MANAGEMENT RECOMMENDATIONS FOR WASHINGTON'S PRIORITY SPECIES – VOLUME V: MAMMALS (Interim)

Washington Department of FISH and WILDLIFE

IMPORTANT NOTE REGARDING PHS VOLUME V

Management Recommendations for Washington's Priority Species, Volume V: Mammals

This volume currently is in preparation. Until the entire volume is completed, several completed priority species accounts have been published and are available in this document. Additional species accounts will be added as they are finalized.

Front cover illustration by Darrell Pruett

Management Recommendations for Washington's Priority Species

Volume V: Mammals

Interim

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INTRODUCTION

Fish and wildlife are public resources. Although the Washington Department of Fish and Wildlife (WDFW) is charged with protecting and perpetuating fish and wildlife species, the agency has very limited authority over the habitat on which animals depend. Instead, protection of Washington's fish and wildlife resources is currently achieved through voluntary actions of landowners and through the State Environmental Policy Act (SEPA), Growth Management Act (GMA), Forest Practices Act (FPA), Shoreline Management Act (SMA), and similar planning processes that primarily involve city and county governments. Landowners, agencies, governments, and members of the public have a shared responsibility to protect and maintain fish and wildlife resources for present and future generations; the information contained in this document is intended to assist all entities in this endeavor.

The Washington Department of Fish and Wildlife has identified those fish and wildlife resources that are a priority for management and conservation. Priority habitats are those habitat types with unique or significant value to many fish or wildlife species. Priority species are those fish and wildlife species requiring special efforts to ensure their perpetuation because of their low numbers, sensitivity to habitat alteration, tendency to form vulnerable aggregations, or because they are of commercial, recreational, or tribal importance. Descriptions of those habitats and species designated as priority are published in the Priority Habitats and Species (PHS) List.

PHS Management Recommendations

The department has developed management recommendations for Washington's priority habitats and species to provide planners, elected officials, landowners, and citizens with comprehensive information on important fish, wildlife, and habitat resources. These management recommendations are designed to assist in making land use decisions that incorporate the needs of fish and wildlife. Considering the needs of fish and wildlife can help prevent species from becoming extinct or increasingly threatened and may contribute to the recovery of species already imperiled.

Agency biologists develop management recommendations for Washington's priority habitats and species through a comprehensive review and synthesis of the best scientific information available. Sources include professional journals and publications, symposia, reference books, and personal communications with professionals on specific habitats or species. Management recommendations are reviewed within the Department and by other resource professionals and potential users of the information. The recommendations may be revised if scientists learn more regarding a priority habitat or priority species.

Because PHS management recommendations address fish and wildlife resources statewide, they are generalized. Management recommendations are not intended as site-specific prescriptions but as guidelines for planning. Because natural systems are inherently complex and because human activities have added to that complexity, management recommendations may have to be modified for on-the-ground implementation. Modifications to management recommendations should strive to retain or restore characteristics needed by fish and wildlife. Consultation with fish and wildlife professionals is recommended when modifications are being considered.

The locations of priority habitats and species are mapped statewide. The maps represent WDFW's best knowledge of Washington State's fish and wildlife resources based on research and field surveys conducted over the past 20 years. Management recommendations should be addressed whenever priority habitats and species occur in a particular area whether or not the WDFW maps show that occurrence. These maps can be used for initial assessment of fish and wildlife resources in an area, but they should also be supplemented with a field survey or local knowledge to determine the presence of priority habitats or priority species. The PHS data show WDFW's knowledge of important fish and wildlife resources but cannot show the absence of these resources.

In summary, management recommendations for Washington's priority habitats and species...

Are:	**Are not:**
Guidelines	Regulations
Generalized	Site specific
Updated with new information	Static
Based on fish and wildlife needs	Based on other land use objectives
To be used for all occurrences	To be used only for mapped occurrences

Goals

Management recommendations for Washington's priority habitats and species are guidelines based on the best available scientific information and are designed to meet the following goals:

- Maintain or enhance the structural attributes and ecological functions of habitat needed to support healthy populations of fish and wildlife.
- Maintain or enhance populations of priority species within their present and/or historical range in order to prevent future declines.
- Restore species that have experienced significant declines.

Format

Management recommendations for each priority species are written in six primary sections:

General Range and Washington Distribution –	Summarizes information on the geographic extent of the species in Washington and throughout its range.
Rationale –	Outlines the basis for designating the species as priority.
Habitat Requirements –	Delineates the species' known habitat associations.
Limiting Factors –	Specifies factors that may limit the species' distribution and abundance in Washington.
Management Recommendations –	Provides management guidelines based on a synthesis of the best available scientific information.
Key Points –	Summarizes the most important elements of the species' biology and associated management recommendations.

Management recommendations for Washington's priority habitats and species are intended to be used in conjunction with mapped and digital data which display important fish, wildlife, and habitat occurrences statewide. Data can be obtained by calling the PHS Data Request Line at (360) 902-2543. For more information visit the PHS Website at http://wdfw.wa.gov/conservation/phs/. Questions and requests for additional PHS information may be directed to:

Priority Habitats and Species
WDFW Habitat Program
600 Capitol Way N
Olympia, WA 98501-1091

SPECIES STATUS DEFINITIONS

State Listed and Candidate Species

State Endangered - Any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state. Endangered species are legally designated in WAC 232-12-014.

State Threatened - Any wildlife species native to the state of Washington that is likely to become endangered within the foreseeable future throughout a significant portion of its range within the state, without cooperative management or the removal of threats. Threatened species are legally designated in WAC 232-12-011.

State Sensitive - Any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state, without cooperative management or the removal of threats. Sensitive species are legally designated in WAC 232-12-011.

State Candidate - Wildlife species that are under review by the Department for possible listing as endangered, threatened or sensitive. A species will be considered for State Candidate designation if sufficient evidence suggests that its status may meet criteria defined for endangered, threatened or sensitive in WAC 232-12-297. Currently listed State Threatened or State Sensitive species may also be designated as State Candidate species if evidence suggests that their status may meet criteria for a higher listing of State Endangered or State Threatened. State Candidate species will be managed by the Department, as needed, to ensure the long-term survival of populations in Washington.

Columbian White-tailed Deer

Odocoileus virginianus leucurus

Last updated: 2004

Written by Jennifer Brookshier

GENERAL RANGE AND WASHINGTON DISTRIBUTION

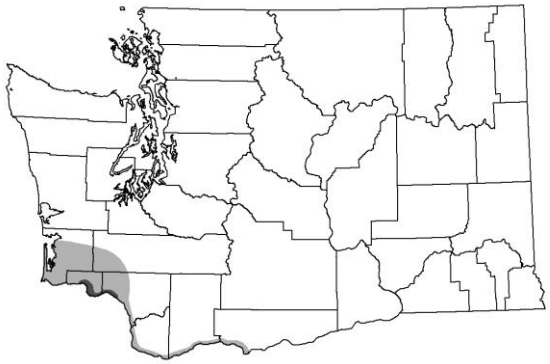

Figure 1. Current (dark) and pre-settlement (light) range of the Columbian white-tailed deer, *Odocoileus virginianus leucurus,* in Washington. Map derived from Washington Department of Fish and Wildlife Heritage and Priority Habitats and Species databases, GAP Analysis of Washington, and Smith (1985).

The Columbian white-tailed deer (*Odocoileus virginianus leucurus*) is the westernmost subspecies of white-tailed deer and the only white-tailed deer found west of the Cascades (Baker 1984). One other subspecies of white-tailed deer occurs in Washington, the northwestern white-tailed deer (*O. v. ochrourus*). The range of this subspecies lies about 300 km (186 mi) east of the current range of the Columbian white-tailed deer (Smith 1985, Smith 1991). Historically, Columbian white-tailed deer were distributed throughout the lowlands of southwestern Washington (see Figure 1) and western Oregon (Smith 1985). Lewis and Clark observed white-tailed deer in 1806 along the Columbia River from The Dalles to Astoria, Oregon (Thwaites 1905). In 1829 David Douglas encountered white-tailed deer in the bottoms of the Cowlitz River in Washington, and the Willamette and Umpqua Rivers in Oregon (Douglas 1914). By the early 1900s, Columbian white-tailed deer had been extirpated throughout much of their historic range (Jewett 1914, Bailey 1936).

Currently, there are two geographically isolated and distinct populations of Columbian white-tailed deer, one along the lower Columbia River in Washington and Oregon (see Figure 1) and the other in Douglas County, Oregon (Brown 2003, Smith et al. 2003). The Columbian White-tailed Deer National Wildlife Refuge (now the Julia Butler Hansen Refuge for the Columbian White-tailed Deer) was created in 1972 to protect 2105 ha (5200 ac) of Columbia River shoreline and island habitat near Cathlamet, Washington, where a large number of Columbian white-tailed deer remained (Gavin 1979). The lower Columbia River population is divided into four main subpopulations, separated from each other by major channels of the Columbia River (USFWS 1983). These main subpopulations consist of the refuge's mainland and Puget Island in Washington and Tenasillahe Island and the lowlands near Westport in Oregon (Figure 2). Based on surveys in 2002, Washington has an estimated 250 Columbian white-tailed deer, about half of the lower Columbia River population (USFWS, unpublished data). Recent reintroductions of Columbian white-tailed deer have expanded the deer's range up the Columbia River to islands near Longview, Washington, and it is likely that additional subpopulations will become established as a result of these efforts (Brookshier et al. 2000).

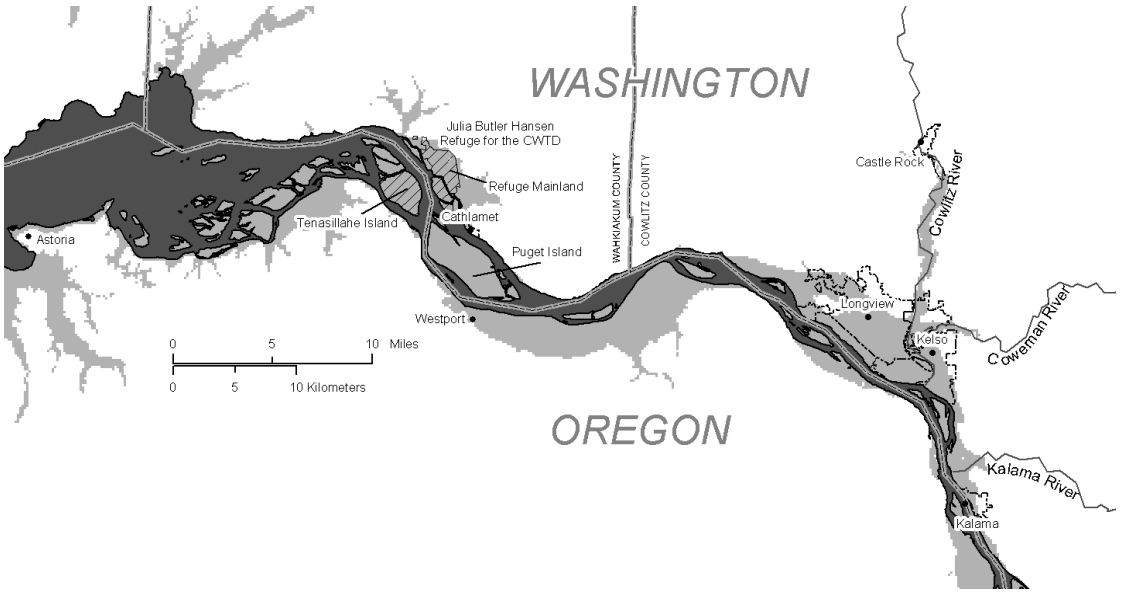

Figure 2. Lower Columbia River bottomlands with elevation at or below 10 m (33 ft) are shown in light gray. Columbian white-tailed deer are currently found on the islands and mainland within this shaded area upriver to Longview.

RATIONALE

In Washington, the Columbian white-tailed deer is listed as a Federal- and State-Endangered species. The clearing of riparian lowlands for agricultural, industrial, and urban development has reduced suitable Columbian white-tailed deer habitat and restricted the deer's range to two disjunct populations (Crews 1939, Scheffer 1940, Gavin 1978, Davison 1979). Small, isolated populations are more vulnerable to extirpation by a variety of factors such as disease and natural catastrophes (Shaffer 1981, Roelke et al. 1993). Continued habitat degradation will impede recovery of the Columbian white-tailed deer by further fragmenting existing habitat and eliminating areas for future range expansion (USFWS 1983).

HABITAT REQUIREMENTS

General Vegetation

Columbian white-tailed deer inhabit riparian forest, brushland, and pasture on islands and within the floodplain of the lower Columbia River (Suring 1974, Gavin et al. 1984). The elevation of these bottomlands is about 3 m (10 ft) above sea level (Gavin 1984). Forested swamps with tall shrubs and Sitka spruce (*Picea sitchensis*), red-osier dogwood (*Cornus stolonifera*), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), and willow (*Salix* spp.) characterize the native vegetation of this area (Franklin and Dyrness 1973, Davison 1979). Many of the islands used by the deer retain this native plant community, with cottonwoods and willows as the co-dominant species (Davison 1979, Davison and Spencer 1979). In contrast, much of the mainland habitat has been significantly altered by two primary human activities. First, native vegetation has been converted from riparian forest to open pasture. For example, forest cover on the refuge's mainland has been reduced from an estimated 70% in 1939 to 17% in 1972 (Suring 1974). Second, hydrological modifications including the construction of dams, dikes, tide

gates and drainage ditches has greatly altered the floodplain of the lower Columbia, removing thousands of acres from the influence of seasonal flooding (Suring and Vohs 1979, USFWS 1983).

Grasses and forbs commonly found in pastures include fescue (*Festuca* spp.), orchardgrass (*Dactylis glomerata*), clover (*Trifolium* spp.), bluegrass (*Poa* spp.), velvetgrass (*Holcus lanatus*), buttercup (*Ranunculus repens*), ryegrass (*Lolium multiflorum*), and vetch (*Vicia* spp.). Reed canary grass (*Phalaris arundinacea*) and water foxtail (*Alopecurus geniculatus*) often invade wet sites (USFWS 1983). The high deer densities on the refuge's mainland compared to the more densely vegetated islands suggests that a combination of wooded habitat and limited agricultural lands may not entirely be incompatible with the requirements of this species (Gavin et al. 1984, Smith 1985). However, the extensive clearing of woody vegetation throughout their historic range has apparently resulted in negative impacts to Columbian white-tailed deer populations (Scheffer 1940, Gavin 1978, Smith 1987).

Cover

An important component of deer habitat selection is the availability of thermal and security cover (Peek et al. 1982). On the refuge's mainland, Columbian white-tailed deer preferred forest communities for cover, and occasionally used areas dominated by tall forbs such as Canada thistle (*Cirsium arvense*) and common rush (*Juncus effusus*) in the spring and summer. Deer primarily used park forest consisting of an open Sitka spruce canopy with a grass understory, especially in the fall, winter and spring. In the spring and summer, deer increased their use of open canopy forest dominated by western red cedar (*Thuja plicata*), red alder, and Sitka spruce. Grasses and shrubs dominated the understory vegetation of forests used in the spring and summer (Suring and Vohs 1979).

The density of Columbian white-tailed deer was greatest where woodland cover exceeded 50% in southwestern Oregon (Smith 1987). On the refuge's mainland, deer use was significantly higher in areas with a greater percentage of cover (22-27% cover) compared to areas with little interspersed cover (8% cover) (Suring 1974). Closed canopy forests, hydric rush, and dogwood communities provided potential cover. However, deer did not frequent these communities, possibly as a result of shade that reduced forage and attracted cattle that damaged vegetation (Suring and Vohs 1979).

In southwestern Oregon, oak-madrone woodlands were frequently used by fawns (Ricca et al. 2003). Fawns also used riparian areas made up of Oregon ash (*Fraxinus latifolia*), red alder, bigleaf maple (*Acer macrophyllum*), and Oregon white oak (*Quercus garryana*). Fawn habitat use was concentrated within 200 m (656 ft) of streams, possibly due to the greater availability of free water and succulent vegetation (Smith 1981, Ricca et al. 2003). Habitat use by fawns along the lower Columbia River is not well documented; however, Suring (1974) suggested that females selected closed canopy forest for fawning. Use of open canopy forest also increased during the fawning period in spring and early summer (Suring 1974). On the refuge, fawns are most commonly found in tall grass (tall fescue [*Festuca arundinacea*], reed canary grass) fields and mixed deciduous (red alder, black cottonwood, willow, Oregon ash) and Sitka spruce forest (A. Clark, personal communication). They avoid pastures and other short grass areas.

Forage

On the refuge, deer fed in maintained pastures, but only within 250 m (820 ft) of forest cover (Suring and Vohs 1979). Deer were also attracted to areas with vegetation > 70 cm (28 in) high near forage species (Suring and Vohs 1979). On the refuge's mainland, the vast majority of deer were observed grazing while very few were seen browsing (Suring 1974, Suring and Vohs 1979). Researchers on the refuge concluded that Columbian white-tailed deer were primarily grazers based on visual observations of foraging deer (Suring 1974, Suring and Vohs 1979) and rumen analysis (Gavin et al. 1984). In contrast, Dublin (1980) quantified deer diets on the refuge using fecal analysis and reported that, on average, their diets consisted of 23% browse, 39% grasses, and 38% forbs. Deer selected browse in all seasons except spring, selected forbs in all seasons except summer, and avoided grasses in all seasons except spring when grasses were consumed in proportion to their availability.

Most of what is known about the diet of Columbian white-tailed deer was derived from studies on the refuge's mainland (Suring 1974, Dublin 1980, Gavin et al. 1984). The heavy use of grasses and forbs may reflect the deer's adaptation to available habitat rather than their actual foraging preference (Davison 1979). The islands along the lower Columbia River more closely resemble the historical tidal spruce habitat with dense forest cover. Preliminary diet composition data for deer on Crims Island, Oregon, indicated that they fed mainly on browse and forbs in August and September and almost entirely on browse in October through January. Grasses were an important part of the diet only during the spring (USFWS, unpublished data).

Important browse species on the refuge included evergreen blackberry (*Rubus laciniatus*), which comprised 17% of the deer's diet during its fruiting period in September (Dublin 1980). Pacific ninebark (*Physocarpus capitatus*) was consumed throughout the year, while red-osier dogwood and salal (*Gaultheria shallon*) were important in the fall and winter. Conifers such as juniper (*Juniperus* spp.) and western red cedar were consumed in fall and late winter and red elderberry (*Sambucus racemosa*) was eaten only during winter. A few resident deer fed heavily on apple, pear, plum, and acorn (Dublin 1980).

Grasses that made up a significant part of deer's year-round diet were foxtail (*Alopecurus* spp.), orchard grass, tall fescue, mannagrass (*Glyceria* spp.) and common timothy (*Phleum pretense*) (Dublin 1980). Deer selected grass in its early stage of flowering (Dublin 1980). In general, mature grasses and forbs have reduced digestibility and protein (Blair et al. 1977). Deer on the refuge were often observed feeding on water foxtail, a native grass that has a high year-round crude protein content (Gavin et al. 1984). Yarrow (*Achillea millefolium*), woodland phacelia (*Phacelia nemoralis*), red clover (*Trifolium pretense*), and buttercup were forbs consumed by Columbian white-tailed deer (Dublin 1980).

Movements and Home Range

The average lifetime home range on the refuge was 192 ha (475 ac) for males and 159 ha (392 ac) for females (Gavin et al. 1984). Adult males had the largest average home range at 209 ha (516 ac) and male fawns had the smallest range at 65 ha (162 ac). Although home ranges overlap, some females appeared to defend certain well-drained, relatively dry sites used for bedding. Columbian white-tailed deer are not migratory and home ranges tend to be very stable in space and time. The distance between annual centers of activity for individual deer rarely exceeded 300 m (984 ft). Roads and water boundaries (e.g., wide channels, ditches) strongly influenced the shape of home ranges on the refuge. Deer density on the refuge's mainland was estimated at 30 deer/km^2 (78 deer/mi^2) in 1975 and 21 deer/km^2 (54 deer/mi^2) in 1976 (Gavin et al. 1984). Deer densities were as high as 62 deer/km^2 (160 deer/mi^2) from 1984 to 1992 when overpopulation occurred on the refuge's mainland (USFWS 1998).

Interspecific Interactions

At high densities, Columbian white-tailed deer appear to exclude Columbian black-tailed deer (*Odocoileus hemionus columbianus*) from lowland riparian habitats (Smith 1987). However, black-tailed deer readily occupy riparian lowlands when densities of white-tailed deer are reduced (Smith 1987). This can lead to increased competition and potential hybridization (Davison 1979, Smith 1987, Gavin and May 1988, Whitney 2001).

Large herbivores such as elk (*Cervus elaphus*) and domestic cattle (*Bos taurus*) can trample understory vegetation and compete with deer for forage (Dublin 1980, Loft et al. 1987, Kirchhoff and Larsen 1998). Columbian white-tailed deer actively avoided close associations with livestock on the refuge (Suring 1974). Deer rarely fed within 30 m (98 ft) of grazing cattle, and deer use of pasture with low cattle stocking rates (below 2.2 cows/ha [1 cow/ac]) was significantly greater compared to those with higher stocking rates (Suring 1974).

LIMITING FACTORS

The degradation of riparian habitat has the greatest negative impact to Columbian white-tailed deer (Crews 1939, Scheffer 1940, Gavin 1978). Habitat alterations favoring Columbian black-tailed deer can also lead to increased competition for food and hybridization between these species (Davison 1979, Smith 1987, Gavin and May 1988, Whitney 2001). Direct causes of adult mortality include malnutrition and disease, vehicle collisions, and poaching (Smith 1981, Gavin et al. 1984, Ricca et al. 2002). Necrobacillosis (foot rot) commonly afflicts deer and probably contributes to adult mortality (USFWS 1983). Deaths from predation, fence entanglement, and drowning occur to a lesser extent. Ricca et al. (2002) reported that 73% of adult mortalities occurred in fall and winter. Malnutrition due to insufficient food resources in winter months is potentially the major limiting factor for Columbian white-tailed deer on the refuge (Creekmore and Glaser 1999). Severe floods, especially when compounded by malnutrition, can result in significant mortality (USFWS 1998). Predation of fawns, primarily by coyotes (*Canis latrans*), can limit recruitment and exacerbate population declines caused by other factors such as flooding, poor nutrition, and habitat loss (USFWS 1998). Fawns are most vulnerable to predation from June through September.

MANAGEMENT RECOMMENDATIONS

Columbian white-tailed deer are strongly associated with riparian habitat (Smith 1985, Ricca 2000), and further degradation of this habitat should be avoided where deer are present or may become reestablished. Riparian corridors are critical to deer dispersal and range expansion (Smith 1985), and protection of riparian habitat is considered a priority (Knutson and Naef 1997). Planting native woody species such as cottonwood, spruce, alder, willow, salal, ninebark, dogwood, and elderberry helps to reestablish cover and browse in extensive clearings. Although the optimum ratio of cover to pasture is unknown for Columbian white-tailed deer, it is reasonable to assume that a diverse landscape with at least 50% woody cover would have the highest probability of meeting deer requirements (Davison 1979, Smith 1987). Based on the Suring and Vohs' (1979) observations, cover should be available within 250 m (820 ft) of foraging areas wherever possible. Trees on cottonwood plantations should be planted and harvested in small, staggered blocks to avoid large displacements of deer when blocks are cut (A. Clark, personal communication). Leaving native trees and shrubs along corridors such as sloughs will help provide cover when cottonwoods are harvested. Islands and low-lying mainland along the Columbia River are susceptible to seasonal flooding, and periodic major floods can result in significant mortality (Davison 1979, USFWS 1998). Diked and higher-elevation mainland areas adjacent to islands inhabited by deer should be managed to provide adequate cover and sanctuary for deer during periodic floods (Davison 1979). Human-deer conflicts can arise when deer damage crops or landscaping. Link (2004) offers suggestions on how to prevent or reduce deer problems using fences, repellents, and deer-resistant plants.

Pasture Management

In improved pastures, grazing by cattle can be manipulated to maintain short, actively growing forage for deer. However, high stocking rates and grazing over extensive areas should be avoided (Whitney 2001). Acceptable stocking rates depend on many factors such as the current condition of the vegetation, soil type, soil fertility, moisture and drainage (see Contacts section for assistance). Cattle should be excluded year-round from woodlots to provide understory development preferred by deer during winter and in the fawning period (Suring and Vohs 1979). Grazing on the refuge occurred from mid-April to late October, which kept forage at a palatable stage of growth (5-10 cm [2-4 in]) in the winter (Gavin et al. 1984). A rotational grazing system can be used to create these favorable foraging conditions for deer (M. Chaney, personal communication). Haying can also be used to maintain short-grass fields in the absence of grazing. However, deer on the refuge selected grazed pastures over hayed fields, and grazed fields apparently had higher plant diversity (Gavin et al. 1984). Small, narrow pastures with interspersed woody cover are recommended over large expanses of unbroken pasture. Pasture and property fences should be no more than 1.2 m (4 ft) high (Link 2004) with at least a 30 cm (12 in) spacing between the top two wires (CDOW 2004). The bottom wire should be 45 cm (17 in) off the ground to allow deer to go under fences (Link 2004). Flagging new fences will help to protect the fence until deer become accustomed to the new barrier

(CDOW 2004). Unused fencing should be removed to prevent deer entanglements (A. Clark, personal communication).

Predation

Coyotes are the main predator for deer on the lower Columbia River (USFWS 1998). Coyote removal may provide short-term benefits to deer by increasing fawn survival and recruitment into older age classes. Predator control can be a useful management tool to maintain the viability of small subpopulations. However, it should not be used indiscriminately because it can lead to deer overpopulation and habitat damage. Decisions regarding predator control should be left to qualified wildlife biologists.

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KEY POINTS

Habitat Requirements

- Strongly associated with lowland riparian forest, brushland, and pasture along the lower Columbia River.
- Use forests and woodlands with a well-developed understory as cover. Prefer habitat that provides both forage and cover.
- Feed in pastures, but only within 250 m (820 ft) of forest cover.
- Browse species in deer diets include evergreen blackberry, Pacific ninebark, red-osier dogwood, and salal.
- Consume grasses such as foxtail, orchard grass, tall fescue, mannagrass, and common timothy. Deer select grasses in the early stage of flowering as mature grasses have reduced digestibility and protein content.
- Consumed forbs include yarrow, woodland phacelia, red clover, and buttercup.
- Home ranges are overlapping and stable. Adult males have the largest home ranges at 209 ha (516 ac).
- Low densities of white-tailed deer may result in the occupation of lowland riparian areas by black-tailed deer.
- Large herbivores such as elk and cattle can trample vegetation and compete with deer for forage. Deer rarely come within 30 m (98 ft) of grazing cattle.

Management Recommendations

- Protect existing riparian habitat and reestablish woody cover in cleared areas.
- Maintain a diverse landscape of at least 50% woody cover wherever possible.
- On cottonwood plantations, plant and harvest cottonwoods in small, staggered blocks. Leave native cover along sloughs and other corridors.
- Provide adequate cover on mainland areas adjacent to Columbia River islands to allow for deer movements off the islands during periodic floods.

- Small, narrow pastures with interspersed cover are recommended over large, unbroken pastures.
- Promote short (5-10 cm [2-4 in]), actively growing forage in pastures by grazing or haying. Grazing should occur on a seasonal basis and cattle should be kept out of woodlots year-round. Rotational grazing systems are recommended.
- Pasture and property fencing should be no more than 1.2 m (4 ft) high with at least 30 cm (12 in) between the top two wires. The bottom wire should be at least 45 cm (17 in) above the ground.
- Remove unused fencing and flag new fencing.
- Predator control should only be considered if a wildlife biologist has determined control is necessary to protect the viability of a small subpopulation.

Merriam's Shrew

Sorex merriami

Last updated: 2004

Written by Jeffrey M. Azerrad

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The Merriam's shrew is found east of the Cascades and Sierra Nevadas, south to southern Arizona and New Mexico, and east to the western Great Plains (Verts and Carraway 1998, Wilson and Ruff 1999). Researchers recently discovered this species outside the United States in the southern Okanagan region of British Columbia (Nagorsen et al. 2001). Because of inadequate and biased sampling, the actual distribution of Merriam's shrews is likely more extensive than documented (Nagorsen et al. 2001). Nowhere do Merriam's shrews appear to be abundant (Verts and Carraway 1998).

In the Pacific Northwest, Merriam's shrews are found primarily in the arid portions of the region (Verts and Carraway 1998). Their Washington range includes portions of central and southeastern Washington (Hudson and Bacon 1956, Johnson and Cassidy 1997; Figure 1).

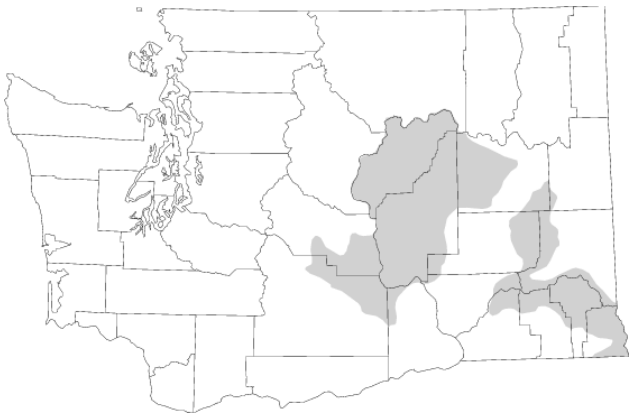

Figure 1. Potential range of the Merriam's shrew (*Sorex merriami*) in Washington based on Johnson and Cassidy's (1997) habitat modeling analysis. Since Johnson and Cassidy's (1997) model is based on a small number of captured shrews, individual Merriam's shrews likely exists beyond areas shaded on this map.

RATIONALE

The Merriam's shrew, classified as a Candidate for listing as Threatened or Endangered in Washington, is primarily associated with arid shrub-steppe and steppe communities (James 1953, Hudson and Bacon 1956, Larrison 1976, MacCracken et al. 1985, Ports and McAdoo 1986). Because agricultural land uses have had a profound effect on steppe communities in the Columbia Basin (Vander Haegen et al. 2001), it is likely that populations of Merriam's shrews have been impacted by related habitat loss, fragmentation, and degradation in eastern Washington. Few studies of small mammals (shrews and rodents) have been conducted in the shrub-steppe habitats of eastern Washington except for studies at the Hanford Reservation, the Arid Lands Ecology Reserve, and the Yakima Training Center (Vander Haegen et al. 2004). Therefore, additional survey information needs to be collected to have a better understanding of the actual abundance and status of Merriam's shrews in Washington (Vander Haegen et al. 2004).

HABITAT REQUIREMENTS

A limited number of studies have examined the habitat requirements of Merriam's shrews, and most published literature has been based on the capture of a small number of individuals. The most commonly reported habitat of this species is sagebrush-steppe, but it also has been found in semi-arid grasslands, pinyon-juniper (*Pinus-Juniperus*) woodlands, high elevation brushlands, and even mixed woodlands of ponderosa pine (*Pinus ponderosa*), Douglas-fir *(Pseudotsuga menziesi*i), and cottonwood (*Populus balsamifera*) (Wilson and Ruff 1999). Based on captured specimens, this species is commonly reported to be associated with sagebrush (*Artemisia* spp.)-bunchgrass habitats in eastern Washington (James 1953, Hudson and Bacon 1956, Johnson and Clanton 1954). Big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* sp.), and bitterbrush (*Purshia tridentata*) are commonly found in areas where Merriam's shrews are present (MacCracken et al. 1985, Ports and McAdoo 1986, Kirkland et al. 1997, Nagorsen et al. 2001). In eastern Nevada, Merriam's shrew habitat included areas of moderate shrub cover, sparse forb and bunchgrass understory and extensive bare ground as well as south-facing slopes of dense big sagebrush, bitterbrush, squaw current (*Ribes cereum*), and mountain snowberry (*Symphoricarpus oreophilus*) (Ports and McAdoo 1986).

Although this species appears to be primarily associated with dry habitats, they have been observed in wetland communities on very rare instances (McDaniel 1967, Williams 1984). Merriam's shrews are estimated to occur at elevations ranging between 365 and 915 m (1200-3000 ft) in the Columbia Basin and 185 and 975 m (600-3200 ft) in the Blue Mountains (Johnson and Cassidy 1997).

Merriam's shrews feed on an assortment of invertebrates. Stomach and intestines of Merriam's shrews trapped in eastern Washington contained spiders, beetles, caterpillars, cave crickets, and ichneumon (wasp-like) flies (Johnson and Clanton 1954). The winter and summer diets of shrews are generally similar, consisting of active, ground dwelling invertebrates (Aitchison 1987). Aitchison (1987) suggested that during the winter shrews hunt insects beneath the snow layer by means of sound and vibrissae (touch receptors).

Merriam's shrews are believed to be associated with other small, burrowing mammals (Johnson and Clanton 1954, Brown 1967). Specifically, Merriam's shrews were found using runways of voles (*Microtus*) along fencerows in Montana (Armstrong and Jones 1971). They have been trapped coming out of the burrow of a sagebrush vole (*Lemmiscus curtatus*) (James 1953, Johnson and Clanton 1954). Johnson and Clanton (1954) suggested that the underground passages furnished protection for the shrews and the insects on which they subsisted. Ports and McAdoo (1986) trapped Merriam's shrews at two locations where two other shrew species, voles, pocket gophers, mice, and chipmunks also were caught. However, they also trapped Merriam's shrews at two locations where no other small mammals were caught, indicating that an association with other small, burrowing mammals might not be requisite.

LIMITING FACTORS

Merriam's shrews are closely associated with shrub-steppe communities (Wunder and Carey 1994) that formerly extended over nearly all non-forested lands in Washington east of the Cascade crest (Daubenmire 1970). Currently, over half of Washington's native shrub-steppe has been converted to agriculture, resulting in a fragmented landscape with few extensive tracts (Vander Haegen et al. 2000). With the widespread decline and fragmentation of shrub-steppe, concern has focused on those species that might be most affected by these impacts (Jacobson and Snyder 2000, Vander Haegen et al. 2000), including Merriam's shrews (Wunder and Carey 1994).

MANAGEMENT RECOMMENDATIONS

The information available on the distribution and ecological needs of the Merriam's shrew is not adequate enough to provide species-specific recommendations. Therefore, the following are generalized guidelines based on the major factors influencing species that depend on the availability of steppe communities.

This species is associated with arid shrub- and grass-dominated habitats. Consequently, these important areas should be conserved. Because Merriam's shrews are found most often in sage-grass and undisturbed bunchgrass habitats (Larrison 1976), these habitats should not be degraded through activities such as conversion to croplands, chaining, spraying of chemicals, burning, or overgrazing (i.e., repeated grazing that exceeds the recovery capacity of the vegetation and creates or perpetuates a deteriorated plant community).

Habitat fragmentation most greatly impacts small mammals, such as the Merriam's shrew, that have low mobility (Vander Haegen et al. 2001). Therefore, when identifying areas in need of protection for this species, one should attempt to not only protect patches of known habitat, but adjacent habitat corridors (e.g., riparian areas) that potentially allow individuals within a population to disperse and not become isolated and vulnerable.

Merriam's shrews are insectivorous, and the use of insecticides may negatively impact this species. If insecticide or other chemical use is planned for areas where this species occurs, review Appendix 1 for contacts to assist in assessing the use of chemicals and other alternatives.

Our knowledge of shrews is principally based on work in forested habitats, and comparatively little is known about shrews associated with arid regions (Kirkland et al. 1997). Until more local research and surveys are conducted, the possibility for specific management geared towards the conservation of Merriam's shrews is limited. Research and monitoring are needed to more fully understand the distribution and ecological needs of Merriam's shrews. Researchers also should focus on understanding factors that influence the success of this species and of other small mammals that use steppe and other arid communities.

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KEY POINTS

Habitat Requirements

- Primarily inhabit sagebrush-steppe, but also has been found in semi-arid grasslands, pinyon-juniper woodlands, high elevation brushlands, and even mixed woodlands of ponderosa pine, Douglas-fir, and cottonwood.
- Big sagebrush, rabbitbrush, and bitterbrush as well as bunchgrasses are commonly found in areas where Merriam's shrews are present.
- Feed on an assortment of invertebrates consisting of active, ground dwelling invertebrates that include spiders, beetles, caterpillars, cave crickets, and ichneumon (wasp-like) flies.
- Believed to be associated with other small, burrowing mammals because they have been found using runways of voles along fencerows as well as other small mammalian species.

Management Recommendations

- Additional research, surveys, and monitoring are needed to develop species-specific management recommendations for Merriam's shrews.
- Sage-grass and undisturbed bunchgrass habitats should not be degraded through activities such as conversion to croplands, chaining, spraying of chemicals, burning, or overgrazing (i.e., repeated grazing that exceeds the recovery capacity of the vegetation and creates or perpetuates a deteriorated plant community).
- Attempt should be made to not only protect patches of known habitat, but adjacent habitat corridors (i.e., riparian areas) that potentially allow individuals within a population to disperse.
- Review Appendix 1 for contacts to assist in assessing the use of chemicals and other alternatives if insecticide or other chemical use is planned for areas where this species occurs.

Pallid Bat

Antrozous pallidus

Last updated: 2004

Written by Howard Ferguson and Jeffrey M. Azerrad

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The pallid bat (*Antrozous pallidus*) is the second largest bat in Washington. The species ranges from central Mexico northward through western Texas, New Mexico, Arizona, southern and western Colorado, south-central Utah, western Nevada, California, Oregon, eastern Washington, western Idaho, and north to the southern Okanagan Valley of British Columbia (Orr 1954, Shryer and Flath 1980, Hermanson and O'Shea 1983, Verts and Carraway 1998).

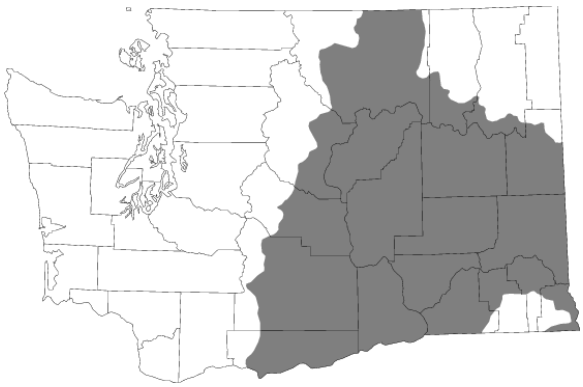

Figure 1. Range of the pallid bat (*Antrozous pallidus*) in Washington (Johnson and Cassidy 1997).

The range of the pallid bat in Washington includes potential locations throughout eastern Washington, with the exception of much of the northeastern corner of the state and the east-slope of the Cascades (see Figure 1; Johnson and Cassidy 1997). The pallid bat has been captured or visually documented in Clark, Skamania, Benton, Douglas, Grant, Klickitat, Spokane, and Yakima counties. Gitzen et al. (2002) captured 16 pallid bats at the Hanford Site where this species comprised 27% of the total number of identified calls. Hibernation behavior is poorly known. O'Farrell and Bradley (1970) reported winter activity in Nevada; however, no winter records are known from Washington or British Columbia (Nagorsen and Bingham 1993).

RATIONALE

The pallid bat is classified as a Priority Species in Washington due its propensity to congregate in large numbers. Significant bat losses can result from individual disturbance events occurring near these congregation areas. The pallid bat is a Threatened species in Canada (Willis 1999, Environment Canada 2003) and critically imperiled in Idaho and Montana (Idaho Conservation Data Center 2003, Montana Natural Heritage Program 2003). The U.S. Forest Service ranks the subspecies *Antrozous pallidus pacificus*, that has a range limited to southwest Oregon, as a sensitive species (P. Ormsbee, personal communication). The pallid bat seems to have suffered declines in some areas, although in other areas it might just be naturally rare (Chapman et al. 1994). Additional research is necessary in Washington because the status and population trends of this species are essentially unknown.

HABITAT REQUIREMENTS

The pallid bat generally inhabits arid areas with rocky outcrops and vegetation dominated by dry shrub or dry forested habitat near water (Orr 1954, van Zyll de Jong 1985). Pallid bats prefer arid and semi-arid climates with an average rainfall of 20-38 cm/year (8-15 in) (Vaughan and O'Shea 1976, van Zyll de Jong 1985) and an average summer daily maximum temperatures up to 38 EC (100 EF) (Vaughan and O'Shea 1976). This species is closely associated with arid desert, canyons, karst formations, and grasslands throughout its range (Hermanson and O'Shea 1983, van Zyll de Jong 1985, Nagorsen and Bingham 1993). It also is associated with rock cliffs in shrub-steppe or desert areas across the west (van Zyll de Jong 1985, Holroyd et al. 1994). Typical shrubs in areas where pallid bats occur include antelope bitterbrush (*Purshia tridentata)*, sagebrush (*Artemesia* spp.), rabbit-brush (*Chrysothamnus* spp.), and forest cover types including ponderosa pine (*Pinus ponderosa*) along lower slopes, and riparian forests (van Zyll de Jong 1985). In British Columbia the pallid bat occurs in arid grasslands and ponderosa pine forests near cliff faces (Nagorsen and Bingham 1993). In western Oregon, this species is associated with oak-woodlands and grasslands, and ponderosa pine forests in the foothills surrounding the Rogue and lower Willamette River valleys (Cross and Waldien 1995, P. Ormsbee, personal communication). Pierson (1998) reported that pallid bats were associated with oak (*Quercus* spp.) woodlands, ponderosa pine, redwoods (*Sequoia sempervirens*) and giant sequoias (*Sequoiadendron giganteum*) in northern California. In Arizona, pallid bats were captured in the arid ponderosa pine-oak habitat (Morrell et al. 1999). Forested habitat selected by this species consists of riparian forest along lakeshores and streams, and dry forest dominated by ponderosa pine on the lower slopes (Genter and Jurist 1995).

Feeding

The pallid bat has been observed foraging close to the ground, along the base of cliffs, and over lava flows (Whitaker et al. 1981). They forage primarily in uncluttered, sparsely vegetated habitats. In British Columbia, radio-tagged pallid bats foraged primarily in large tracts (>0.5 km [0.3 mi] in length) of exposed, sandy soil with sparse vegetation consisting primarily of sagebrush, greasewood (*Sarcobatus vermiculatus*), rabbit-brush, cheatgrass (*Bromus tectorum*), and bunchgrasses (e.g. *Pseudoroegneria spicata*, *Festuca idahoensis*, *Poa sandbergii*) (Nagorsen and Bingham 1993, Chapman et al. 1994).

The pallid bat is a terrestrial forager, taking large, ground-dwelling or slow-flying prey (Hatt 1923, O'Shea and Vaughan 1977, Bell 1982). Pallid bats feed on a variety of invertebrates that include but are not limited to beetles (Coleoptera), moths (Lepidoptera), and crickets (Orthoptera) (Verts and Carraway 1998). While foraging, the pallid bat flies within a few meters of the ground and lands to pursue and capture prey. Bats that are terrestrial foragers search for prey over sparsely vegetated areas locating their prey by the low frequency (4-8 kHz) rustling sounds produced by prey on the ground rather than by using echolocation (i.e., the use of echoes to determine the direction and distance of objects) (Brown et al. 1978, Bell 1982, van Zyll de Jong 1985). Pallid bat populations would likely be adversely impacted if foraging habitats become more densely vegetated as a result of expansion of development, agriculture, or irrigation (Chapman et al. 1994).

Roosts

Pallid bats roost in caves, mines (van Zyll de Jong 1985), open man-made structures such as porches and garages (van Zyll de Jong 1985, Lewis 1996), cliff overhangs (Hermanson and O'Shea 1983, Lewis 1996), rock crevices, trees and tree cavities (Nagorsen and Bingham 1993), and under abandoned bridges (van Zyll de Jong 1985, Lewis 1994, Pierson et al. 1996). In British Columbia, this species uses ponderosa pine as night roosts (Nagorsen and Bingham 1993).

Most pallid bats roost in groups ranging from 20 to 200 individuals (Vaughan and O'Shea 1976). Group size is important to conserve energy and is also important for the growth of young. Young animals occupy the center of clusters while individuals outside of clusters experience higher rates of weight loss (Trune and Slobodchikoff 1976, 1978). Group numbers peak in maternity colonies during late-July and early-August, when young bats are weaned and capable of flight. Prior to this, males roost separately from females (O'Shea and Vaughan 1977). Pallid bats will not use the same roost for both night and day (Lewis

1994). The pallid bat is known to roost with a number of other species of bats, principally Myotis (*Myotis* spp.) and Brazilian free-tailed bats (*Tadarida brasiliensis*) (Vaughan and O'Shea 1976, Tatarian 1999). Bats may switch roosts to reduce their parasite load (Fleming 1988), avoid disturbance or predation (Kunz 1982), acquaint young with future roost sites (O'Shea and Vaughn 1977), or respond to changing roost conditions (Lewis 1995).

Males are relatively nomadic, live singly or in small groups, and can exist in harsher environments than females (Chapman et al. 1994). Males can be gregarious when roosting apart from females. Up to 60 males have been found in day roosts (Dalquest 1947) and over 100 in night roosts (Davis and Cockrum 1963). Males also may select areas of low ambient temperature for hibernation (Chapman et al. 1994). In contrast, both sexes roost together from September through March during hibernation (Chapman et al. 1994).

Day roosts. Pallid bats spend most of their time in day roosts (Vaughan and O'Shea 1976, Chapman et al. 1994). In general, pallid bats show a high degree of flexibility in their choice of day roosts. However, day roosts are usually in more enclosed protected sites as compared to night roosts (Tatarian 1999). The day roost is usually in a warm, horizontal crevice, most often a rock crevice (Holroyd et al. 1994). Pallid bats have also been found roosting in rock cracks, holes, tree hollows, behind tree bark, under rock overhangs, mud tubes or cracks in basalt, bridges, caves, mines, and buildings (e.g., porches, walls, attics, eaves) (Bell 1980, Hermanson and O'Shea 1983, Brown et al. 1997, Tatarian 1999).

Trees selected for day roosting by reproductive females tended to be large in diameter (dbh) (average = 66 cm [26 in] dbh). Roost trees were also surrounded by a higher density of snags, logs, and trees (large diameter [>61.0 cm (24 in) dbh] trees) had a higher surrounding basal area, and were more likely to have loose bark compared to random snags (Rabe et al. 1998). Most females roosted under loose, exfoliating bark of large diameter ponderosa pine snags (Rabe et al. 1998). Roosts often consisted of large sheets of loose bark that surrounded the snag and could provide a variety of microclimates advantageous to bats. Large diameter snags may be selected for their thicker exfoliating bark to provide greater insulation for reproductive females (Rabe et al. 1998). Alternate roosts are chosen frequently during the summer when young first begin to fly. Rallying and relocation of roosts may serve to aid young in achieving skill at finding retreats (O'Shea and Vaughan 1977).

Pallid bats in Oregon and Arizona favor rock slabs on cooler days and rock crevices on warmer days (Vaughan and O'Shea 1976, Lewis 1996). Lewis (1996) also found that roosts tended to open to the south or southeast for morning warmth and protection from intense afternoon sun. Horizontal crevices with stable warm temperatures of 30° C (86E F) are preferred as summer day roosts. Vertical crevices with widely fluctuating ambient temperatures are often selected during cooler seasons (Hermanson and O'Shea 1983).

Maternity roosts. Maternity roosts can serve as day roosts, provide protection from predators, and provide optimal conditions for gestating and lactating females and their developing young (Humphrey 1975). Only females care for young within maternity roosts. Pallid bat maternity roosts have been found in ponderosa pine snags (Rabe et al. 1998), in rock crevices, within spaces behind exfoliating rock , and "potholes" in rock-overhangs (Lewis 1996). A number of maternity sites have been found under bridges in southwestern Oregon, and fidelity to these sites is evident from year to year (P. Ormsbee, personal communication). In central Oregon, reproductive females tended to roost in spaces behind exfoliating rock when the daily maximum temperature was below the summer average (32° C) and in rock crevices when temperatures were higher than average. Maternity roosts faced south-southeast (Lewis 1996). Pregnant pallid bats used both crevices and "slabs," while lactating females used only crevices. Snags used as day roosts were located higher on slopes and closer to water as compared to random snags (Rabe et al. 1998).

Night roosts. Night roosts are very important for pallid bats. Night roosts may be used for digestion and energy conservation, to provide shelter from predators, to serve as centers of information exchange about food resources, and to aid in social interaction. After feeding, pallid bats spend up to several hours at a night roost (Lewis 1994). O'Shea and Vaughan (1977) reported that pallid bats in Arizona spent 40-60% of their entire summer activity period in night roosts. For individual bats (e.g., bats not in maternity

colonies), night roosts are often more open than day roost crevices, but are normally protected from the weather.

Buildings, rock overhangs, bridges (Lewis 1994), caves, and mines (Howell 1980) have been reported to contain roosting pallid bats. In British Columbia, radio-tagged pallid bats used live ponderosa pine trees as night roosts (Chapman et al. 1994). Night roosting appears to be widespread under bridges (Barbour and Davis 1969, Lewis 1994, Keeley and Tuttle 1996, H. Ferguson, personal observation), and these roosts are a reasonable indicator of the presence or absence of pallid bats (Pierson et al. 1996). In California, Pierson et al. (1996) found that concrete girder bridges were used but unmodified box girder bridges were not used for night roosting. This study parallels Lewis's (1994) findings in Oregon, and suggests that bridge structure plays an important role in roost selection.

Lewis (1994) reported night-to-night and year-to-year fidelity to night roosts in a two-year study in Oregon. In Arizona, O'Shea and Vaughn (1977) found that females showed roost fidelity during late pregnancy and lactation, but not during the spring and autumn. In California, pallid bats exhibited fidelity to night roosts (Pierson et al. 1996).

Winter roosts - hibernacula. Pallid bats use buildings, rock crevices, mines, and caves as hibernacula (Nagorsen and Bingham 1993). In areas of mild climate or sites with stable microclimates that permit hibernation (Humphrey 1975), winter roosts may also be used as daytime roosting sites. Winter habits are poorly known for this species and pallid bats are presumed to hibernate. They have been seen hibernating in vertical cracks along the ceiling of a Nevada mine (Alcorn 1944). There is speculation that they hibernate in the vicinity of their summer range; however, there are few winter records to support this assumption. No winter roost sites are known from British Columbia (Nagorsen and Bingham 1993) or Washington.

LIMITING FACTORS

The pallid bat is a colonial species and at times appears to be particularly sensitive to human disturbance (Lewis 1996). O'Shea and Vaughan (1977) found that during warm summer months when night roost temperatures were high, pallid bats showed no tolerance for disturbance by observers. Once the observers were detected, the bats fled the roost immediately; however, during the cooler months bats appeared to enter a deeper state of hibernation and were less susceptible to disturbance (O'Shea and Vaughan 1977). Accordingly, Morrell et al. (1999) suggest that intensive forest management practices in ponderosa pine habitats during the summer months may adversely affect reproductive success. Some researchers have stated that any human activity (e.g., logging, industrial projects, hiking, and rock climbing) that disturbs the bats in their night roost, day roosts, or foraging grounds could potentially cause pallid bats to move out of an area (O'Shea and Vaughan 1977, Hoffmeister 1986, Miller 2000). Fidelity of pallid bats toward roosts, especially night roosts, makes them even more vulnerable to disturbance (Lewis 1994, Pierson et al. 1996).

Use of caves and mines as roost sites also places this species in jeopardy with regards to closure projects (Howell 1980, van Zyll de Jong 1985, Nagorsen and Bingham 1993). Mines are an important roosting habitat that concentrates large numbers of bats. This concentration of bats in relatively few roosts makes them vulnerable to disturbance and eradication (Tuttle and Taylor 1994).

Because habitat loss from conversion of sagebrush-steppe is on the increase in Washington (Washington State Department of Natural Resources 1998), it is likely that this factor has further limited pallid bat numbers. The reduction of open foraging areas due to development and cattle grazing may degrade foraging areas and reduce prey diversity and density (Chapman et al. 1994).

Bridges can be important for night roosting (Barbour and Davis 1969, Lewis 1994; H. Ferguson, personal observation). Bats use parallel box beam design bridges as day roosts more than any other type of bridge. The next most preferred bridge designs are cast in place or made of pre-stressed concrete girder spans (Keeley and Tuttle 1996). A general trend of highway departments is the use of smooth design bridges with few if any crevices, thereby offering little potential roost sites for the pallid bat.

The preference for ponderosa pine trees as night and maternity roosts in British Columbia points to the importance of this tree species to the pallid bat (Chapman et al. 1994). Loss of tree roosts may occur through commercial timber harvest (Morrell et al. 1999).

This species roosts in snags that are often associated with foothill habitats such as ponderosa pine or oak - savanna that are susceptible to urban growth pressures (Pierson and Rainey 1998, P. Ormsbee, personal communication). In addition to direct effects of habitat loss from urban growth, indirect effects also arise from fire suppression activities that modify forest/valley transition areas (P. Ormsbee, personal communication).

Since the pallid frequently uses human structures, the feral domestic cat poses a threat to this species (Tuttle 1996, Coleman et al. 1997, The Mammal Society 1998, Crooks and Soule 1999). Crooks and Soule (1999) estimated that cats surrounding a moderately sized area (approximately 100 residences) returned about 2000 small vertebrates to residences/year.

Pesticides, especially those used in fruit-growing areas, can harm the pallid bat due to poisonings from contaminated insect prey (Collard 1991, Chapman et al. 1994, Environment Canada 2003). Bats in colder regions may be more affected by pesticides than those in warmer climates (Fenton 1983, Collard 1991). There have been records of widespread bat mortality due to bad weather in association with pesticide poisoning (Fenton 1983). Pesticides may have the greatest detrimental affect on young of the year that rely on their fat reserves when switching from nursing to foraging, and later during migration to hibernation (Collard 1991).

Wind power facilities have been shown to adversely impact wildlife, especially birds (e.g., Orloff and Flannery 1992, Leddy et al. 1999, Woodward et al. 2001, Hunt 2002, USFWS 2003) and some bats (Keeley et al. 2001, Johnson et al. 2002, West 2002, Johnson 2003, West 2003). No direct impacts to pallid bats have been reported in these studies. This may be due to the fact that no wind power projects have been situated in known pallid bat habitat.

MANAGEMENT RECOMMENDATIONS

Lack of knowledge about the biology of the pallid bat severely hinders our ability to protect and manage the life history requirements necessary to sustain and enhance Washington populations. Clearly, further research is required to more effectively manage pallid bat habitat. In order to fill these knowledge gaps, surveys need to be conducted in eastern Washington to identify pallid bat roost sites.

Because of habitat loss due to conversion and development (Chapman et al. 1994), all known roost sites of the pallid bat need to be protected from human activity when there is potential conflict (especially hibernacula and maternity roosts). Given that pallid bats are closely associated with steep rocky cliffs and rock outcrops in arid habitats (particularly those near water) (Orr 1954, Vaughn and O'Shea 1976, Whitaker et al. 1981, van Zyll de Jong 1985,), these areas should be preserved and protected where pallid bats are known to occur. In light of the fact that conversion of sagebrush-steppe is increasing in Washington (Washington State Department of Natural Resources 1998), future conversions should be avoided and restoration of potential habitat is recommended. Minimizing conversion of foraging habitat that is in close proximity to suitable roosting habitat is most important from a conservation perspective.

In areas where large maternity or hibernacula roosts are known to exist, applying either spatial or temporal restrictions can minimize the impact of forest management practices. Logging operations in areas with known maternity colonies should be restricted during May to August. If operations must take place during these months, a buffer area around the maternity site should be identified. A qualified wildlife biologist with a background in bat ecology should be consulted when setting buffer widths. These same restrictions should be applied to other activities (e.g., industrial, hiking, rock climbing, etc.) that may impact a maternity site or hibernaculum because many researchers have identified potential impacts (see O'Shea and

Vaughan 1977, Hoffmeister 1986, Miller 2000), especially during the warm summer months (O'Shea and Vaughan 1977, Lewis 1996).

Since pallid bats use caves and mines as roost sites (Howell 1980, van Zyll de Jong 1985, Nagorsen and Bingham 1993), all caves and mines within the range map of the pallid bat should be surveyed to determine the presence or absence of bats following appropriate survey protocols (Tuttle and Taylor 1994, Washington Department of Fish and Wildlife [WDFW] 1994, Altenbach 1995, Riddle 1995). If bats are detected and if there is potential for human disturbance in a cave, then bat-friendly gates should be installed (Dalton and Dalton 1995, Pate 1995, Riddle 1995). Some other general recommendations for bat-occupied caves are: buffer zones should be established when appropriate; all efforts should be made to reduce or eliminate access; avoid activities that affect the climatic quality of the cave; logging should not occur around the cave; caves containing maternity colonies should be closed from 1 May through 30 August; and, caves containing hibernacula should be closed from 1 November through 1 April (WDFW 1994).

Bridges have also been shown to be important night roosts for the pallid bat (Barbour and Davis 1969, Lewis 1994). Therefore, as many new bridges as possible should incorporate bat-friendly designs (Keeley and Tuttle 1996, 1999), and older bridges should be retrofitted following bat friendly designs (Keeley and Tuttle 1996). Bat-friendly habitat can be provided in either new or existing bridges or culverts, at little or no extra cost. For a thorough discussion of bridge construction and retrofitting see www.batcon.org/bridge/ambatsbridges/index.html.

To reduce bat predation near residential areas, pet-owners should refer to www.abcbirds.org /cats/brochure/brochure.htm for recommendations.

Because pesticides can potentially harm the pallid bat (Collard 1991, Chapman et al. 1994, Environment Canada 2003), the use of pesticides within the range of this species should be minimized, particularly around areas with known maternity colonies and hibernacula. In general, pesticide use around caves, wetland and riparian areas should be restricted or closely controlled. Review Appendix 1 for contacts to assist in assessing the use of chemicals and other alternatives if their use is planned in such areas.

With the increase of wind power plants in the Pacific Northwest and their potential negative impact on bats (Keeley et al. 2001, Johnson et al. 2002, West 2002, Johnson 2003, West 2003), all proposed projects within the range of pallid bats need to identify potential impacts, especially if a project is near a maternity or hibernacula site. The impact of wind power on pallid bats and other bat species needs further study.

Because some researchers suspect that foraging areas are impacted by livestock grazing (Chapman et al. 1994), it is suggested that land managers reduce grazing, use deferred rotation or rest-rotation grazing systems, and space water developments to disperse livestock to mitigate the effects of grazing on this species' habitat.

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PERSONAL COMMUNICATIONS

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KEY POINTS

Habitat Requirements

- Pallid bats roost in a variety of substrates in or around grasslands and vegetation dominated by dry shrub or dry forested habitat near water and in arid and semi-arid climates with an average rainfall of 20-38 cm/year (8-15 in) and an average summer daily maximum temperatures up to 38E C (100E F).
- This species has been found to roost in rocky outcrops, karst formations, caves, mines, mud tubes, basalt cracks, open man-made structures (e.g., porches and garages), cliff overhangs, rock crevices, trees and tree cavities, and under bridges.
- Typical shrubs in areas where pallid bats occur include antelope bitterbrush, sagebrush, rabbit-brush, and forest cover types including ponderosa pine along lower slopes, and riparian forests.
- Forested habitat used by pallid bats consists of riparian forest along lakeshores and streams, and dry forest dominated by ponderosa pine on lower slopes.
- They forage primarily in large (>0.5 km [0.3 mi] in length) uncluttered, sparsely vegetated habitats.
- Reproductive female bats select day roost trees that are large in diameter (average = 66 cm [26 in] dbh) having loose exfoliating bark and surrounded by high densities of snags, logs, and trees of large diameter (>61.0 cm [24 in] dbh).
- The pallid bat is a terrestrial forager, taking large, ground-dwelling or slow-flying prey.
- Pallid bats seem to favor rock slabs on cooler days and rock crevices on warmer days.
- Roosts tend to open to the south or southeast for morning warmth and protection from intense afternoon sun.
- Horizontal crevices with stable warm temperatures of 30° C (86E F) are preferred as day roosts during the summer.

Management Recommendations

- Identify pallid bat roost sites.
- Preserve and protect steep rocky cliffs and rock outcrops in arid habitats, particularly those near water.
- Protect pallid bat roost sites, placing these sites off limits to human activity when there is potential conflict (especially hibernacula and maternity roosts).
- Avoid shrub-steppe conversions, especially in close proximity to suitable roosting habitat.
- Avoid disturbance of hibernacula sites at all times if possible, but in particular from May through August. If disturbance cannot be avoided or delayed, establish buffers surrounding site.
- Survey all caves and mines within the range of the pallid bat following appropriate survey protocols. If bats are detected, then bat-friendly gates should be installed.
- Design new bridges and retrofit older bridges following bat-friendly designs.
- See http://www.abcbirds.org/cats/brochure/brochure.htm for information to reduce predation of bats and birds by domestic cats.
- Decrease the use of pesticides within the range of the pallid bat, particularly around areas with known maternity colonies and hibernacula.
- Analyze the impact of all proposed wind power projects within the range of the pallid bat, especially when a project is near a maternity or hibernacula site.
- Reduce livestock grazing, use deferred rotation or rest-rotation grazing systems, and space water developments to disperse livestock to minimize the effects of grazing on pallid bat habitat.

Townsend's Big-eared Bat

Corynorhinus townsendii

Last updated: 2005

Written by Kent Woodruff and Howard Ferguson

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Townsend's big-eared bat (Townsend's bat) occurs from Williams Lake in south-central British Columbia to Baja California, Sonora, and Oaxaca in Mexico, north through the central highlands of Mexico, central Texas, western Oklahoma, eastern Colorado, and central South Dakota, and northwest through central Montana to Creston, British Columbia. Isolated populations occur in the limestone regions of Missouri, Arkansas, Oklahoma, Kentucky, Virginia, and West Virginia (Barbour and Davis 1969, Hall 1981, Kunz and Martin 1982, van Zyll de Jong 1985, Nagorsen and Brigham 1993, Verts and Carraway 1998).

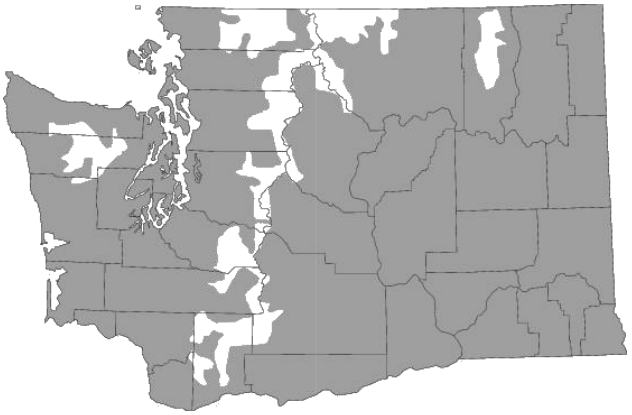

Figure 1. Potential range of the Townsend's big-eared bat (*Corynorhinus townsendii*) in Washington based on Johnson and Cassidy's (1997) habitat modeling analysis.

Townsend's bats have been documented in nearly every county in Washington (Johnson and Cassidy 1997, Washington Department of Fish and Wildlife 2005). This species occurs statewide where there is suitable habitat (see Figure 1; Johnson and Cassidy 1997).

RATIONALE

The U.S. Fish and Wildlife Service has designated the Townsend's bat as a Federal Species of Concern. Locally, this bat is a Candidate for the Washington Department of Fish and Wildlife's Threatened and Endangered species list, and the U.S. Forest Service has designated it as a sensitive species for Washington (U.S. Forest Service 2004). Townsend's bats are considered rare throughout their North American range (Fellers and Pierson 2002). Population declines have been noted in Washington (Senger 1973), Oregon (Perkins and Levesque 1987), and California (Pierson and Rainey 1998).

HABITAT REQUIREMENTS

Most bats in temperate climates have a strategy for survival where part of the time is spent foraging in various habitats, while the remaining time (daytime in summer, or for extended periods in winter) is spent in roosts. Most habitats in Washington are suitable for feeding by Townsend's bats. However, the distribution of suitable roosts influences the actual locations where they are able to feed. Another limiting factor may be the availability of water, particularly in the arid regions of the Great Basin (Geluso 1978).

This species uses caves, mines, hollow trees, and built structures for roosting (Pearson et al. 1952, Graham 1966, Humphrey and Kunz 1976, Pierson 1988, Pierson et al. 1999). During summer, females roost in communal maternity colonies, while males roost solitarily or in small groups (Sherwin et al. 2003). Mixed-gender colonies have been documented in winter hibernacula (Doering 1996). No comprehensive studies of year-round habitat use by Townsend's bats exist. Therefore, a complete picture of this species' life history is unknown.

Vegetation

In Washington, Townsend's bats are found in westside lowland conifer-hardwood forest, ponderosa pine (*Pinus ponderosa*) forest and woodlands, mixed highland conifer forest, eastside mixed conifer forest, shrub-steppe, and both eastside and westside riparian-wetlands (Johnson and Cassidy 1997, Washington Department of Fish and Wildlife 2005). The current extent of suitable habitat is similar to the historical distribution for Townsend's bats in the interior Columbia basin (Wisdom et al. 2000).

Information about the effects of land management on habitat use by Townsend's bats is limited. In western Washington, Erickson and West (1996) found minor use of clearcuts and pre-commercially thinned Douglas-fir (*Pseudotsuga menziesii*) / western hemlock (*Tsuga heterophylla*) stands, and no use of young or mature stands.

Snags and large trees may be important roosts for this species. In northwestern California, Fellers and Pierson (2002) documented individual Townsend's bats using tree hollows created by fire or rot in very large redwood (*Sequoia sempervirens*) and California bay trees (*Umbellularia californica*). A nursery colony was found using the basal hollows of large redwood trees in northwestern California (Mazurek 2004) and in Muir Woods National Monument near San Francisco (Heady and Frick 2001).

Water

For many insectivorous bats, daily water requirements are mainly met through metabolic water (i.e., water generated by the biochemical processing of digested nutrients) or water contained in captured prey. Remaining water needs are met through drinking water gathered at ponds, streams, and artificial impoundments (Kurta 2000). Townsend's bats may depend to a greater extent on drinking water compared to other species (Geluso 1978). This species is known to lick water from the ceilings of caves (J. Nieland, Personal Communication).

Food

Townsend's bats are moth specialists but consume a variety of other arthropods when available (Ross 1967, Whitaker et al. 1977, Bauer 1986, Dalton et al. 1986, Sample and Whitmore 1993, Burford and Lacki 1998). The most common food gathering strategies are gleaning insects from foliage and hawking insects in flight (Fellers and Pierson 2002).

Townsend's bats lose an average of 1/4 to 1/2 of their body weight during winter hibernation (Humphrey and Kunz 1976, Wackenhut 1990). Therefore, when bats emerge from hibernation in early spring, fat reserves are depleted, and survival depends on finding insects. Females also need abundant food to provide nutrition to nursing young.

Insect populations change, sometimes drastically (e.g., moth "outbreaks") over the course of a season, a year, or several years (Wickman et al. 1993). It is probable that Townsend's bats opportunistically forage on the most available or abundant food and will alter their diet when another suitable food source becomes available. It is also possible that nursing females have different food and water requirements than males (Whitaker et al. 1977, Bauer 1986). The difficulty in determining specific food habits over time and space limits our understanding of how these bats adjust to changing insect fauna.

Roosts

Suitable roosts are critical components for survival of Townsend's bats. Roosts are used for hiding, resting, and to conserve energy or to meet various other needs. Temperature and substrate are likely key factors in determining which structures will be used for roosting. Pearson et al. (1952) noted that in all seasons, bats of either sex tended to be awake when roosting in places warmer than 17°C (62°F), while those roosting at lower temperatures were usually torpid (i.e., lowered body temperature to reduce energy loss).

Day Roosts. Day roosts are structures used during daylight hours in the active season (as opposed to the hibernation season) to rest or hide. In Washington, old buildings, silos, concrete bunkers, barns, caves, and mines are common roost structures (Washington Department of Fish and Wildlife 2005). Sherwin et al. (2000a) surveyed 820 potential roost sites in northern Utah in bridges, caves, and mines. One hundred ninety-six were used as day roosts by Townsend's bats. Caves and mines were found to be valuable day roosts while bridges were not. Individual males occasionally day-roosted in cave-like bridge abutments in California (Pierson et al. 2001)

Maternity/Nursery Roosts. These are day roosts used by females during the spring and summer to bear and care for young. Nursery roosts in Washington have been found in caves, mines, barns, abandoned houses, actively used buildings, concrete silos and bunkers, and large "rooms" in concrete dams (Washington Department of Fish and Wildlife 2005). Colonies typically contain 20 to 250 females (Pearson et al. 1952, Turner and Jones 1968, Humphrey and Kunz 1976, Perkins 1992, Pierson and Rainey 1998) that give birth to one young after a gestation period of 55-100 days (Pearson et al. 1952). Annual production in nursery colonies ranges from 20–90% of females raising volant (i.e., capable of flight) young (Pearson et al. 1952, Humphrey and Kunz 1976, Fellers 1993, Pierson and Fellers 1998).

Temperature within nursery roosts has long been considered a key factor for survival and development of young; however, recent studies at a number of Washington and Oregon sites indicate that a wide range of temperatures is tolerated by nursery colonies (H. Ferguson unpublished data, K. Woodruff unpublished data). Temperatures at maternity roosts in California ranged from 19^{o}C-30^{o}C (Pierson et al. 1991).

Newborn young have been observed in nursery colonies in Washington between June-mid July (Scheffer 1930, Dalquest 1947, H. Ferguson unpublished data, K. Woodruff unpublished data). Young can fly feebly at about three weeks of age, and are weaned by six weeks (Pearson et al. 1952). Summer colonies in Washington begin breaking up by early September (D. Young, Personal Communication, H. Ferguson unpublished data).

Although a comprehensive survey of available roosts has not been done in Washington, buildings are the most commonly reported nursery sites in the state (Washington Department of Fish and Wildlife 2005). In Washington and Oregon, Townsend's bats are known to use individual caves for both maternity roosting and winter hibernation. This phenomenon likely occurs at caves with complex features that produce appropriate airflow and temperatures in summer and winter (J. Nieland, Personal Communication).

Night Roosts. Night roosts are sites where bats digest food, rest, and seek safety from predators (Kunz and Martin 1982). These sites also facilitate social interaction among Townsend's bats (Kunz and Martin 1982). Unlike day roosts, these are very short-term roosts used for minutes to hours during the night as stopover hiding and resting places between feeding bouts. Beyond chance encounters with Townsend's bats in locations that are easy to access, little is known about the use of night roosts. Keely and Tuttle (1999) reported the use of bridges as day and night roosts by Townsend's bats in southwestern Oregon in July. Of 744 bats recorded at night roosts on bridges in western Oregon, only a single bridge had a Townsend's bat (Adam and Hayes 2000). Occasionally, Townsend's bats have been encountered night-roosting under bridges in eastern Washington and California (Pierson et al. 2001, Washington Department of Fish and Wildlife 2005).

Winter Roosts/Hibernacula. Townsend's big-eared bats require "rooms" for hibernation that provide 1) protection from predation, 2) cold, but not freezing, temperatures, and 3) a degree of solitude that limits unwanted arousal from torpor. These are long-term roosts used for weeks to months at a time. Hibernacula

frequently serve as breeding sites (Pearson et al. 1952). Townsend's bats in northern temperate latitudes have been found hibernating in caves, lava tubes, mines, and occasionally built structures (Dalquest 1948, Pearson et al. 1952, Humphrey and Kunz 1976, Pierson 1988, Pierson and Rainey 1998). In Washington, the few known hibernacula are mostly in caves and mines (Senger 1973, Adler 1977, Perkins 1990, Washington Department of Fish and Wildlife 2005).

Townsend's bats hibernate singly or in clusters. They tend not to roost close to other bat species, although individuals of other species are often present elsewhere in the roost (Marcot 1984, Genter 1986, Stihler and Brack 1992, Choate and Anderson 1997, Kuenzi et al. 1999, Hendricks et al. 2000, Sherwin et al. 2000b). Large numbers of Townsend's bats have been found in single hibernacula, including 3,500 before 1959 and 1,187 in 1992 in Jewel Cave South Dakota (Choate and Anderson 1997), and 2,000 in 1994 and 1,672 in 2003 in a cave in Idaho (S. Earl, Personal Communication).

Although cold temperatures are a critical quality of hibernacula, temperature variations have been documented. Doering (1996) found successful hibernacula to have temperatures less than that of deep soil in Idaho. Townsend's bats chose locations where temperatures ranged from 0.0-2.5°C (32-37°F), despite higher temperatures found in surrounding areas. In contrast, Townsend's bats in another Idaho study inhabited significantly warmer regions of caves even when cooler areas existed (Genter 1986). In a third Idaho study, Wackenhut (1990) recorded a wide range of temperatures (0.6 to 13.7°C [33 - 57°F]) and humidity (44 to 90%) in 13 caves occupied by over 500 Townsend's bats. This study found no relationship between relative humidity and bat numbers.

Movements

Tracking bats equipped with radio transmitters is the most effective method to obtain information on movement. However, limitations of this technology and difficulties while tracking individuals in the field typically result in information for only a small number of individuals over short time periods. Townsend's bats typically move up to 5 km (3 mi) from roosts to foraging sites during the summer. In eastern Washington, one individual traveled 23 km (14 mi) in a single night (H. Ferguson, unpublished data). In California, Townsend's bats traveled up to 10.5 km (6.5 mi) from day roost to foraging area and were loyal to foraging sites over consecutive nights. Centers of activity from roosts in this study averaged 3.2 km (2 mi) for females and 1.3 km (0.8 mi) for males (Fellers and Pierson 2002).

Lactating females have high-energy demands and may travel several kilometers to meet these demands. Maximum foraging distances from nursery roosts ranged between 5 and 13 km (3-8 mi) in Kentucky (Adam et al. 1994), California (Brown et al. 1994), and Oklahoma (Clark et al. 1993, Wethington et al. 1996). Bradley (1996) found females in east-central Nevada commonly foraging up to 7 km (4 mi) from nursery roosts and repeatedly returning to the same locations. As the nursery season progressed, females in Oklahoma traveled farther from nursery sites to forage, averaging about 1 km (0.6 mi) early in the season, and eventually averaging 4 km (2.5 mi; Clark et al. 1993).

The distance traveled between hibernacula and nursery sites is more difficult to discern. Individuals apparently use a series of interim roosts between hibernacula and nursery sites and show little fidelity to any interim roost. In Oregon, an individual Townsend's bat migrated 24 km (15 mi) from hibernaculum to its foraging areas and stayed in temporary roosts before arriving at the nursery site (Dobkin et al. 1995). The choice of interim roost sites likely depends on availability of suitable foraging locations (Dobkin et al. 1995). Wackenhut (1990) reported that the longest distance moved between caves over different seasons was 8.3 km (5 mi).

Townsend's bats are thought to frequently survey their environment for alternate summer roosts and may easily adapt to new roost structures. Townsend's bats in Nevada appeared to have a working knowledge of alternate summer roost locations, using alternate caves up to 6 km (4 mi) away (Bradley 1996). Individual bats in California were found using nine alternate roosts (Fellers and Pierson 2002). In eastern Washington, up to three alternate nursery sites in buildings have been documented (H. Ferguson unpublished data, K. Woodruff unpublished data). Also, the use of newly constructed buildings (e.g.,

buildings with windows not open previously, or broken windows) as day roosts and maternity sites has been noted (K. Woodruff unpublished data). In one instance, a building containing a nursery roost in eastern Washington was physically moved 1 km (0.6 mi) and subsequently reoccupied (McCreary 2003).

Movements also occur between nursery sites (Pearson et al. 1952, Graham 1966, Humphrey and Kunz 1976, Clark et al. 1996, Szewczak et al. 1998; J. Nieland, Personal Communication). Bats in nursery colonies in Nevada moved an average of 2.3 times, and as many as 5 times during one nursery season using three distinct roosts on average (Sherwin et al. 2000b). Fellers and Pierson (2002) located nine alternate roosts during a recent study of a colony in coastal California.

Movements between winter roosts have also been observed (Twente 1955, Senger 1973, Humphrey and Kunz 1976, Adler 1977, Wackenhut 1990, St. Hillaire 2005). In a survey of 1200 mines and 43 caves in Utah and Nevada, winter movement among sites was found to be common (Sherwin et al. 2000b).

LIMITING FACTORS

Disturbance of roosts by humans (e.g., recreation, mining, bat research, vandalism) is noted as a concern by many researchers (Graham 1966, Barbour and Davis 1969, Senger 1973, Humphrey and Kunz 1976, Perkins and Levesque 1987, Pierson and Rainey 1998, Ellison et al. 2003). However, in some cases, what has been interpreted as roost abandonment might actually reflect normal movements (Sherwin et al. 2000a, Sherwin et al. 2000b, Sherwin et al. 2003).

While careful monitoring of Townsend's bats in hibernacula appears to have had little effect on long-term population stability (Choate and Anderson 1997, Jagnow 1998, St. Hillaire 2005), research-related handling at roosts has apparently resulted in declines of hibernating populations in later years (Graham 1966, Humphrey and Kunz 1976, Pierson 1988, Brown et al. 1994, Choate and Anderson 1997, Pierson and Rainey 1998). Because it is difficult to thoroughly identify and census discrete populations, actual effects of human activity at roosts is still unclear.

The loss of old buildings, barns, warehouses, silos, and other buildings, and the physical closure or reactivation of underground mines reduces available roosts. Normal hillside erosion can also close entrances to mines used by bats. The loss of roosts is a critical limiting factor because new mines are not being created at the rate they are being lost, and abandoned buildings are becoming much less common.

Forest and range management with fire is becoming common and the effect of vegetation changes resulting from fire is unknown. With the exception of loss of large hollow trees that might serve as valuable roosts, our knowledge of the effect of vegetation changes following timber management on Townsend's bat habitat also is limited.

Several mammals are known to prey on Townsend's bats (Clark et al. 1990, Pierson et al. 1999, Fellers 2000). Domestic cats are a problem in some areas (Pierson et al. 1999). Black rats (*Rattus rattus*) were a serious problem at a roost in California (Fellers 2000).

While there is much to learn regarding the impact of wind turbines to bat populations, initial indications suggest that consequences for Townsend's bats are minor (Erickson et al. 2002).

The degree that insecticides and other chemicals affect bats is largely unknown (see Clark and Hothem 1991, Clark et al. 1997, Clark 2001, and Clark and Shore 2001, O'Shea et al. 2001, O'Shea and Clark 2002 for discussion of effects of pesticide). However, insecticides reduce insects that are potential sources of prey (Sample 1991). Because nursing bats and those leaving hibernacula have high insect demands (Humphrey and Kunz 1976, Wackenhut 1990), insecticide use near hibernacula and nursery roosts likely limits populations. Bats may be harmed by ingesting water containing toxic chemicals (Clark 1991, Clark and Hothem 1991). Water quality can have indirect effects on bats by influencing insect abundance (Vaughan et al. 1996).

MANAGEMENT RECOMMENDATIONS

Our ability to assess the current and future use of roosting habitat for Townsend's bats is limited. Incomplete protection of existing and potential roosts could greatly impact this species (Humphrey 1975, Sheffield et al. 1992, Altenbach and Sherwin 2000). Where caves and mines are proposed for management (especially mine closures or reactivations), carefully assess the site's potential as summer and/or winter roosting habitat (Altenbach et al. 2000).

Limit the potential for vandalism and other disturbances at all known and suspected Townsend's bat roosts. Periodically evaluate the effectiveness of methods used to deter disturbance. Posting signs, closing roads and trails, erecting fences, requiring licensed visitation, and closure with vandalism-resistant structures are options that should be considered. If monitoring shows that protective measures are insufficient, more restrictive methods should be applied. If it is necessary to exclude human activity from a cave or mine, close entrances using bat-friendly designs (see http://www.batcon.org/home/index.asp?idPage=53&id SubPage=87 for examples; Nieland 1998, Tuttle and Taylor 1998, Vories and Throgmorton 2002). Populations of Townsend's bats have increased when caves and mines are seasonally or completely closed (Pierson et al. 1991). Where recreational use in caves and mines can be accomplished without affecting habitat, provide access only when bats are known to be absent. For hibernacula this is May 15 to September 15. For nursery sites this is September 15 to April 1. If bats are encountered during these periods, use by humans should be terminated. For sites where both nursery and hibernation roosts occur, recreational use is incompatible.

Support entrances to caves and mines used by bats to keep them from caving in or sliding shut.

When old mines are reopened for mining or other situations occur that are hazardous to bats, eviction of colonies should only be a last resort. If such action is warranted, consult and follow guidelines in Brown et al. (2000) (see http://www.mcrcc.osmre.gov/PDF/Forums/Bats%20and%20Mining/Proceedings/3i.pdf).

When surveying to determine if abandoned mines are occupied by colonies, follow protocol developed by Altenbach et al. (2000) (see http://www.mcrcc.osmre.gov/PDF/Forums/Bat Gate/TOC.pdf). Sherwin et al. (2003) noted that in surveys of over 1300 mines and caves in Utah and Nevada, an average of more than 8 visits was required to reliably determine the absence of Townsend's bats from a site. Analysis of bat guano can also confirm use by Townsend's bats (Zinck et al. 2004).

Assess old buildings, caves, and mines in spring, summer, and fall near proposed projects to determine the presence or absence of bats before beginning any project. Consult a qualified biologist to inventory sites using standard, accepted methods described in the Townsend's Big-eared Bat Conservation Assessment and Conservation Strategy (Pierson et al. 1999). Favor acoustic and visual inventory methods over internal surveys. Protect all sites where bat roosting has been documented. Maintain and repair buildings used by Townsend's bats to reduce loss of roosting habitat. Local fire departments should survey abandoned buildings for bat colonies prior to selecting them for practice burns.

Because Townsend's bats use bridges (Barbour and Davis 1969, Keely and Tuttle 1999), all new or repaired bridges should use bat-friendly designs (e.g., concrete cast in place "open beam" or "I-beam" construction) (Keeley and Tuttle 1999). Such designs can be accomplished in bridges or culverts at little or no extra cost. For a discussion on designs see http://www.batcon.org/bridge/ambatsbridges/index.html.

Restrict bat access to contaminated water such as cyanide impoundments, standing water at "heap leach" facilities, water at pulp facilities, standing water at landfills, spilled/sprayed pesticides associated with agriculture, and waste water at livestock and poultry facilities by using netting or other non-lethal means.

Insecticides often eliminate prey that would otherwise be consumed by bats. Specific insecticides, such as those designed to kill only moths (e.g., controls used in agriculture and forestry) likely have negative consequences to bats by reducing potential prey. Use pesticides only in accordance with labels and

consistent with Material Safety Data Sheets. Because Townsend's bats routinely forage up to 5 km (3 mi) from roosting colonies, do not use insecticides within 5 km of known nursery or winter roosts.

Retain the largest trees in timber management activities consistent with historic conditions for the site, and retain all trees >50 cm (20 inch) diameter with hollows and cavities. Follow Timber Fish and Wildlife guidelines for timber management activities.

Healthy riparian and aquatic systems provide a valuable source of insect prey and, consequently, are important for bats (Diaz and Mellen 1996, Knutson and Naef 1997). Recommendations for managing riparian habitat are available in WDFW's *Management Recommendations for Washington's Priority Habitats: Riparian* (see PHS Riparian).

Limit domestic predator access to bat roosts (Pierson et al. 1999) and, if necessary, conduct live trapping and removal. Such removal is critical at sites where feral cats or rats are present.

During research activities, follow approved methods for bat surveys that are consistent with Sheffield et al. (1992), Province of British Columbia (1998), Pierson et al. (1999), and Altenbach et al. (2000) to reduce disturbance.

Carefully assess any proposed wind projects near known Townsend's bat colonies (Kunz 2004). Follow guidelines identified in *Interim Guidelines to Avoid and Minimize Wildlife Impacts From Wind Turbines* (see http://www.blm.gov/nhp/what/lands/realty/FWS_wind_turbine_guidance_7_03.pdf).

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KEY POINTS

Habitat Requirements and Natural History

- Forages nightly during spring, summer, and fall in various habitats, while remaining time (mostly daytime in summer, or for extended periods in winter) is spent in roosts.
- Uses caves, mines, large snags and trees, and built structures for roosting.
- Found in a diverse range of vegetative communities throughout Washington.
- Consumes moths primarily, but will opportunistically forages on the most available food.
- Suitable roosts are critical to survival:
    - *Day Roosts*. Structures used during daylight hours to rest or hide. Old buildings, silos, concrete bunkers, barns, caves, and mines are common roost structures.
    - *Maternity/Nursery Roosts.* Sites include caves, mines, barns, abandoned houses, actively used buildings, concrete silos, bunkers, and large "rooms" in concrete dams to bear and care for young. Young are present between June and mid August, and colonies leave nursery sites by early September.
    - *Night Roosts.* Sites that assist with social interaction, digestion, rest, and serve as refuge from predators. Little is known about locations or use of night roosts.
    - *Winter Roosts/Hibernacula.* Sites must provide protection from predation; cold, but not freezing temperatures; and a degree of solitude that limits unwanted arousal. The few known hibernacula in Washington are mostly in caves and mines.
- Lactating females may travel up to 13 km to forage for insects.
- The distance traveled between hibernacula and nursery sites is difficult to discern. Individuals use a series of interim roosts between hibernacula and nursery sites, showing low fidelity to interim roosts.
- Townsend's bats possibly survey for alternate maternity, nursery, and day roosts during the summer and may easily adapt to new roost structures. Movements between winter roosts have also been documented.

Management Recommendations

- Where caves and mines are proposed for management (especially mine closures or reactivations), carefully assess the site's potential for roosting in all seasons.
- Limit vandalism and other disturbances at known and suspected roosts. Posting signs, closing roads and trails, erecting fences, requiring licensed visitation, and closing with vandalism resistant structures should be considered. If human exclusion is required, close cave/mine entrances with bat-friendly gates (see http://www.batcon.org/ home/ index.asp?idPage= 53&idSubPage=87 for examples).
- Where cave/mine recreation can be done without affecting habitat, provide access only when bats are known to be absent. For hibernacula this is May 15 to September 15. For nursery sites this is September 15 to April 1. If bats are found during these periods, use by humans should be terminated. At sites used as both nurseries and hibernacula, recreational use is incompatible.
- When old mines are reopened for mining or other situations occur that are hazardous to bats, colony eviction should be a final resort.
- When surveying to see if abandoned mines contain colonies, follow protocol at http://www.mcrcc.osmre.gov/PDF/Forums/Bat Gate/TOC.pdf.
- Before beginning any project, use qualified biologists to assess nearby old buildings, caves, and mines in spring, summer, and fall to determine the presence or absence of bats.
- Maintain and repair buildings used by Townsend's bats to reduce loss of roosting habitat. Fire departments should survey abandoned buildings prior to selecting them for practice burns.

- Because Townsend's bats use bridges, all new or repaired bridges should use bat-friendly designs (see www.batcon.org/bridge/ambatsbridges/index.html).
- Where forests stands are being used for roosting, retain all trees >50 cm (20 inch) diameter with hollows and cavities.
- Maintain healthy riparian/aquatic systems as a source of insect prey (see the PHS riparian publication for details).
- Limit and remove domestic predators, especially feral cats and rats, by qualified animal damage specialists.
- Follow approved methods for bat surveys and research.
- Assess proposed wind projects near known colonies (see http://www.fws.gov/r9dhcbfa/wind.pdf).

Western Gray Squirrel

Sciurus griseus

Last updated:2010

Written by Mary J. Linders, W. Matthew Vander Haegen, Jeffrey M. Azerrad, Robin Dobson, Ted Labbe

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Western Gray Squirrels (*Sciurus griseus*) range from north-central Washington to the southern border of California, west to coastal California, and east to the Nevada border (*3*).

Historically, Washington's Western Gray Squirrels were found along the entire length of the East Cascades from southern Klickitat County up through Chelan and southern Okanogan Counties (Figure 1; *44*). Their range likely ran along the Columbia River from eastern Klickitat County west through Cowlitz County, and from Cowlitz County north through western Pierce County.

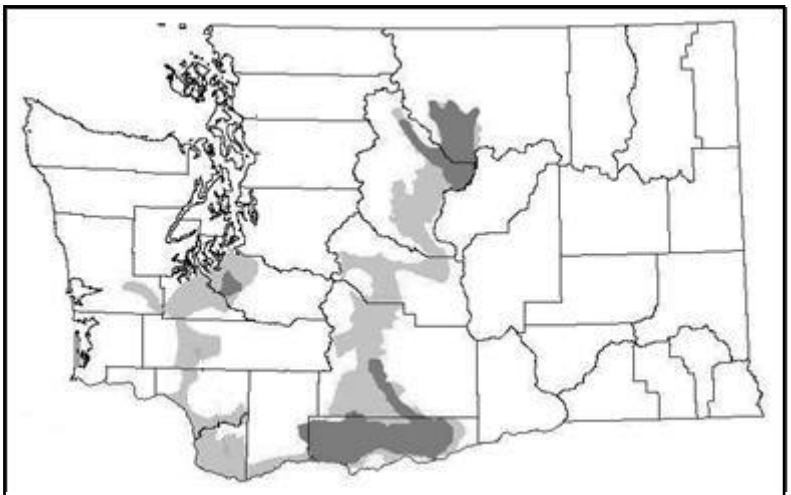

Figure 1. Historic (light) and current (dark) range of the Western Gray Squirrel in Washington.

The range of the Western Gray Squirrel has contracted significantly, leaving three isolated populations (Figure 1). The largest population is unevenly distributed from Underwood in Skamania County east through Klickitat County into southern Yakima County (*44*). This will be referred to hereafter as the Klickitat population. Another population is in northern Chelan and southwestern Okanogan counties, hereafter referred to as the Okanogan population. The Okanogan population is the only one outside of Washington's Oregon White Oak (*Quercus garryana*) range. The only population in western Washington is restricted to Joint Base Lewis-McChord in Pierce County (*44*). This will be referred to hereafter as the Puget Trough population. Scattered observations have been verified in localized areas outside of the range shown in Figure 1. Many of these isolated observations are over 20 years old and are likely in locations that are no longer occupied (WDFW's Wildlife Survey Data Management Database). More recent observations outside the current range may represent dispersing individuals or small populations that have yet to be verified.

Within Washington's Western Gray Squirrel range other similarly sized tree squirrels also occur. The non-native Eastern Gray Squirrel (*Sciurus carolinensis*) is one that sometime is misidentified as being a Western Gray Squirrel. Although a trained observer can readily distinguish these closely related species, a pamphlet titled *The Western Gray Squirrel and Other Squirrels in Washington* has useful information for those that are not as familiar with the morphological differences between these tree squirrel species.

RATIONALE

The U.S. Fish and Wildlife Service designated the Western Gray Squirrel as a "Species of Concern" in Washington (*59*, *60*). In the Columbia Gorge National Scenic Area this species was designated as "sensitive" by the U.S. Forest Service (*10*). The State of Washington designated Western Gray Squirrel as "Threatened" (WAC 232-12-011) in 1993 (*66*). Joint Base Lewis-McChord has committed to help recover this species in south Puget Sound (*14*). Although the current statewide population remains unknown, it likely falls somewhere between 468 and 1,405 individual squirrels (*44*). Because of their small population and given that high-quality habitat is isolated and in limited availability, this species is unlikely to persist without adequate conservation measures.

HABITAT REQUIREMENTS

Western Gray Squirrel habitat is typically in transitional, conifer-dominated areas that merge with open patches of oak and other deciduous trees. Mature and large seeded mast-producing trees provide abundant food and sites for nest construction (*27*, *33*, *42*). In Washington, pine and oak are especially important for their ability to produce an abundance of large-seeds. Seeds and nuts from other trees like hazelnut are also consumed. Trees >38 cm (15 in) diameter at breast height (dbh) may be important for reproductive fitness, given larger trees offer greater food and cover, as reported for the closely related Abert's squirrel (*Sciurus aberti*; *15*, *16*, *46*). Western Gray Squirrel habitat requires the presence of diverse foods such as nuts, seeds, and fungi. Higher quality habitat also has an interconnected canopy that can be used for arboreal travel (*25*, *27*, *32*, *42*, *52*). Ground cover in high-quality habitat is fairly sparse as a result of the relatively dense overstory (*42*, *53*). In general, the best habitat contains all the features just described within a relatively small geographical area. Females appear to select habitat based on food production, while males may choose locations that maximize their access to females (*42*). The best sites are occupied by adult females.

Western Gray Squirrel habitat patches range in size from individual trees to large forested stands. Forested stands used as habitat offer a long-term supply of seed and fungi, escape cover, and plentiful nest sites. Stands used as habitat typically have highly variable tree spacing. While suitable forested stands are critical, the presence of isolated, open-grown trees may provide a locally abundant source of seed (mast), secluded den sites for rearing young, or "stepping stones" used for travel across open expanses.

Western Gray Squirrels prefer stands consisting of clumps of trees that form a dense upper canopy intermingled within areas of lower canopy cover (*44*). Small canopy gaps are also characteristic of stands favored by squirrels. These qualities of Western Gray Squirrel habitat helps to create the following features within a localized area: 1) an interconnected canopy for escape cover, nest concealment, and discrete access to nests; 2) thermal protection of nests; 3) sunlight for basking; 4) abundance of seeds close to canopy gaps; 5) fungal concentrations under closed forest canopies, and 6) "viewsheds" for predator avoidance. Small patchy stands may also limit the spread of fire, and could help in restoring past fire regimes.

Habitat connectivity (i.e., via corridors) is essential for accessing mates, juvenile dispersal, predator avoidance, or movement between habitat patches. Almost any habitat containing trees can provide connectivity. However, corridors are more likely to be used when they have an irregular or complex canopy structure and when they are composed of mature trees. These features provide additional habitat value, and may assist squirrels in moving between habitat patches. Given the linear character of riparian areas, these may serve as important movement corridors, especially where dry uplands support limited tree cover. For small stands to effectively function as habitat, they must connect with larger areas of forested habitat.

Home Range

Western Gray Squirrel habitat must have food, shelter, safety, and access to mates within an animal's home range (i.e., area encompassing an animal's daily and seasonal travels). To access these resources, squirrels often have home ranges that encompass a mixture of habitats that vary in structure and composition (*2*, *27*, *33*, *42*, *52*). This mix of habitats can range from an isolated, open-grown oak or pine to a dense conifer-dominated stand. The presence of large-seeded mast producing species such as maple, ash, and hazel contributes to food diversity and possibly a more stable food supply within a home range (*30*), which may be tied to female reproductive fitness (*42*).

Home range size and shape can be highly variable depending on the nature and distribution of available resources. In Klickitat County, home ranges[1] averaged 22.1 ± 2.6 ha [2] (54.6 ± 6.4 ac) for females and 73.9 ± 16.9 ha (182.6 ± 41.8 ac) for males (*42*). In Okanogan County, female home ranges[1] averaged 75.2 ± 11.1 ha (185.8 ± 27.4 ac), whereas males averaged 281.0 ± 25.6 ha (694.4 ± 63.3 ac; *27*). The amount of overlap among adjoining home ranges tends to be low in Washington (*27*, *42*). Low home range overlap and large home range size is thought to be indicative of the relatively low habitat quality in Washington compared with populations further south (*27*, *42*, *43*). Consistent with this, these management recommendations consider differences in habitat quality across Washington State that result from site productivity.

A Western Gray Squirrel's home range, regardless of the resident's sex and age, usually consists of two types of use areas, referred to here as primary and secondary habitat. While these use areas may share many characteristics, it is the manner in which these habitats are used that best distinguishes them. Squirrels typically move daily between primary and secondary habitat in search of food, mates, and water and usually return to primary areas to sleep, rest, care for young, and feed during inclement weather. While areas of primary habitat exhibit little or no overlap between individuals, areas of secondary habitat can overlap considerably (*27*, *42*). The following descriptions are given to help identify the characteristics of primary and secondary habitat.

Primary Habitat. – While tracking radio-collared animals, core use areas used by individual squirrels were identified (*42*). Squirrels spent about 80% of their time in these core areas, particularly for nesting and foraging. Primary habitat was identified by evaluating the structure and composition of vegetation recorded in core-use areas. When squirrels are present, a concentration of stick nests is indicative of primary habitat; these are frequently-used nests, which occur in relatively dense conifer-dominated habitat (*27*, *42*).

Primary habitat for individual Western Gray Squirrels in Klickitat County averaged 4.9 + 0.75 ha (12.0 + 1.85 ac; N = 18), and varied based on habitat quality and composition (Linders, unpublished data; Table 1; *42*). Primary habitat may consist of one contiguous patch or several smaller patches in a matrix of secondary habitat (see secondary habitat description below; *42*). High-quality primary habitat is conifer-dominated (≥75 %) and composed of a multi-layered, well-connected canopy (45-75 % canopy cover[3]; *27*, *42*). These conditions enhance the production of underground fungi such as truffles (*41*), a staple in the squirrel's diet (*57*, *58*).

Trees in primary habitat are typically mature with dominant and co-dominant crowns. These trees have a patchy distribution where they form dense stands for nesting (*42*) and a variety of microclimates and light gaps that possibly help diversify food production (*39*, *41*, *47*, *56*). On the Klickitat Wildlife Area, an average of 28.8 ± 4.7 large conifers (≥40 cm) occurred for every hectare (12 trees/ac >16 in) of female occupied primary habitat (Vander Haegen, unpublished data). The forest structural characteristics needed for the Abert's squirrel (*15*) were similar to those of primary habitat in Klickitat County (*42*), particularly in areas occupied by reproductive females. Dodd et al. (*15*) recommends retaining at least 20 large trees/ha >40 cm (8 trees/ac >16 in) dbh to provide suitable nest trees and a good supply of food within primary areas.

Table 1. General characteristics of high quality primary and secondary Western Gray Squirrel habitat.

Characteristic	Primary Habitat	Secondary Habitat
Size	4.9 ha (12 ac) [1]	15 - 160 ha (37 - 395 ac)
Forest Composition	≥75% Conifer, ≤25% Deciduous	Variable, but conifer dominated
Canopy Cover	45 - 75%	25 - 75%
Shrub Cover	≤10%	≤30%
Ground Cover	Dominated by forest litter and moss	

1. Average size of a primary habitat area in Klickitat County

An open understory and low-growing shrubs are also characteristic of primary habitat. Shrub cover is typically less than 10 % (*33*, *42*) and shrub height is usually less than one meter (*42*). The ground surface is dominated (50 –

[1] 95% Fixed Kernel estimators of home range size developed from radio-telemetry data. Kernel estimators are based on probability "kernels", which are regions around each point location containing some likelihood of animal presence.

[2] Standard error around the mean is given for all average values presented from this point on.

[3] Canopy cover in Klickitat and Okanogan counties were estimated using a cover scope along with aerial interpolation.

80%) by forest litter and moss (*33, 42, 52*). The absence of taller (>1 m) understory vegetation (e.g., saplings, tall shrubs) likely reduces predation risk during foraging and travel.

Secondary Habitat. – The remaining 15 to 160 ha (37 -395 ac) of a squirrel's home range, with the exception of maternal den sites, is secondary habitat (*27, 42*). The size of a secondary habitat area is dependent on the sex and age of the occupant as well as habitat quality (i.e., lower quality habitat requires a larger secondary use area; *42*). The use of the word "secondary" does not imply a lack of importance, as this habitat may contain seasonal food resources critical to survival.

Compared to primary habitat, secondary habitat is more variable in tree species composition, canopy cover, and other characteristics. However, squirrels still favor stands of secondary habitat with moderate cover (26-75%) and a multi-layered, conifer-dominated canopy (>75%; *42*). Nest sites in secondary habitat are used by residents or visiting squirrels (*42*). Squirrel use of secondary habitat in Klickitat County almost always occurred in areas of limited cover (<30%) of low-growing shrubs (<1 m). Although they typically avoid areas of sparse canopy cover (<25 %), occasional use is possible in open areas where food or a secluded cavity make them attractive (*42*).

Breeding, Nesting, and Denning

The influence of habitat quality on reproductive fitness has not been established for Western Gray Squirrels. However, females promptly move into primary habitats that are vacated when an established female dies, suggesting a fitness value to the habitat (*62*). Breeding females typically exhibit exclusive use of primary habitat except while in estrous or while they are with their weaned offspring (*42*). Although Western Gray Squirrels have an extensive breeding season, individual females are known to have only one litter/year. This contrasts with other squirrels (e.g., Eastern Gray Squirrel) that are able to produce multiple litters in a single year (*38*). A Western Gray Squirrel litter typically consists of 1 to 5 young (*8*). While there are peaks in the number of pregnant females, fitness, age and local food supply ultimately determine the timing of an individual's reproductive cycle (*31*). As a result, there is considerable annual and spatial variation in the reproductive season, with most females pregnant by February or March and the last litters typically weaned by late August (Linders and Vander Haegen, unpublished data).

Like other tree squirrels, Western Gray Squirrels sleep in a nest at night, and use them to rest during the day (*31*). Nests are placed in the live (green) crown of the tree and within the live canopy of the stand[4]. Squirrels construct two types of stick nests: large, round shelter nests that provide protection from the elements and are sometimes used to rear young, and broad platforms for seasonal or temporary use (*42*). Shelter and platform nests may not be readily distinguishable from the ground as both are built with sticks, twigs, leaves, moss, and bark and have a length of 43-91 cm (17-36 in) and a height of up to 46 cm (18 in; *21, 29, 36*). Nests can be difficult to locate visually from the ground. An evaluation using radio-collared animals confirmed that the actual number of nests in primary habitat usually is higher than what an observer (even an experienced observer) is able to locate visually (Vander Haegen, unpublished data).

Typically found in tree cavities, natal dens are nests in which females give birth and rear their young. Although cavities are thought to provide better protection, stick nests are also used (*28, 42*). Natal dens are found in a range of environments including riparian areas, dry open slopes, and areas of moderate forest canopy. Natal den cavities usually occur in oaks, but may also be found in Black Cottonwood **(***Populus balsamifera***),** alder (*Alnus* spp.) and in conifers (Vander Haegen, unpublished data; *27, 28, 62*). Stick nests in Douglas-fir (*Pseudotsuga menziesii*) and Ponderosa Pine (*Pinus ponderosa*) have also been used for this purpose (*27*). Although oaks as small as 25 cm (10 in) may be used as natal dens, most dens in Klickitat County occurred in oaks >40 cm (16 in) dbh (*42*). Females sometimes use isolated oaks in forest openings as natal dens (*42*).

Within an individual's home range there are often numerous nests. This is believed to reduce exposure to parasites and predators, while improving access to distant habitat patches (*13*). Western Gray Squirrels frequently build nests in mature conifers >40 cm (16 in) dbh (*28, 33, 42*). The crowns of these trees are typically dominant or co-dominant and often interlock (<1 m separation) with the crowns of 3-4 surrounding trees (*27, 28, 33, 42*). This connection to adjacent trees provides an arboreal route to access a nest as well as protection from inclement weather (*31*). Smaller

[4] The "live crown of the tree" represents the portion of a nest tree containing live foliage (e.g., green needles). The "live canopy of the stand" is the point where live crowns of surrounding trees connect with one another.

trees can be used for nesting, but only where they intersect with the dominant or co-dominant crowns of surrounding trees. Nest tree characteristics are similar across the range of the Western Gray Squirrel (*7*, *21*, *25*, *28*, *42*, *52*).

Foraging habitat and food availability

Food is the primary factor regulating tree squirrel populations (*31*). Large squirrels must maximize access to a diversity of large-seeded trees such as oak and pine (*17*, *31*, *42*). Habitat quality in Washington is generally thought to be relatively poor compared to other parts of the species' range. This is believed to be the result of fewer species of large-seeded, mast-bearing trees (*42*). Ponderosa Pine may be the most reliable food in eastern Washington due to the shorter time between good crops (3-4 year) and the relatively large-sized seeds (*42*). Mature, larger diameter trees (>61 cm [24 in]) with crowns that dominate a stand tend to produce more seeds than smaller trees (*22*, *39*). Stands where ground water is readily available (e.g., riparian habitat) contain diverse vegetation that may produce more food (*47*, *48*, *54*). Ponderosa Pine cone production increases with tree diameter up to 80 cm (31 in), leveling off thereafter (*39*).

Acorns are another key source of food for most Western Gray Squirrels, but Oregon White Oaks do not produce large acorn crops every year (*9*, *56*). Oaks need to be at least 20 years old to produce acorn crops and maximum productivity is not attained until a tree is 80 years old (*47*). Although optimal stand density is unknown, open-grown oaks with a large leaf area are better acorn producers than crowded trees (*47*, *56*).

Hypogeous fungi (e.g., truffles) also make up a large portion of the Western Gray Squirrel diet, and are critical in years of poor mast production (*57*, *58*). Increasing forest canopy closure is positively correlated with fungal richness and biomass (*41*, *55*).

Western Gray Squirrels have been observed digging up and eating larval and adult rain beetles (*Pleocoma* spp.) in late winter and early spring in Klickitat County (*44*). It is not known if rain beetles constitute a significant portion of their diet during that part of the year.

Washington's Western Gray Squirrel Populations

Characteristics of Western Gray Squirrel habitat were studied in the Puget Trough (*53*), Klickitat (*42*), and Okanogan (*28*, *33*) regions. The following describes characteristics of habitat specific to each of these regions.

Klickitat Population. – Western Gray Squirrels in the Klickitat region favored conifer-dominated stands over mixed oak-conifer and pure oak (*42*). These squirrels were typically observed in areas with a conifer overstory and an open understory. Occupied stands often were dominated by a multi-layered canopy of Ponderosa Pine and an upper canopy >14 m (46 ft). Locally, the composition of stands sometimes varied to include Douglas-fir and Oregon White Oak. A sparse understory of oak with little or no shrub or ground vegetation was characteristic of occupied stands. Pine was most frequently used for nesting, foraging, and cover. Squirrels on the Klickitat study area selected habitat with moderate conifer cover (26–75%) at the scale of an individual's home range and moderate and dense (>75% canopy cover) conifer cover (>75% conifer) in primary habitat (*42*). Primary habitat in the Klickitat region averaged 54 ± 1.1% canopy cover (32 ± 1.1% cover pine, 16 ± 0.9% cover oak, 7 ± 1.0% cover Douglas-fir) where individual overstory trees averaged 2.9 ± 0.1 interlocking crowns (< 1 m from adjacent tree; *42*). Litter dominated the ground cover (75.6 ± 1.0%), while shrub and grass cover averaged 7.5 ± 0.6% and 6.8 ± 0.7% respectively.

Large conifers were used for nesting more often than expected relative to trees in surrounding stands (*42*). Nest trees used by radio-collared squirrels averaged 40 ± 1.3 cm (16 ± 0.5 in) in diameter for pine, 48 ± 2.8 cm (19 ± 1.1 in) for fir, and 46 ± 14.1 cm (18 ± 5.5 in) for oak. Of active nest trees, 72% were pine, 16% were fir, and 12% were oak, where pine and fir were used more often than expected. Nest trees were located in the stand interior, had crowns that connected to adjacent trees, and primarily had dominant or co-dominant crowns (*42*).

Okanogan Population. – In this region, squirrels were more likely to choose a site for nesting if basal area[5], tree diameter, and the number of tree species were all relatively high (*28*). The factors most important in nest tree selection were mistletoe infection (46% of nests incorporated mistletoe brooms in their structure), tree diameter, percent live canopy, and connectivity (*28*). Similar to the Klickitat population, Ponderosa Pine and Douglas-fir were the primary trees used for nesting (*28*, *33*). Nest trees were larger (average = 45 ± 1.8 cm [18 ± 0.7 in]) than random trees and the crowns were often connected to adjacent trees, although they exhibited less connectivity than that of nest trees in Klickitat County (*28*).

Average canopy cover for nesting areas in Okanogan County's Black Canyon watershed was 45.2 ± 2.6 % (*28*). In Chelan County's Stehekin Valley, most nests occurred in plots classified as having >25-50% or 50-75% canopy cover (*33*). Douglas-fir, Bigleaf Maple (*Acer macrophyllum*), and Ponderosa Pine accounted for most trees >10 cm (4 in) diameter in Stehekin Valley nest plots. Similar to Klickitat County, nesting occurred in areas with an open understory, sparse shrub and herbaceous cover, with the dominant ground cover of grass and woody debris. Most nesting plots in the Stehekin had ≤5% shrub cover (*33*). The few shrubs in nesting areas were fruit-bearing.

Puget Trough Population. – Western Gray Squirrels in the Puget Trough tended to use mixed oak-conifer stands >8 ha (20 ac) that were <600 m (1970 ft) from water (*53*). Squirrels were observed more frequently in stands with abundant and diverse food-bearing trees and shrubs and were found more often in mixed stands verses stands of pure oak (*53*). Stands where squirrels were observed most frequently had greater basal area in Douglas-fir, more young oaks, lower average ground cover, and more coarse woody debris. Recent research on Joint Base Lewis-McChord indicates that squirrels make high use of conifer-dominated stands and use Douglas fir most often for nesting (Vander Haegen, unpublished data). Bowles (*6*) and Ryan and Carey (*52*) noted that Western Gray Squirrel habitat in the Puget Trough was relatively low in shrub cover.

POTENTIAL LIMITING FACTORS

Habitat loss and degradation, road-kill mortality, competition, and disease all adversely influence Western Gray Squirrels in Washington (*27*, *44*). Habitat fragmentation and alteration from activities like development, road building, logging, wildfire, and fire suppression are likely to have had the greatest adverse effects on squirrels (*44*). Development can pose a challenge to conservation, especially in eastern Washington where nesting often occurs on private lands (*44*, *62*). Habitat used by squirrels is also sensitive to construction given that shallow roots of species like oak (*53*) are vulnerable to soil compaction (*26*, *51*). Roads bisecting squirrel habitat cause road-kills and can isolate local populations (*19*, *24*, *44*, *52*). Although carefully planned forestry can enhance Western Gray Squirrel habitat (e.g., thinning overstocked stands), logging can degrade habitat by destroying nest sites, reducing food supplies, and fragmenting the tree canopy that is used for travel and escape (*63*). While infrequent, low intensity ground fires can improve habitat, frequent or intense wildfires have the opposite effect. Fire suppression reduces habitat value by facilitating encroachment of excessive understory cover and less desirable species (*1*, *20*, *49*).

In addition to factors that influence habitat, disease and non-native species may impact Western Gray Squirrels. Disease outbreaks such as mange are an important factor regulating tree squirrel populations. Disease can temporarily reduce populations or increase the risk of local extinctions. Poor seed years or habitat conditions that reduce the availability of food may contribute to the likelihood and severity of a mange outbreak (*12*, *44*). Introduced and non-native competitors also may adversely impact Western Gray Squirrels. Eastern Gray Squirrels and Fox Squirrels (*Sciurus niger*) eat many of the same foods; they may also compete for food, nests, and other resources (*7*). Introduced Wild Turkeys also occur with Western Gray Squirrels in much of eastern Washington. Turkeys eat some foods that squirrels depend on (*64*) and can occur in large flocks with high food demands. Although turkeys and squirrels use forests of similar structure and competition may occur, no studies have explored their interactions. California Ground Squirrels climb trees and consume some of the same foods as Western Gray Squirrels; currently these species co-occur in Klickitat and Yakima counties (*44*). Predation and harassment by domestic pets may also impact Western Gray Squirrels (*52*). Other factors include military training, sporadic or irregular noise, and incidental hunting mortality (*44*).

[5] The area of a given section of land that is occupied by the cross-section of tree trunks and stems at their base.

MANAGEMENT RECOMMENDATIONS

Although the area surrounding a nest is important and should always be considered when managing for Western Gray Squirrels, the recommendations presented here have departed from the standard approach in favor of the protection of the habitat where squirrels spend the majority of their time. Rather than focusing conservation around each and every nest, we recommend that key habitat features be the focus of Western Gray Squirrel management. No matter if nests can or cannot be found, primary habitat should receive the most protection, followed by areas of secondary habitat (as described below). In many instances primary habitat will contain nest clusters and these nests should be a high priority for protection. However, areas within the recovery area (Figure 2) that have the right habitat characteristics should also be considered when managing for squirrels.

General Habitat and Vegetation Management

Information presented in the General Habitat and Vegetation Management section is meant to serve as a guide for managing any type of project that could impact Western Gray Squirrel habitat. Here guidance is given to protect primary and secondary habitat as well as critical habitat features such as nest trees and dens. Project timing, the use of buffers, and landscape-level management are also discussed in this section. Appendix 2 summarizes the key information provided in this section. Anyone involved in habitat enhancement, grazing, forestry, or residential development in Western Gray Squirrel habitat should also use the project-specific recommendations found later in this publication.

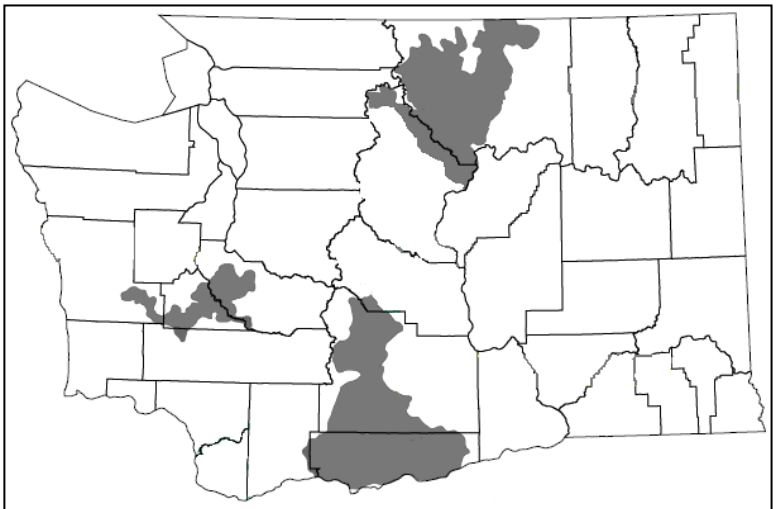

Figure 2. Recovery areas for Western Gray Squirrel in Washington.

Primary Habitat. – Intensive use of primary habitat by Western Gray Squirrels makes its protection a high priority. Retaining uncut patches of primary habitat provides suitable nest sites and helps maintain important resources that are sensitive to disturbance (e.g., truffles). Primary habitat may be identifiable by a concentration of stick nests, but where knowledge of nest locations is lacking or inadequate, stands in the Western Gray Squirrel recovery area (Figure 2) that exhibit the primary habitat characteristics listed below should also be considered for Western Gray Squirrel management. When a proposed project area is found to have characteristics of primary habitat, a survey of the site should be carried out to identify potential nest locations. Contact your nearest WDFW regional office to speak with a biologist in the Wildlife Program about accessing the most up-to-date WDFW survey protocol and to ask about survey training.

Because primary habitat appears to be limiting at the landscape scale, we recommend retaining at least 2 patches $\geq$2.5 ha (6 ac) of primary habitat per 20 ha (50 ac) of potential (primary and secondary) squirrel habitat. This ratio of primary to secondary habitat is based on data for female squirrels in Klickitat County (Linders, unpublished data; *42*). On less productive sites such as those found in the Okanogan region, the ratio of primary to secondary habitat may be lower (e.g., 2 patches $\geq$2.5 ha (6 ac) of primary habitat per 75 ha (185 ac) of potential squirrel habitat). Figure 3 provides the range of acceptable conditions for key components affecting Western Gray Squirrel habitat quality. When applying these ranges for habitat management, we recommend not aiming for the low end as that type of management has been shown to cause gradual population declines in forest species (*11*). Aiming for values somewhere in the middle of these ranges is likely to be more beneficial to local populations.

Managers should retain or strive for the following primary habitat characteristics:

- ✓ conifer-dominated tree composition[6] ;
- ✓ multi-layered and well-connected canopy (45-75 % canopy cover) with trees exhibiting a clumped distribution;
- ✓ ≥ 20 large conifers >40 cm (16 in) dbh per ha (8/ac), preferably Ponderosa Pine, alternatively Douglas-fir;
- ✓ ≤ 30% cover of native shrubs; and
- ✓ 50-80% ground cover of forest litter and/or moss.

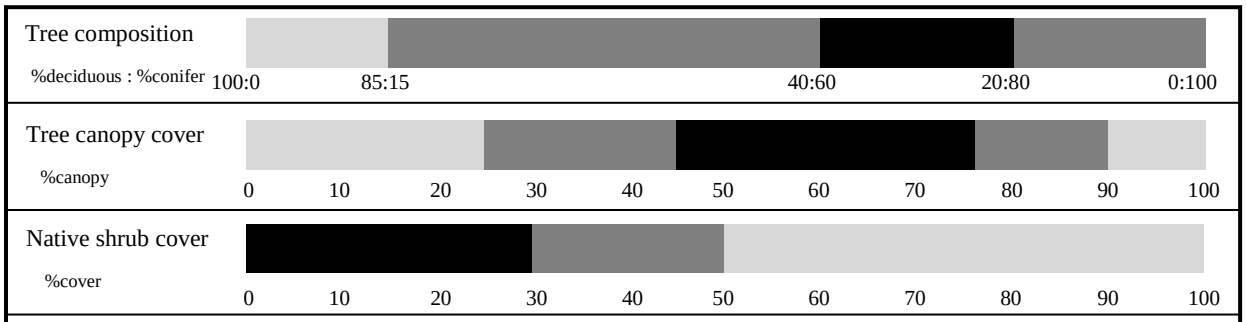

Figure 3. Key components affecting squirrel habitat quality throughout Washington. Tree composition refers mainly to the upper canopy in a stand. Ranges shaded black are considered suitable for primary habitat; black or dark grey areas are both appropriate as secondary habitat; and ranges shaded light grey are of low suitability for Western Gray Squirrels at the home range scale. Given the inherent variability found within primary and secondary habitat, Western Gray Squirrel habitat should be managed as a series of stands that accommodate this variability within the ranges provided for suitable habitat in this figure.

Figure derived using citation numbers 25, 27, 32, 33, 42, 52, as well as expert judgment based on statewide observations.

Disturbance of primary habitat should be limited to carefully-planned, small-scale habitat enhancement activities, subject to the timing restrictions below. Although intensive work within primary habitat is not recommended, a long-term hands-off approach may also be inappropriate, especially in dry forests or where fire suppression has increased wildfire risk. In these areas, enhancements and periodic maintenance is probably needed as long as they are carefully planned and carried out. Such activities should be limited to the removal of fine fuels (e.g., saplings, dense shrub cover, debris, invasive plants) through mechanical means or prescribed fire outside the breeding and nesting season. More information about eliminating fine fuels is described in the *Habitat Enhancement* section.

Secondary Habitat. – Although secondary habitat is used less than primary habitat, the daily use of secondary habitat implies that these areas are necessary to sustain local populations. Consequently, conserving the functional aspects of secondary habitat is recommended. For each 5 ha (12 ac) of primary habitat, 15 ha (38 ac; or up to 185 ac on less productive sites) of the surrounding landscape should be managed as secondary habitat.

Typical secondary habitat characteristics are as follows:

- ✓ moderate canopy cover (26-75%) dominated by conifer where feasible;
- ✓ at least 20 large diameter (>40 cm [16 in]) trees per hectare (8 trees/ac) for food. These large trees should be dominated by conifer but also can consist of a mix of mast-producing species (in order of preference: Ponderosa pine, Douglas-fir, Oregon White Oak, Big Leaf Maple, and Oregon Ash);
- ✓ a diversity of large-seeded mast-producing tree species for food;
- ✓ a mix of age classes to ensure large trees are available for nesting and foraging; young trees contribute to canopy complexity and forest stand recruitment;
- ✓ <50% shrub cover.

[6] Recommend using basal area or stem count of overstory trees to estimate forest composition.

Breeding, Nesting, and Denning. – The largest trees (>40 cm [16 in] dbh) in the stand are potential nest/den trees (*28*, *42*), and should be retained wherever possible within primary and secondary habitat. Large trees that connect with at least three surrounding tree crowns (<1 m [39 in] span), or that contain potential cavities, broken tops, and broken major limbs (*27*, *42*) are prime candidates for retention. Nest trees located in primary habitat should be protected by a clearly-marked, permanent year-round buffer [7] of 15 m (50 ft) radius to guard the nest tree from harm and to retain escape routes. Retaining more than one potential cavity tree >40 cm (16 in) dbh for each 5 ha (12 ac) of primary habitat and for each 15 ha (37 ac) of secondary habitat increases the likelihood that female Western Gray Squirrels can locate a suitable cavity for denning. Clusters of nests should be buffered and protected as a larger patch of protected forest (e.g., a Primary Habitat patch).

In addition to the year-round buffers, seasonal buffers should be reserved around known nest trees to reduce the exposure of pregnant females and newly weaned young to potentially harmful activities. From March 1 to August 31, activities (e.g., prescribed fire, logging, road-building) that may disrupt access to mates or young should not occur within 120 m (400 ft) of a nest. This distance is the approximate radius of occupied primary habitat in Klickitat County (*62*). Since activities producing sudden and irregular noise may impact squirrels when adults are rearing their young, such activities should be carefully timed to avoid disturbances during this sensitive period.

Foraging habitat and food availability. – Large (>40 cm [16 in] dbh) pines, firs, and oaks should be retained and well distributed within a squirrel's primary and secondary habitat. Seed-bearing shrubs and green vegetation are secondary food sources which may be important seasonally or in years of poor mast. Hazelnuts are particularly valuable for their nutritional content and because they can be cached for later consumption. Forests occupied by Western Gray Squirrels are typically dry and trees that produce necessary food may be stressed for water or nutrients, a situation easily exacerbated by some management practices (e.g., overstocking, dense understory vegetation; *39*, *47*). Seed-bearing shrubs should be protected (Appendix 3), but areas of dense shrub cover are generally avoided (Figure 3). Any activity that might promote the spread of invasive shrubs should be avoided or mitigated. Taking measures to control or thin existing areas of dense shrub cover (Appendix 4) in potential habitat are also recommended.

Landscape Management. – Western Gray Squirrel habitat should be managed at the patch, stand, and landscape scale to accommodate the needs of individuals and breeding groups. Primary habitat should be well-distributed across the landscape with at least 2 patches >2.5 ha (6 ac) of primary habitat per 20 ha (50 ac) of (primary and secondary) habitat. At the stand or landscape scale, squirrel habitat might best be viewed in 100-300 ha (247 – 741 ac) units. Units of this size are large enough to accommodate one male, one female, and her litter based on the observed home range size and overlap in Klickitat (*42*) and Okanogan (*27*) counties. These larger units should also be well-distributed and about 80%[8] of each land unit should consist of the 20 ha (50 ac) habitat blocks just described. This type of landscape-scale approach should maintain healthy populations, reduce inbreeding, and help to recover the species. The best way to protect Western Gray Squirrels over the long-term is by maintaining high-quality habitat across different ownerships throughout the landscape. As small ownerships (<100 acres) may not provide all critical habitat features, adjacent landowners should work together to develop landscape plans that maintain all key habitat components required by squirrels within a localized area. Cities and counties can provide incentives to encourage cooperative landscape conservation and management among adjacent property owners.

At the landscape scale, corridors must be present to connect key habitats or features (e.g., primary habitat, pine or pine-oak stands). In thinned stands, a corridor of upper canopy trees with interlocking crowns should be retained to connect forested patches. While squirrels occasionally use corridors consisting of a string of single trees, this type of corridor likely places squirrels at risk of predation and can easily be severed when trees become diseased or are blown down. A corridor two or more trees wide with an irregular or complex canopy is likely to provide better protection from predators and greater connectivity. Larger habitat patches should be linked by more than one corridor given that predators may quickly learn to focus on a single route where squirrels move between forested patches. Because of the linear shape of riparian habitat, these areas are likely to serve as natural corridors. Riparian areas should be conserved for this reason as well as for their known significance as wildlife habitat (*37*). Trees

[7] Research on forest practice sites in Klickitat County found that a 50 ft no-entry buffer increased the likelihood that nests continued to be used by squirrels (Vander Haegen et al. 2004).

[8] The home ranges of radio-collared squirrels in Klickitat County covered this percentage of the landscape. The remaining 20% was mostly comprised of habitat that was not suitable for use by this species.

retained as a corridor should be comprised of the tallest trees present in the stand and should not be bisected by roads or other land uses that could hinder squirrel movement. Where a corridor cannot avoid an existing road, crossings (e.g., natural and artificial squirrel bridges) should be considered to connect habitats and reduce mortality (J. Foster, personal communication; *19*).

Grazing

Although a study of grazing on squirrel habitat in the Klickitat Wildlife Area is underway (Van Leuven, personal communication), the effect of light to moderate grazing on Western Gray Squirrel habitat has not yet been quantified. Western gray squirrels currently occupy parts of the wildlife area where grazing has been permitted for over 25 years (Van Leuven, personal communication). Consequently, carefully managed grazing may be compatible with Western Gray Squirrel occupancy. As squirrel occupancy has not been rigorously measured in the grazed portions of the wildlife area, controlled studies are necessary to assess low-level effects (e.g., lower reproductive success) and to test various grazing strategies.

In Western Gray Squirrel habitat repeated grazing that exceeds the recovery capacity of the vegetation and creates or perpetuates a deteriorated plant community (i.e., overgrazing) should be avoided. Overgrazing is linked to inhibited growth of some mycorrhizal fungi (J. Trappe, personal communication; *5*), damaged root systems of essential trees, altered soil moisture retention, and soil compaction (*4*, *18*, *40*, *45*). To protect against these factors, grazing should occur soon after soil has firmed[9] up in the spring. At that time, light grazing ($\leq$25 percent removal of annual herbaceous growth; *23*, *35*) combined with rest-rotation one out of every three years may be compatible with Western Gray Squirrel management. To measure utilization, an assessment using the Landscape Appearance Method should be carried out wherever Western Gray Squirrel habitat is being grazed (*61*). This rapid assessment should be done just before livestock are turned out to get baseline data and then periodically during the season to decide when to remove livestock from a unit.

To ensure that livestock do not disproportionately graze certain portions of a unit, the operator should herd livestock as necessary to keep them well dispersed and to limit overuse in more accessible areas. Strategic placement of salt/mineral blocks or water troughs in areas less frequently grazed can also help to redistribute livestock. Annual inspections of grazed units in Western Gray Squirrel habitat should be carried out to assess the degree of vegetation utilization and noxious weed problems.

Knutson and Naef (*37*) recommend no grazing or highly controlled grazing (see PHS Riparian for more specific recommendations) within riparian zones. The use of grazing should never be carried out without careful planning to eliminate or significantly minimize the spread of noxious weeds. Grazing should be discouraged where encroachment by noxious weeds is likely. Although a carefully planned prescribed fire is a more efficient way to eliminate fine woody fuels, in locations where prescribed burns cannot be used to restore and maintain an open understory, livestock may have utility in reducing some of the fuels that would carry a wildfire.

[9] Soil firmness guidelines require that 1) all snow is melted off the pasture, with the exception of brushy draws and large drifts, and 2) normally dry sites are fairly dry and firm. Soil is not considered firm if upland soils are wet, loose, or subject to excessive compaction or damage.

Forest Stewardship and Management

Forestry in Western Gray Squirrel habitat that neglects to consider the needs of this species can greatly impact local populations. However, carefully planned forestry can have minimal impacts when the habitat needs of Western Gray Squirrels are accommodated. Forestry projects in squirrel habitat should promote healthy stands by protecting and enhancing key primary and secondary habitat features. Retaining habitat diversity (e.g., variable tree density, small canopy gaps, densely forested patches), rather than creating stand uniformity, is important to maintaining squirrel habitat. Figure 4 illustrates an example of what good forested habitat might look like post-harvest. Although protecting nest sites is important, it is equally important not to focus habitat conservation solely on stands where nests are known to occur. Instead, forest management plans should also account for the needs of squirrels when planning the harvest of unoccupied stands that have the characteristics of primary and secondary habitat.

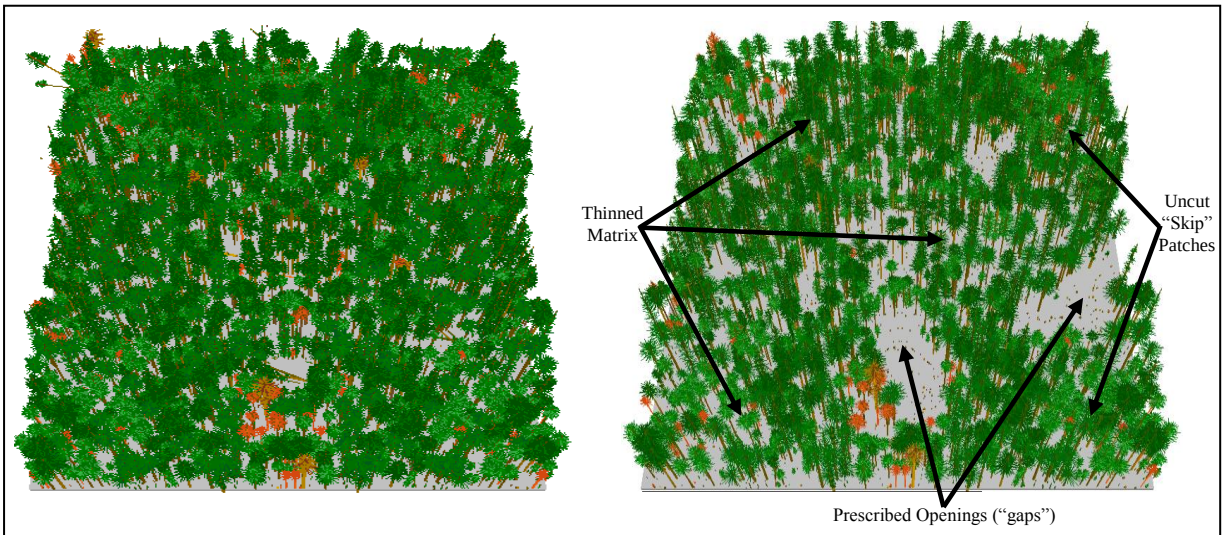

Figure 4. This example shows what a variable density thinning might look like within a 20 acres harvest unit. Small openings (gaps) and unthinned patches are part of a planned thinning which was designed to retain key features necessary to sustain Western Gray Squirrel.

Variable-density thinning is the most appropriate method of timber harvest in Western Gray Squirrel habitat. This strategy should include the retention of more densely forested "skip" patches; enhancement of tree growth through thinning and by establishing small gaps; and the retention or creation of variable herbaceous, shrub, and tree canopy cover within a stand (Figure 4). Areas best suited for skip patches will have clusters of nests and/or characteristics of primary habitat. Maintaining adequate primary habitat is critical to the continued use of sites by Western Gray Squirrels. Prior to conducting a forest practice, areas of characteristic primary habitat should be identified. These areas should then be designated as limited-entry patches (primarily for fine fuel removal) within harvest units and should be managed to meet the needs of Western Gray Squirrels.

Most forest management activities occurring in Western Gray Squirrel habitat should be limited to the portion of a squirrel's home range outside of its primary habitat. By definition, this encompasses the squirrel's secondary habitat, which should be managed to meet the needs of this species, though not necessarily to the extent identified for primary habitat. Carefully planned forest management in secondary habitat can allow for harvest while benefitting squirrels. For instance, harvest can create small forest gaps that can enhance growth and mast production of trees retained at the edges of gaps. Increasing tree spacing in selected areas can encourage growth and crown development of trees that are retained (e.g., removing firs overtopping oak) and those at the edge of a skip patch. Creating stands of evenly spaced trees is not recommended, as this practice fails to provide adequate opportunities for nesting, food, cover, and escape due to diminished habitat complexity. In general, timber harvest in secondary habitat should be carried out by managing for the key secondary habitat characteristics. An example of such management may include harvesting denser stands to achieve optimal canopy cover (45-75%) and tree composition (Figure 4). In general, harvest in secondary habitat should be achieved by enhancing rather than compromising overall habitat complexity.

Forested stands should be surveyed for Western Gray Squirrel nests and for the presence of squirrels prior to any timber sale or harvest in potential Western Gray Squirrel habitat. To ensure a timber harvest does not negatively impact local squirrel populations, forest landowners should develop habitat management plans before harvesting timber or preparing a stand for harvest (e.g., marking trees, road building, moving in equipment). Specific recommendations found in the *General Habitat and Vegetation Management* section should guide the development of a management plan. The following forestry-specific guidance should also be used to develop the plan:

- Practices that remove much of the tree canopy (e.g., clearcutting, shelterwood) should be avoided in Western Gray Squirrel habitat because of its potential to eliminate key habitat for long periods of time. Rotational length for such management must be sufficiently long to attain suitable forest structure and to maintain it long enough to be of value to squirrel populations. Thinning a stand only to later return and remove the remaining overstory is not a suitable strategy for maintaining squirrel habitat. Clearcutting should only be done under the guidance of a landscape plan to ensure maintenance of squirrel habitat in the surrounding landscape.
- Mature oaks adjacent to suitable conifer stands or those in conifer openings are of high value to Western Gray Squirrels. "Release" of oaks by removing overtopping conifers can improve growth to maximize acorn production and to provide den sites. Release seems to be most successful with oaks that have many live branches (*34*). Releasing oaks at the edge of a conifer stand may be preferable since these trees will likely require the removal of fewer conifers.
- The best mast-producing oaks are large, open-grown trees with spreading canopies. Dense stands of pure oak may be thinned to enhance the growth of individual oaks. Because sprouting can occur around exposed oak stumps, measures can be taken to avoid this outcome. One involves covering stumps with black plastic, extending the plastic to the ground and fastening it with wire to keep out light. Enhancing oaks that are in close proximity to conifer habitat is of most value.
- In the Okanogan region, forested areas to be retained as "skip" patches should prioritize large diameter conifers infected by mistletoe brooms, which are an important component of Western Gray Squirrel habitat.
- Forest fuel reduction aimed at lowering the risk of wildfire near homes is becoming common in eastern Washington (see *Residential Development* for defensible space guidelines for homes that have yet to be built). When creating defensible space near existing homes, provisions should call for the protection of nests and primary habitat to a level that will not compromise public safety. The creation of defensible space in squirrel habitat should occur outside of the breeding and nesting season (March 1st – August 31st) when conducted within 120 m (400 ft) of a nest. Defensible space areas should occur on the minimum amount of land necessary to effectively protect homes and outbuildings. If buildings have not yet been built, placing them in such a way as to minimize forest fragmentation is recommended.
- To reduce fine fuels (e.g., saplings), post logging prescribed burns should be carried out in dry forests. In habitat without nests, spring burns may be preferred since they run cooler and are less likely to harm important resources (e.g., large trees, truffles). In occupied habitat, fall burns are preferred to reduce risks to juveniles, and to reduce the likelihood of impacting food resources in a time of scarcity. In either case, controlled burns should be carefully planned and implemented to ensure safety and desired outcomes (Appendix 4).
- Recent research in the south Puget Trough suggests that Eastern Gray Squirrels use forested stands with a greater non-oak deciduous component (primarily ash and maple) than do Western Gray Squirrels (Vander Haegen, unpublished data); forest management that favors retention of conifer-dominated and conifer/oak stands may benefit Western Gray Squirrels where these stand types overlap.
- Dense stands of small conifers should be thinned since they can attract bark beetles and other detrimental insects. Dense stands also limit a tree's ability to become large enough to produce sufficient seed.

Potential Adverse Effects of Forestry. –

- Heavy equipment can compact forest soils, possibly reducing the production of underground fungi. Forestry in squirrel habitat should minimize soil compaction by limiting the use of heavy equipment to localized trails and by laying slash on these same trails to buffer the impact of treads or wheels.
- Reduced canopy cover limits opportunities for squirrels to move within a stand and has been shown to lower production of underground fungi.

- Slash can attract California Ground Squirrels (*Spermophilus beecheyi*), primarily in south-central Washington (Van Leuven, personal communication). As California Ground Squirrels may compete with Western Gray Squirrels, slash should be removed from sites or piled and carefully burned in open areas. Scattering limbs on-site (e.g., for equipment trails) should be temporary or limited to levels not likely to provide excessive fuels.
- Soil disruption combined with increased sunlight penetration can lead to the spread of invasive plants. Activities in squirrel habitat should seek to minimize soil disturbance, and management plans should allow for follow-up treatments (i.e., to control invasives, plant natives, and to thin seedlings). Follow-up treatments should occur in areas of increased light penetration or soil disturbance.
- Given the difficulty of locating nests in the field, many undetected nest trees are removed during harvest operations. Experienced observers should carry out pre-harvest nests surveys. Protection of habitat with characteristics of primary habitat should be implemented as a fallback.

Residential Development

This section summarizes important factors to consider when a development proposal or a change in land use designation will likely to lead to new home sites in Western Gray Squirrel habitat. The following recommendations are meant to protect squirrel habitat by:

- providing information about zoning and compatible development densities;
- identifying best management practices for residential developments; and
- presenting other tools (e.g., covenants, flexible lot sizes) to help minimize habitat impacts.

Zoning, Development Density, and Habitat Connectivity. – Traditionally, most development proposals have taken squirrel protection into account only when an individual parcel contained a documented nest. Although protecting nests is strongly recommended, the conservation of habitat is also critical when a parcel is in the recovery area (Figure 2) of this species and when primary and secondary habitat attributes are present. As proposals to upzone or divide a large parcel often precede development, such proposals should be assessed for potential impacts (as part of the approval process) and to determine the presence of nests or possible habitat.

Although research on the response of this species to development is lacking, local experts agree that encroaching development compromises populations by reducing the availability of food and nest trees. An advisory panel of experts provided their best professional judgment on how squirrels fare at different dwelling densities (*65*). Although development at any density will impact squirrels if, for instance, a home is sited near a nest or if much of a parcel is cleared of key vegetation, squirrels can generally persist where densities are no greater than 1 dwelling/20 acres (1/20 ac; *65*). As densities increase beyond 1/20 ac, it becomes more difficult to retain enough habitat for long-term squirrel persistence. Although Western Gray Squirrels may occur in areas of higher-density development, over time these occurrences seem unlikely to persist due to the loss of key habitat features and increased mortality.

Depending on a site's habitat potential, different zoning or land use strategies should be considered. Areas with existing nests (especially nest concentrations) are best maintained as open space or in a natural resource designation (e.g., forestry). Although a natural resource designation will generally have fewer impacts, densities should not exceed 1 du/20 ac when development is planned in such an area. For Western Gray Squirrels, the best sites to develop are those altogether lacking critical habitat features (see *General Vegetation and Habitat Management*).

Careful planning and review is needed for any proposal to build where nests are present. However, it is also important to consider the impacts of proposals in unoccupied portions of the recovery area (Figure 2) where habitat is present. These sites are important because this species will decline without dispersal habitat to connect distant nesting, rearing, and feeding habitats. An important first step when considering development on a parcel containing habitat is to survey for squirrels using WDFW's survey protocol. When developing a parcel that has squirrels or squirrel habitat, best management practices (BMPs) should be applied to minimize impacts.

Site-Specific Best Management Practices. – When proposing to develop an area where there are squirrels or squirrel habitat, a qualified wildlife biologist who understands Western Gray Squirrel ecology should be consulted at the earliest planning stages. This professional should survey for squirrels using an accepted survey protocol, identify habitat, and develop a plan that would later be carried out to protect habitat.

Identification of habitat is critical to effective conservation, and the key habitat characteristics within a parcel (and adjacent parcels) should be mapped. Throughout the parcel, canopy cover, tree composition (% deciduous:% conifer), and shrub cover should be measured and mapped. Also large seed-producing trees should be identified, marked, and retained to the greatest extent possible. Nest trees should also be retained. Habitat information described in the *General Habitat and Vegetation Management* section should be evaluated to determine where key primary and secondary habitat exist. This same map should be used to identify where non-habitat is present. Areas of non-habitat are where development or land use modifications should occur.

Permanent buffering of active nests in and around existing or planned development will minimize nest disturbance. In addition to maintaining a 50 ft buffer around nests (*44*), a building setback beginning at the outer edge of the buffer also is recommended to prevent trees from falling on structures from within the buffer. The provision of a setback is important to help ensure that the function of the buffer is not compromised by the later removal of trees that are deemed a hazard to buildings. The width of the setback should be the same as the 100 year site index or the tallest standing tree within the buffer (whichever is greater). Activities that could disturb active nesting (e.g., construction activities) should also not occur within 120 m (400 ft) of a nest(s) from March 1st to August 31st.

Landowners should also maintain any primary habitat outside the building footprint. This includes limiting the clearing or altering of vegetation (e.g., landscaping); by keeping appropriate levels of forest canopy closure (45-75% in primary habitat, 26-75% in secondary habitat); preserving large (>40 cm [16 in] dbh) food-producing oaks, pines, and fir; and maintaining sparse shrub cover. Stewardship also means that stands should be comprised of clusters of trees, small canopy gaps, and interconnected canopy corridors to support arboreal travel. Landscaping with native trees/shrubs favored by squirrels is encouraged (Appendix 3). For parcels where multiple homes (i.e., subdivisions) are planned, primary habitat should be set aside as protected open space. Open spaces boundaries should be clearly marked and have signs pointing out any restricted activities (e.g., logging).

Infrastructure (e.g., roads) typically accompanying development can also adversely impact squirrels. New roads and driveways should be located on or close to existing right-of-ways to limit forest fragmentation. Placement of new roads should avoid removal of large trees and the isolation of important resources. Along road corridors that bisect habitat, reduced speed limits, road signage, and road crossings (e.g., natural and artificial squirrel bridges) should be considered to connect habitats and reduce mortality (J. Foster, personal communication; *19*).

Covenants, Tools, Incentives, and Mitigation. – Residential development covenants can be used to guarantee permanent protection of open space. Covenants can protect wildlife habitat by calling for limited native plant removal or restricted herbicide use and can also be used to limit impacts from domestic animals.

Local governments can provide the right tools and incentives to make it easier for landowners to conserve habitat. For instance, local governments can help landowners reduce habitat impacts by allowing for flexible lot sizes rather than requiring every lot in a subdivision to be of equal size (*65*). Jurisdictions can also allow landowners to cluster homes on the portion of a parcel lacking habitat. Compared to dispersed development, "cluster development" can lead to fewer habitat impacts when properly done. Jurisdictions can make incentives available to ease the financial costs that sometimes accompany habitat conservation. Specific incentives are discussed in detail later in this publication (see *Incentives*).

In the event of unavoidable impacts, a habitat management plan (HMP) outlining site-specific mitigation and monitoring is recommended. An HMP should give preference to actions which avoid or minimize impacts, while compensatory mitigation should be a last resort. Compensatory mitigation replacement ratios should be greater than 1:1 to account for temporal losses, performance uncertainty, and the loss of functions and values when impacted habitat is mitigated. Regional habitat and wildlife biologists at WDFW can work with planners and applicants to assess potential impacts to habitat and to help identify appropriate mitigation measures. Mitigation sites should be permanently protected through a conservation easement, deed restriction, or by another legally binding method.

Landscape Planning

Although the conservation of Western Gray Squirrels often is evaluated at the individual project scale (e.g., parcel, forested stand), landscape planning is necessary. Landscape-scale planning helps to avoid the pitfalls of making decisions using fine scale information only. Specifically, conserving squirrels on a parcel-by-parcel basis often overlooks factors that are best addressed at broader scales (e.g., habitat connectivity). Parcel-by-parcel planning also fails to address the cumulative impacts that occur when many parcels are altered by various means. Through means long-range planning activities (e.g., comprehensive plans), landscape-scale conservation measures should be put in place. Good long-range planning policies help ensure that the needs of Western Gray Squirrels are not overlooked.

To plan at a landscape scale it helps to be able to identify where important habitat occurs across broad areas. Figure 5 shows a map identifying where Western Gray Squirrel nesting habitat is most likely to occur across Klickitat County (*44*). Similar maps have been developed for the Puget Trough and Okanogan regions (see Figures 10, 11 *in* the Western Gray Squirrel Recovery Plan). It is important to note that not all shaded areas in these maps necessarily are squirrel habitat. However, the likelihood that shaded areas represent habitat is higher than that of unshaded areas. Using these types of maps, communities can proactively plan for this species when making decisions about zoning, land division, and transportation, as well as identifying areas where conservation-oriented incentives can be encouraged.

Figure 5. Green shaded area[1] represents the areas most likely to contain habitat suitable for Western Gray Squirrel nesting in Klickitat County (i.e., squirrel planning area).

[1] Same as modified Rodrick (50) depicted as Figure 7 in Linders and Stinson (42).

Linking a Landscape to a Project. -- Using maps like these, decisions can be made to guide broad planning decisions such as zoning and transportation. Given that long-range, landscape-scale planning policies are used to determine where individual projects can occur, it is useful to reference the site scale recommendations in local long-range plans. For instance, site-scale recommendations found in this publication can be referenced in CAOs and comprehensive plans to make sure the impacts of forestry, development, and grazing on Western Gray Squirrels are addressed in the major phases of planning (e.g., current and long-range planning).

Habitat Enhancement

The decline of Western Gray Squirrels in Washington is in large part the result of habitat degradation. Consequently, enhancement can improve lost or degraded habitat. This section lays out factors that should be considered before embarking on a habitat enhancement project, such as:

- prioritizing a proposal to enhance squirrel habitat;
- identifying what important questions need to be asked prior to enhancement; and
- finding the right tools and resources to enhance different habitat elements.

Prioritizing Enhancement Proposals. - For enhancement to occur, the needs of Western Gray Squirrels must be understood. The *General Habitat and Vegetation Management* section provides vital habitat information (e.g., ideal canopy, ground and shrub cover; forest composition) that should be reviewed when preparing for an enhancement project. These vital characteristics of squirrel habitat should define one's enhancement goals.

The first step to enhancing a site is to evaluate how easily a proposed enhancement project will result in improved squirrel habitat. Below are factors to consider when prioritizing a proposal:

- Enhancement is most successful where Western Gray Squirrels occur onsite or nearby. Although chances for success decline when enhancing habitat further from a known population source, enhancing these areas may eventually help the species expand into portions of their historic range. WDFW maintains squirrel location data that is available to project designers and reviewers (see PHS Data). Although the absence of data does not necessarily mean that squirrels are not present (e.g., because a site was never surveyed), this data can help identify whether squirrels have been observed nearby.
- Enhancement has the greatest likelihood of success when conducted in stands that have slight to moderate habitat degradation. Critical features of primary and secondary squirrel habitat (e.g., large trees, conifer dominance, minimal understory, etc.) found in the *General Habitat and Vegetation Management* section can help in assessing habitat quality. Severely degraded sites have a lower chance of successful enhancement.
- Enhancement in localized areas containing a diversity of key habitat characteristics is beneficial to squirrels. Such a site may have variable tree spacing; clumps of trees with intermittent canopy gaps; isolated, open grown, large seed-producing trees; and habitat corridors, all within in a localized area.
- The landscape context of a site can affect the chances for successful enhancement. For instance, enhancing a small patch of habitat that is completely isolated by development will have a lower chance of success compared to enhancing a large patch of habitat or a smaller patch of habitat that is in close proximity to other patches of quality habitat.
- Although sites altogether lacking in Western Gray Squirrel habitat characteristics are typically inappropriate for enhancement, areas of non-habitat or poor-quality habitat adjacent to or between known habitat may be suitable for enhancement. These areas may be managed for connectivity or to enlarge a patch of squirrel habitat.

Although a site does not necessarily need to fulfill every one of these factors to justify its enhancement, each factor should be evaluated and weighed to see what benefit can be gained if habitat enhancement is carried out.

Important Questions. – Once it has been determined that successful enhancement is possible, the following questions should be asked before planning any enhancement activity:

What habitat characteristics need enhancement to benefit Western Gray Squirrels? By answering this question you will identify where you should focus your resources. The more key characteristics that can be enhanced, the better the chances the site will be representative of squirrel habitat. Some actions are more important than others, such as increasing food supply, nesting opportunities, and escape cover.

How quickly should enhancement be done? You should proceed at a pace that you can handle and afford financially. Grants to defray some of the costs are often found in WDFW's *Fish and Wildlife Planner* newsletter.

Tools and Resources. – Once you have identified the elements that need enhancement, there are a number of tools that can help you achieve your goals (Appendix 4). Asking for assistance from knowledgeable individuals and organizations (see Appendix 4 for useful contacts) is critical to successful enhancement. As enhancement is as much science as it is an art that requires meticulous planning and patience, the use of some tools can be challenging. For instance, the proper use of prescribed fire requires professional assistance from properly trained and certified personnel. It also requires someone who understands how to use fire to achieve the desired habitat improvement. Figure 6 shows a stand that was enhanced using some of the tools identified in Appendix 4.

Photos courtesy of Sanders Freed

Figure 6. A before (left) and after (right) photo of restoration on Fort Lewis in Pierce County. The objective was to improve the structure and function of habitat for Western Gray Squirrels. The before photo shows a stand that has been invaded by Scotch Broom. The same stand is then shown after mechanical removal, followed by an herbicide treatment. This site is now ready for prescribed fire to maintain suitable understory characteristics.

The squirrel's survival depends on there being a sufficient amount of habitat over a landscape. Most small landowners are rarely in a position to affect such large areas, although collectively they can be very effective. Large industrial timber companies, public agencies, and other large landowners are in a good position to help enhance habitat across broad landscapes. For large landowners, opportunities become more numerous and flexible as the land base increases. Enhancing and managing broad scale habitats for the Western Gray Squirrel essentially employs the same principles as those detailed above.

Applying the Recommendations

These management recommendations are meant to inform a wide array of approaches to Western Gray Squirrel conservation. Diversifying how to conserve the Western Gray Squirrel not only provides better protection, but also provides flexibility to those who own or manage lands that are critical to the survival of this species. We recommend that regulatory and non-regulatory (i.e., incentive-based) measures be built into the local conservation framework of communities where Western Gray Squirrels occur. Another critical element is the acquisition of important habitat by organizations (e.g., land trusts) whose mission includes conserving wildlife habitat.

Regulatory Measures. – Critical areas safeguards under the Growth Management Act (GMA) are the main tools communities use to protect species like the Western Gray Squirrel. Communities planning under GMA must prepare development regulations that designate fish and wildlife habitat conservation areas and govern changes in land uses and new activities that could potentially impact such areas. Such regulations prohibit clearly inappropriate actions and restrict, allow, or condition other activities as appropriate. The recommendations we provide in this publication are designed to be useful in preparing a process to conserve Western Gray Squirrels through GMA.

Local zoning and comprehensive planning activities can also play an important role in species conservation. In particular, land use designations that are tied to zoning and comprehensive planning should be evaluated to make sure the most important Western Gray Squirrel habitat areas are designated for land uses that are compatible. Given

that squirrel populations require more than just protection at the scale of an individual property, the review of local land use designations across squirrel habitat (see *Landscape Planning* section for guidance) can help identify large areas where the use of certain designations (e.g., open space) may benefit Western Gray Squirrels.

Incentives. – Although regulatory approaches are important to Western Gray Squirrel conservation, a balanced strategy includes opportunities for protection through non-regulatory means. Some non-regulatory options include transfer of development rights (TDR), current use taxation (via the development of a Public Benefit Rating System [PRBS]), and Conservation Futures. Local land trusts can also help property owners protect squirrel habitat through the use of incentives such as conservation easements. Each of these options can be implemented to protect squirrels by providing landowners with monetary or other incentives to avoid harmful activities. For instance, communities with TDR programs allow certain landowners to transfer their right to develop in exchange for monetary compensations. Such programs can be designed to allow landowners with important wildlife habitat to be eligible, or even preferred, as a program participant, allowing their rights to be transferred to less sensitive locations. Similarly, participants in a PBRS (current use taxation) program could have their property "scored" higher if they own lands with known value to Western Gray Squirrels. Conservation Futures or other conservation funding or easement programs may be designed to give preference to properties with such habitat. Counties and cities with squirrels are encouraged to consider adopting some or all of these options as a way to balance regulatory with non-regulatory protections of Western Gray Squirrels and other imperiled species.

Habitat Management Plans. – We suggest that habitat management plans be developed when applying our recommendations to individual projects that could impact Western Gray Squirrels. A habitat management plan is a detailed plan that outlines and documents the location of the important habitat area, any incursions or impacts into the habitat by a proposed land use action, and ways to limit any impacts to the habitat and to associated species. Using our management recommendations as a guide, a habitat management plan should describe or inventory:

- the resources (e.g., tree species composition, key forest structural characteristics) on the property, while also considering connectivity to habitat on adjacent properties;
- habitat features found within the stand that are specifically required by the species;
- past, present, and future land uses;
- habitat features and/or processes impacted by the proposed land use action;
- specific habitat enhancement or mitigation measures, including quantitative goals, objectives, and performance standards;
- objectives that carefully balance the needs of the species with the landowner's needs;
- a detailed implementation plan with maps, as-built drawings, and an operation/maintenance plan;
- specific prescriptions that will best meet the needs of the species and promote forest health; and
- periodic monitoring, evaluation, and a contingency plan outlining corrective actions if conservation or mitigation actions do not lead to the desired outcome.

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APPENDIX 1: CONTACTS USEFUL WHEN EVALUATING PESTICIDES AND THEIR ALTERNATIVES

Government Organizations

United States Environmental Protection Agency

Provides information, brochures, and technical help on pesticide application.

Region 10 Public Affairs Office, Seattle 1-800-424-4372

Washington State Department of Agriculture

Pesticide Management

General Information.....(360) 902-2010
Toll Free General Information.....(877) 301-4555
Assistant Director.....(360) 902-2011

Compliance

Enforces state and federal pesticide laws; investigates complaints of pesticide misuse.

Manager .....(360) 902-2036
Olympia Compliance .....(360) 902-2040
Moses Lake .....(509) 766-2575
Spokane Compliance .....(509) 533-2690
Wenatchee Compliance.....(509) 664-3171
Yakima Compliance .....(509) 225-2647

Registration and Licensing

Registers pesticides sold and used in Washington.

Manager .....(360) 902-2026
Pesticide Registration - Olympia .....(360) 902-2030
Pesticide Registration - Yakima.....(509) 255-2647

Program Development

Licenses pesticide application equipment and pesticide dealers; commercial, public, and private pesticide applications; and operators and consultants. Conducts waste pesticide disposal program; responsible for public outreach and education.

Manager .....(360) 902-2051
Pesticide Licensing and Recertification
Eastern Washington.....(509) 225-2639
Western Washington.....(360) 902-1937

Waste Pesticide Collection.....(360) 902-2050
Farmworker Ed. and Pest. Licensing - Yakima .....(509) 255-2639

Washington Department of Ecology, Regional Contacts

DOE provides information and permits on applying pesticides directly or indirectly into open bodies of water.

Eastern Region, Spokane .....(509) 456-2926
Central Region, Yakima ....(509) 575-2490
Northwest Region, Bellevue ....(206) 649-7000
Southwest Region, Lacey..... ....(360) 407-6300

Washington Department of Fish and Wildlife

Regional Contacts

Your regional program manager will direct your questions to a biologist. The department can provide information on what priority habitats and species are known to be in your area, and the life requisites of priority species.

Region 1, Spokane ....(509) 456-4082
Region 2, Ephrata..... .....(509) 754-4624
Region 3, Yakima ....(509) 575-2740
Region 4, Mill Creek..... .....(206) 775-1311
Region 5, Vancouver..... .....(360) 696-6211
Region 6, Montesano ....(360) 249-4628

Habitat Research and Information Services

Mapped information and management recommendations for Washington's priority habitats and species can be obtained by calling (360) 902-2543.

Washington Poison Control Center .. ..(800) 222-1222

Provides information on who to contact in case of exposure to or spill of pesticides or other toxic substances.

Non-Government Organizations

Agricultural Support Groups

Tilth Producers..... ....(206) 442-7620
Chapter of Washington Tilth
P.O. Box 85056
Seattle, WA 98145-1056

Provides a directory of organic growers, food and farm suppliers, and resources, called the Washington Tilth Directory. Can help place farmers wishing to reduce pesticide use in touch with those who have already done so.

Northwest Coalition for Alternatives to Pesticides.....(541) 344-5044
P.O. Box 1393
Eugene, OR 97440-1393

Provides information on a network of farmers practicing sustainable agriculture.

Palouse-Clearwater Environmental Institute .. ..(208) 882-1444
P.O. Box 8596
112 W. 4th, Suite 1
Moscow, ID 83843

Coordinates farm/consumer improvement clubs in eastern Washington and is the western coordinator of the Campaign for Sustainable Agriculture.

Alternative Energy Resources Organization... .....(406) 443-7272
25 S. Ewing Suite 214
Helena, MT 59601

Coordinates a network of farm improvement clubs and produces a list of organic growers in Montana. Has information on growing grains in the Palouse region.

Financial Support for Farmers Shifting to Sustainable Agriculture

Cascadia Revolving Loan Fund .....(206) 447-9226
1901 NW Market Street
Seattle, WA 98107

A non-profit organization that lends money to small businesses.

Sustainable Agriculture Research and Education .....(435) 797-2257
Western Region SARE
Room 305 Agricultural Science Building
4865 Old Main Hill Road
Logan, UT 84322-4865

A federal grant program for farmer-directed, on-farm research. The grants are called Farmer/Rancher Research Grants.

The Organic Farming Research Foundation.....(831) 426-6606
P.O. Box 440
Santa Cruz, CA 95061

Provides funding for organic farming methodology research.

Insectaries

Northwest Biocontrol Insectary/Quarantine Insectary.....(509) 335-5504
Terry Miller

Can provide limited technical advice on using beneficial insects as biological control agents.

Integrated Pest Management and Non-Chemical Alternatives

Bio-Integral Resource Center) .....(510) 524-2567
P.O. Box 7414
Berkeley, CA 94707

Publishes "Common Sense Pest Control Quarterly", and "The IPM Practitioner Monitoring the Field of Pest Management."

Integrated Fertility Management.....(800) 332-3179
333 Ohme Gardens Rd.
Wenatchee, WA 98801

Provides information on organic farming, biological pest control, and soil amendments. Also provides a network with which growers can contact each other.

Northwest Coalition for Alternatives to Pesticides.....(541) 344-5044

Located in Oregon, provides information regarding integrated pest management, a list of private consultants, as well as other sources and contacts.

Washington Toxics Coalition.....(206) 632-1545

Has an information file on many topics involving chemical pesticides, including effects on the environment and on human health, as well as alternatives to household and garden chemicals.

National Organizations

Appropriate Technology Transfer for Rural Areas.....(800) 346-9140
P.O. Box 3657
Fayetteville, AR 72702

Information service on sustainable agriculture. Not ideal for questions that are regionally specific, but good for crop production questions.

Chemical Referral Center .....(800) 262-8200

This center, which is sponsored by the Chemical Manufacturers Association, will refer the caller to the manufacturer of the chemical in question, and provide telephone numbers of other hotlines.

National Agricultural Library .....(301) 504-6559
Alternative Farming Systems Information Center
10301 Baltimore Blvd.
Beltsville, MD 20705-2351

Provides bibliographies on topics such as cover crops, living mulches, compost, etc. Will do individual searches on national agricultural databases for free. This organization's strong point is specific, technical information.

National Pesticide Telecommunication Network .....(800) 858-PEST (7378)

Provides 24-hour information on pesticide products, poisoning, cleanup and disposal, enforcement contacts, certification and training programs, and pesticide laws.

Safety, Storage, Handling, and Disposal

Washington Toxics Coalition.....(206) 632-1545

Has an information file on many topics involving chemical pesticides, including effects on the environment and on human health.

Local Solid Waste/Recycling Centers

Your county or municipal solid waste center may be of assistance when disposing of pesticides and herbicides.

Washington State University Cooperative Extension Service, County Agents

County	Address	City	Phone #	County	Address	City	Phone #
Adams	210 W. Broadway	Ritzville 99169	(509) 659-3209	Lewis	360 NW North St. MS: AES01	Chehalis 98532	(360) 740-1212
Asotin	2535 Riverside Drive	Asotin 99402	(509) 758-5147	Lincoln	PO Box 399	Davenport 99122	(509) 725-4171
Benton	5600-E W Canal Drive	Kennewick 99336	(509) 735-3551	Mason	11840 Hwy 101 N.	Shelton 98584	(360) 427-9670 Ext. 395
Chelan	303 Palouse Street	Wenatchee 98801	(509) 667-6540	Okanogan	PO Box 391	Okanogan 98840	(509) 422-7245
Clallam	223 East 4th St.	Port Angeles 98362	(360) 417-2279	Pacific	PO Box 88	South Bend 98586	(360) 875-9331
Clark	11104 NE 149th Street	Bush Prairie 98606	(360) 397-6060	Pend Oreille	PO Box 5045	Newport 99156	(509) 447-2401
Columbia	202 S. 2nd Street	Dayton 99328	(509) 382-4741	Pierce	3049 S 36th, Suite 300	Tacoma 98409	(253) 798-7180
Cowlitz	207 4th Ave N	Kelso 98626	(360) 577-3014	San Juan	221 Weber Way, Suite LL	Friday Harbor 98250	(360) 378-4414

County	Address	City	Phone #
Douglas	PO Box 550	Waterville 98858	(509) 745-8531
Ferry	350 E. Delaware Ave #9	Republic 99166	(509) 775-5235
Franklin	Courthouse 1016 N. 4th	Pasco 99301	(509) 545-3511
Garfield	PO Box 190	Pomeroy 99347	(509) 843-3701
Grant	PO Box 37 35 C Street NW	Ephrata 98823	(509) 754-2011 Ext. 413
Grays Harbor	PO Box R 32 Elma-McCleary Road	Montesano 98541	(360) 482-2934
Island	PO Box 5000 101 NE 6th	Coupeville 98239	(360) 679-7327
Jefferson	201 W. Patison	Port Hadlock 98339	(360) 379-5610
King	919 SW Grady Way, Suite 120	Renton 98055	(206) 205-3100
Kitsap	614 Division Street MS-16	Port Orchard 98366	(360) 337-7157
Kittitas	507 Nanum Ave, Room 2	Ellensburg 98926	(509) 962-7507
Klickitat	228 W Main, MS-CH 12	Goldendale 98620	(509) 773-5817
Skagit	306 S First Street	Mount Vernon 98273	(360) 428-4270
Skamania	PO Box 790	Stevenson 98648	(509) 427-9427
Snohomish	600 128th St. SE	Everett 98208	(425) 338-2400
Spokane	222 N Havana	Spokane 99202	(509) 477-2048
Stevens	985 S Elm, Suite A	Colville 99114	(509) 684-2588
Thurston	720 Sleater Kinney Road SE, Suite Y	Lacey 98503	(360) 786-5445
Wahkiakum	PO Box 278	Cathlamet 98612	(360) 795-3278
Walla Walla	328 W Poplar Street	Walla Walla 99362	(509) 527-3260
Whatcom	1000 N Forest Street, Suite 201	Bellingham 98225	(360) 676-6736
Whitman	310 N Main, Room 209	Colfax 99111	(509) 397-6290
Yakima	128 N 2nd Street, Room 233	Yakima 98901	(509) 574-1600

Appendix 2. Summary of key recommendations given in the General Habitat and Vegetation Management section.

Retain these features in primary habitat	Retain these features in secondary habitat	Other key recommendations
conifer-dominated tree composition.	conifer-dominated tree composition.	all nest trees should be protected by clearly-marked, permanent year-round no entry buffer of 50 ft. Clusters of nests should be buffered and protected as a larger patch of protected forest.
multi-layered, well-connected canopy cover (45-75%) with trees exhibiting a clumped distribution.	moderate canopy cover (26-75%).	from March 1st to August 31st land use activities that may disrupt access to mates or young should not occur within 400 ft of a Western Gray Squirrel nest.
≤30% cover of native shrubs.	<50% shrub cover.	activities promoting the spread of invasive shrubs should be avoided or mitigated.
≥8 large conifer trees >16 in dbh/ac, preferably Ponderosa Pine, alternatively Douglas-fir.	≥8 large (>16 in dbh) trees/ac dominated by conifer but may consist of a mix of trees (in order of preference: Ponderosa Pine, Douglas-fir, Oregon White Oak, Big Leaf Maple and Oregon Ash).	retain corridors ≥ two trees in width connecting key habitat areas. Corridors should be made up of the tallest upper canopy trees that have interlocking crowns, an irregular or complex canopy structure, and should not be bisected by land uses that could sever connectivity.
50-80% ground cover of forest litter and/or moss.	mix of age classes to ensure large trees are available for nesting and foraging.	
≥1 tree >16 in dbh/12 ac for denning. Suitable den trees connect to at least 3 surrounding tree crowns or potential cavities, broken tops, or broken major limbs.	≥1 tree >16 in dbh/37 ac for denning. Suitable den trees connect to at least 3 surrounding tree crowns or potential cavities, broken tops, or broken major limbs.	
≥2 patches ≥6 ac of primary habitat per every 50 ac of potential (primary and secondary) squirrel habitat at the stand or landscape scale (nest clusters and/or the characteristics described in primary habitat should be used to locate habitat).	for each 12 ac of primary habitat, ≥38 ac of the surrounding landscape should be managed as secondary habitat (characteristics described in secondary habitat should be used to locate habitat).	
in general, disturbance to primary habitat should be avoided or limited to carefully planned, small-scale habitat enhancement activities.	diversity of large-seeded mast-producing tree species for food.	

Appendix 3. Seasonal availability of food items (trees and shrubs) for Western Gray Squirrels in oak woodlands at Fort Lewis, Pierce County (*53*).

Common Name	*Scientific Name*	Spring	Summer	Fall	Winter
Bigleaf Maple	*Acer macrophyllum*			Samaras	
Saskatoon Serviceberry	*Amelanchier alnifolia*		Fruit	Fruit	
Pacific Dogwood	*Cornus nuttallii*			Fruit	
Oregon Ash	*Fraxinus latifolia*			Samaras	Samaras
Ponderosa Pine	*Pinus ponderosa*	Strobili		Cone seed	
Black Cottonwood	*Populus balsamifera*	Catkins			
Bitter Cherry	*Prunus emarginata*		Fruit	Fruit	
Douglas-fir	*Pseudotsuga menziesii*	Strobili		Cone seed	Cone seed
Oregon White Oak	*Quercus garryana*	Catkins		Acorns	
Cascara Buckthorn	*Frangula purshiana*		Berry	Berry	
Pacific Yew	*Taxus brevifolia*	Catkins		Fruit seeds	
Vine Maple	*Acer circinatum*			Samara	
Grand Fir	*Abies grandis*			Cone seed	
Indian Plum	*Oemleria cerasiformes*		Fruit		
Pacific Beaked Hazelnut	*Corylus cornuta* var. *californica*			Nuts	
Salal	*Gaultheria shallon*		Fruit	Fruit	
Douglas' Hawthorn	*Crataegus douglasii*		Fruit		
Common Snowberry	*Symphoricarpos albus*	Berry	Berry	Berry	Berry
currant	*Ribes* sp.		Berry		
Red Huckleberry	*Vaccinium parvifolium*		Berry	Berry	
fungi		truffles/mushroom	truffles/mushroom	truffles/mushroom	

Appendix 4. Useful tools that can be used for projects where the goal is the enhancement of Western Gray Squirrel habitat.

Stresses being addressed through enhancement [1]	Enhancement tool [2]	Habitat benefits	Considerations	When appropriate	Useful contacts and resources to help carry out the use of a enhancement tool
Low food production Lack of suitable nest/den trees Lack of habitat diversity Lack of small forest openings	Selective thinning or harvest of trees	• Creates larger, more mature trees for better seed/nut production. • Creates more diverse habitat. • Provides variable density forests where squirrels can find cover to escape predators and find security.	• Requires experienced fellers or loggers. • Avoid removal of or damage to nest trees. • Avoid removing large trees (>40 cm dbh). • Avoid removing too much tree canopy (see Figure 3). • Do not compromise habitat complexity. • Retain densely forested "skip" patches (see Figure 7) • Get advice from regional WDFW wildlife biologist.	• Best when large oaks, pine, or firs are present.	• Ian Sinks or Lindsay Cornelius, Columbia Land Trust; Phone: 360.696.0131 • Robin Dobson, US Forest Service; Phone: 541.308.1717 • Darin Stringer, Integrated Resource Management; Phone: 541.484.1217 • Doug Kuehn, WDFW; Phone: 509.899.3361
Densely vegetated understory Low food production	Understory thinning	• Helps enhance seed production of older oaks/pines. • Helps produce a more open forest floor.	• Removal of too much native understory can reduce diversity and harm habitat. • Protect all native seed-bearing shrubs except when cover of these shrubs is unsuitably high (Figure 3). • Get advice from regional WDFW wildlife biologist. • Maintenance of an open understory requires long-term follow-up treatments.	• When understory cover is above optimal levels (see Figure 3).	
Presence of invasive plants Densely vegetated understory	Invasive plant removal	• Helps produce a more open forest floor.	• Difficult manual labor and requires a long-term commitment for periodic follow-up. • Areas of increased light penetration and soil disturbance are where follow-up treatments	• Effective when invasive plants are dominant or aggressively invading.	• Local conservation district or NRCS office. • See Invasipedia for information about controlling a specific species. • The Nature Conservancy's Global Invasive Species Team. • Sanders Freed, The Nature Conservancy; Phone: 360.357.6280

Stresses being addressed through enhancement [1]	Enhancement tool [2]	Habitat benefits	Considerations	When appropriate	Useful contacts and resources to help carry out the use of a enhancement tool
Densely vegetated understory Presence of invasive plants	Low intensity prescribed burning	• Helps maintain large oaks, pine, and fir. • Reduce excess under-story. • Can help create desirable habitat patchiness at the stand-level • May be the easiest and most cost efficient method to maintain desired habitat.	• Burn late summer or early fall when squirrels are not nesting. • Must be done with care. • DNR permits required. • Consult with trained professional. • Prepare site by removing excess seedlings, young trees, shrubs, and duff, and by limbing to reduce fire intensity and the threat of crown fires.	• Only attempt where fire can easily be contained. • Appropriate in most east and west side oak/pine forests.	• Sanders Freed, The Nature Conservancy; Phone: 360.357.6280 • Darren Kennedy, Fire Management Officer, US Forest Service; Phone: 541.308.1724
Low food production	Planting native trees and shrubs	• Improve seed/nut production. • Create shelter forests. • Enhance or replace understory shrubs. • Add to habitat diversity.	• Long term benefits, but will not address short-term problems. • Space trees 30-50' apart or plan to thin after 10 years. • In western Washington, planting Ponderosa Pine and Western White Pine (on more mesic sites) is encouraged given these species have larger seeds and are a superior food source compared to Douglas-fir.	• Primarily suitable in degraded habitat or when opportunities for habitat expansion exist. • Plant native seed-bearing shrubs except when shrub density is unsuitably high (Figure 3).	• Local conservation district or NRCS office. • See Appendix 3.
Presence of invasive plants Poor soil conditions (e.g., compacted soils)	Eliminate or reduce grazing	• Reduce spread of noxious weeds. • Reduces soil compaction. • Increases soil moisture retention.	• Light grazing (<25% annual herbaceous growth removal) with a yearly rest rotation may be compatible with squirrel habitat management.	• Beneficial where grazing has lead to bare soil, soil compaction, or where native trees, shrubs or herbaceous vegetation has been negatively impacted by grazing.	• Susan Van Leuven, WDFW; Phone: 509.773.4459

[1] Some stresses are listed more than once, meaning that they can be dealt with using more than one of the enhancement tools identified in this appendix (e.g., low food production is a stress that can be dealt with through planting trees and shrubs, understory thinning, or selective thinning or harvesting trees).

[2] Avoid using a tool within 400 ft of a nest from March 1st - August 31st where disturbances associated with active management (e.g., noise, human intrusion, use of machinery/equipment) is unavoidable.