks, and ponds. Keep artificial water features full during drought periods and keep all water features clear of anything (e.g., fencing) that would impede clear flight paths for bats (Tuttle et al. 2006).
- Save any snags that have evidence of use by bats (e.g., bats seen exiting or returning to roost tree and guano).
- Where possible, replace snags and roost trees lost through prescribed fire or logging by installing artificial roosts.
- Spraying pesticides for moths or beetles can negatively affect the distribution of insects that serve as prey for bats (Hinman and Snow 2003). Whenever possible, seek and use alternatives to pesticides.
- Maintain forest edges and openings within stands as foraging habitats for insectivorous bat species.


Left: Long-legged myotis (*Myotis Volans*), and Right: Silver-haired (*Lasionycteris octivagans*) bats roost under loose, exfoliating bark and in cavities in large ponderosa pine trees and snags. Captured and held by James Stuart, Grant County. Photos: Mark Watson

Grace's warbler foraging in a ponderosa pine tree, Jemez Mountains. Photo: Mark Watson

Grace's Warbler (*Setophaga graciae*)

Written by Margaret (Peggy) Darr and Christopher Rustay, New Mexico Avian Conservation Partners (NMACP) steering committee members, and reviewed by the NMACP steering committee. Modified as needed to comport with the formatting of this Habitat Handbook.

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Summary of Concern and Status: Grace's warbler is a pine-specialist that primarily occurs in ponderosa pine forest in New Mexico. It is patchily distributed but may be locally common. Data from the U.S. Geological Survey (USGS) Breeding Bird Survey (BBS) show sharp declines in New Mexico and elsewhere, and this species is thought to be less common today than historically due to the loss and alteration of ponderosa pine forest habitat. Light forest thinning may benefit this species in the short term, but the current science strongly suggests moderate to heavy forest thinning has negative, short-term impacts on Grace's warbler populations. Long-term impacts from thinning, after remaining trees grow larger, are unknown.

Grace's warbler is an NMACP level 1 species of conservation concern in New Mexico due to a rapidly declining population, high threats, a relatively small population size and distribution, and a moderately high stewardship responsibility for New Mexico. Grace's warbler is also a national Partners in Flight Watch List species (Rosenberg et al. 2016), a U.S. Fish and Wildlife Service National Bird of Conservation Concern (USFWS 2008), and listed by the Department as a Species of Greatest Conservation Need (NMDGF 2016).

At the time of assessment, Grace's warbler received the maximum score of 5 for population trend (population loss of more than 2% per year; Sauer et al. 2017). In their Landbird Conservation Plan, Partners in Flight estimated a 52% total population loss for Grace's warbler from 1970 to 2014 (Rosenberg et al. 2016).

Threats: The primary threat to Grace's warbler in New Mexico is the loss or alteration of ponderosa pine forest habitat. New Mexico's ponderosa pine forests today differ from pre-European forests due to a history of poor land management practices, including removal of large trees; fire suppression; and overgrazing (Reynolds et al. 2013). Because of this, in many areas, forests are now composed of small ponderosa pine in densities much higher than were found historically. Additionally, these dense forests are now prone to unnatural, high-severity canopy fires, killing all, or nearly all, ponderosa pine (Reynolds et al. 2013). This combination of habitat change caused by historical land management practices, and current stand-replacing fires, is likely responsible for population declines, and will continue to threaten population stability in the future.

GRACE'S WARBLER CASE STUDY (continued)

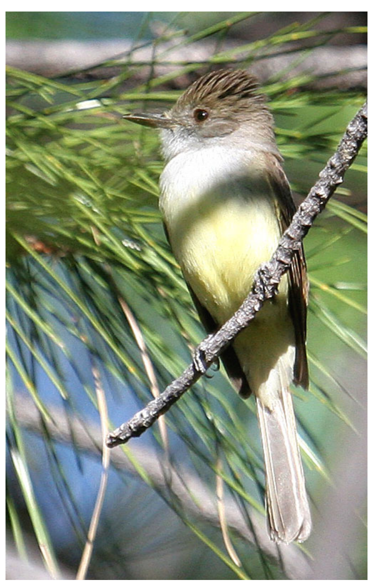
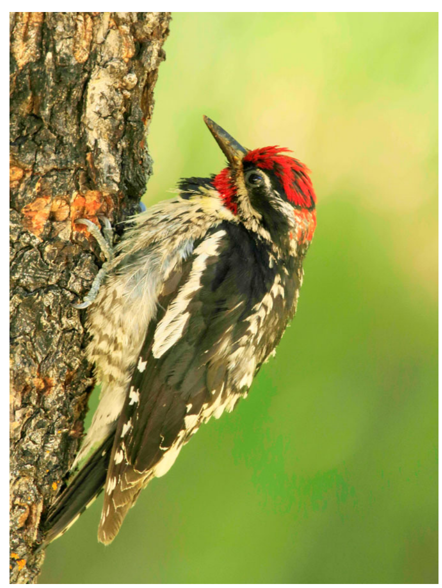
Threats (continued): Grace's warbler is also threatened by projected climate change effects, including increased severity and frequency of wildfires (Westerling et al. 2006), as well as tree mortality resulting from increasing drought, temperatures, and pest outbreaks (Westerling et al. 2006, Seager et al. 2007, Cayan et al. 2010, Williams et al. 2010). Additional potential threats include logging, fuelwood collection, overgrazing, development, and moderate to heavy tree thinning for fuels reduction and/or other management objectives (light thinning may benefit this species).

Ecology and Habitat Requirements: Grace's warbler is primarily a foliage gleaner, feeding on insects and other invertebrates. It mostly forages in the middle and upper portions of conifer canopies, on small branches and needles away from the trunk (Balda 1969, Szaro and Balda 1979, Stacier and Guzy 2002). This foraging ecology suggests canopy cover is important for Grace's warbler. Two studies support this assumption. Flesch (2014) found that Grace's warbler density increased with increasing conifer canopy cover, as well as with increasing densities of canopy trees. Kalies and Rosenstock (2013) documented a weak positive Grace's warbler occupancy response to increasing canopy cover; in this study, canopy cover ranged from 14.9% to 72.5%, with a median of 47.5%, and an average of 47.2%.

The Grace's warbler arrives in New Mexico in April and initiates nesting in May (Stacier and Guzy 2020). Based on studies from numerous locations across its breeding range, it maintains a large breeding territory ranging from 2 to 6.5 ha (approximately 5 to 16 ac), with size dependent upon habitat quality. Within these territories, nests are typically well hidden in the outer foliage of upper ponderosa pine branches ranging from approximately 26 to 59 ft (8 to 18 m) above the ground (Stacier and Guzy 2020).

While canopy cover appears to be important for the Grace's warbler, tree size also appears to be important. One study documented a strong, positive Grace's warbler occupancy response to large ponderosa pine with a dbh greater than approximately 18 in (45.7 cm; Kalies and Rosenstock 2013). This same study documented a weak, positive Grace's warbler occupancy response to medium-sized ponderosa pine with a dbh of approximately 16 to 18 in (40.6 to 45.7 cm; Kalies and Rosenstock 2013). Another study found Grace's warbler occurrence was negatively associated with small-diameter ponderosa pine with a dbh of approximately 1 to 3 in (2.5 to 8 cm; Jentsch et al. 2008). Finally, a literature review of silvicultural treatments in the Rocky Mountains (Hejl et al. 1995) suggests Grace's warbler is associated with old-growth forests (presumably composed primarily of large trees). In addition to trees with a larger dbh, tall trees also appear to be important. Balda (1969) found that Grace's warblers foraged extensively in ponderosa pines with heights between 39 ft (12 m) and 69 ft (21 m).

Treatment recommendations: To benefit Grace's warbler and other forest-dependent migratory bird species that research indicates decline as a result of treatments that significantly reduce overstory canopy cover, the Department recommends implementing treatments that leave some ponderosa pine stands or patches with overstory canopy cover levels of approximately 50%, which is at the higher end of the historic range of variability for ponderosa pine forests.

Left: Hepatic tanager (*Piranga flava*), Peloncillo Mountains; Middle: Dusky-capped flycatcher (*Myiarchus tuberculifer*), Black Range; and Right: Red-naped sapsucker (*Sphyrapicus nuchalis*), near Cochiti, utilize ponderosa pine forests for foraging and nesting. Photos: Mark Watson

ADAPTIVE MANAGEMENT

These guidelines reflect current knowledge about best practices to benefit wildlife when managing and restoring ponderosa pine forests. These guidelines and best practices are anticipated to evolve as new information becomes available about ponderosa pine forest ecosystems and the effects of current land management practices. For example, recent studies are considering the benefits of using nature-based solutions (i.e., letting natural disturbances be the primary driver of forest change and focusing active management activities on protecting the built environment and local communities) to facilitate forest adaptation to changing climatic conditions (Baker et al. 2023). There are also studies considering alternate approaches to getting rid of postharvest woody debris at treated sites (e.g., creating piles for wildlife habitat, using woody material for slope stabilization, etc.; Sullivan et al. 2021). Given the speed and wide-ranging impacts of climate change, it may be necessary to consider the potential for current and historical species composition to persist under changing climatic conditions and facilitate growth of species better able to survive under projected hotter, drier conditions that also provide habitat value for wildlife. Such considerations are consistent with management frameworks that intentionally consider approaches for accepting or directing ecosystem change alongside efforts to resist it (e.g., Resist-Accept-Direct [RAD] framework; Lynch et al. 2021). It is also important to consider full ecosystem health, including soil health, when conducting forest restoration activities (e.g., see effects of fire on soil fungal species richness and colonization post-fire in Dove and Hart 2017). Mycorrhizal fungi may provide food for mammals and insects and enhance plant diversity, growth, resilience to stressors, and canopy cover aboveground (Markovchick et al. 2023). The Department encourages monitoring the success of forest restoration activities, including evaluating outcomes for local wildlife populations and associated, important habitat components, and modifying future management activities as needed to enhance wildlife outcomes.

Use of current practices, San Miguel County: this ponderosa pine demonstration project, based on the Northern goshawk guidelines (Reynolds et al. 1992), survived the 2022 Hermit's Peak/Calf Canyon Fire, the largest wildfire in New Mexico history. Photo: Mark Watson

Considering future conditions, Jemez Mountains: area burned in Dome (1996), Cerro Grande (2000), and Las Conchas (2011) Fires, unlikely to return to ponderosa pine forest due to lack of seed source and warming climate. Photo: Mark Watson

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Table 1 Wildlife Species that Use Logs, Snags, or Both

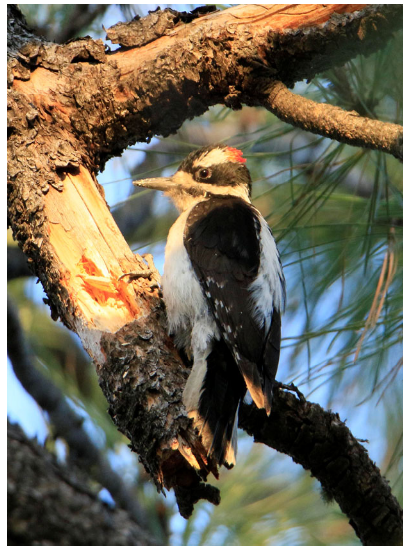
Common Name	Scientific Name	Snag, Log or Both User
Acorn woodpecker	*Melanerpes formicivorus*	Snag and log
American kestrel	*Falco sparverius*	Snag
American three-toed woodpecker	*Picoides dorsalis*	Snag
Bewick's wren	*Thryomanes bewickii*	Snag
Black-capped chickadee	*Poecile atricapillus*	Snag
Brown creeper	*Certhia americana*	Snag
Brown-crested flycatcher	*Myiarchus tyrannulus*	Snag
Cordilleran flycatcher	*Empidonax occidentalis*	Snag
Downy woodpecker	*Dryobates pubescens*	Snag
Dusky-capped flycatcher	*Myiarchus tuberculifer*	Snag
Elf owl	*Micrathene whitneyi*	Snag
Flammulated owl	*Psiloscops flammeolus*	Snag
Great horned owl	*Bubo virginianus*	Snag and log
Hairy woodpecker	*Dryobates villosus*	Snag and log
House wren	*Troglodytes aedon*	Snag
Lewis's woodpecker	*Melanerpes lewis*	Snag
Mexican chickadee	*Poecile sclateri*	Snag
Mexican spotted owl	*Strix occidentalis lucida*	Snag and log
Mountain bluebird	*Sialia currucoides*	Snag
Mountain chickadee	*Poecile gambeli*	Snag
Northern flicker	*Colaptes auratus*	Snag and log
Northern pygmy owl	*Glaucidium gnoma*	Snag
Northern saw-whet owl	*Aegolius acadicus*	Snag
Osprey	*Pandion haliaetus*	Snag
Purple martin	*Progne subis*	Snag
Pygmy nuthatch	*Sitta pygmaea*	Snag
Red-breasted nuthatch	*Sitta canadensis*	Snag
Red-faced warbler	*Cardellina rubrifrons*	Snag
Townsend's solitaire	*Myadestes townsendi*	Snag
Tree swallow	*Tachycineta bicolor*	Snag
Turkey vulture	*Cathartes aura*	Snag and log
Violet-green swallow	*Tachycineta thalassina*	Snag
Virginia's warbler	*Leiothlypis virginiae*	Log
Western bluebird	*Sialia mexicana*	Snag
Western screech-owl	*Megascops kennicottii*	Snag
White-breasted nuthatch	*Sitta carolinensis*	Snag

Table 1 Wildlife Species that Use Logs, Snags, or Both, continued

Abert's squirrel	*Sciurus aberti*	Log
Allen's big-eared bat	*Idionycteris phyllotis*	Snag
Arizona gray squirrel	*Sciurus arizonensis*	Log
Big brown bat	*Eptesicus fuscus*	Snag
Black bear	*Ursus americanus*	Log
Bobcat	*Lynx rufus*	Log
Colorado chipmunk	*Neotamias quadrivittatus*	Log
Coyote	*Canis latrans*	Log
Common porcupine	*Erethizon dorsatum*	Log
Common raccoon	*Procyon lotor*	Snag
Deer mouse	*Peromyscus maniculatus*	Log
Dusky shrew	*Sorex monticola*	Log
Fringed myotis	*Myotis thysanodes*	Snag
Golden-mantled ground squirrel	*Callospermophilus lateralis*	Log
Gray-collared chipmunk	*Neotamias cinereicollis*	Snag and log
Least chipmunk	*Neotamias minimus*	Log
Long-eared myotis	*Myotis evotis*	Snag and log
Long-legged myotis	*Myotis volans*	Snag
Meadow jumping mouse	*Zapus luteus*	Log
Mexican woodrat	*Neotoma mexicana*	Log
Mountain cottontail	*Sylvilagus nuttallii*	Log
Pale Townsend's big-eared bat	*Corynorhinus townsendii*	Snag
Pallid bat	*Antrozous pallidus*	Snag
Red squirrel	*Tamiasciurus hudsonicus*	Log
Silver-haired bat	*Lasionycteris noctivagans*	Snag
Southern red-backed vole	*Myodes gapperi*	Log
Southwestern little brown myotis	*Myotis occultus*	Snag
Southwestern myotis	*Myotis auriculus*	Snag
Striped skunk	*Mephitis mephitis*	Log
Western small-footed myotis	*Myotis ciliolabrum*	Snag
Western spotted skunk	*Spilogale gracilis*	Log
Chihuahuan mountain kingsnake	*Lampropeltis knoblochi*	Log
Great Plains skink	*Plestiodon obsoletus*	Log
Jemez Mountains salamander	*Plethodon neomexicanus*	Log
Madrean alligator lizard	*Elgaria kingii*	Log
Many-lined skink	*Plestiodon multivirgatus*	Log
Milk snake	*Lampropeltis gentilis*	Log
Ringneck snake	*Diadophis punctatus*	Log

Table 1 Wildlife Species that Use Logs, Snags, or Both, continued

Sacramento mountain salamander	*Aneides hardii*	Log
Smith's black-headed snake	*Tantilla hobartsmithi*	Log
Smooth green snake	*Opheodrys vernalis*	Log
Tiger salamander	*Ambystoma mavortium*	Log



Left: Red-breasted nuthatch (*Sitta canadensis*) and Right: Downy woodpecker (*Dryobates pubescens*), near Cochiti. Photos: Mark Watson