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Management Recommendations for Washington's Priority Habitats and Species

Western Gray Squirrel

Sciurus griseus

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Washington Department of
FISH AND WILDLIFE

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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.

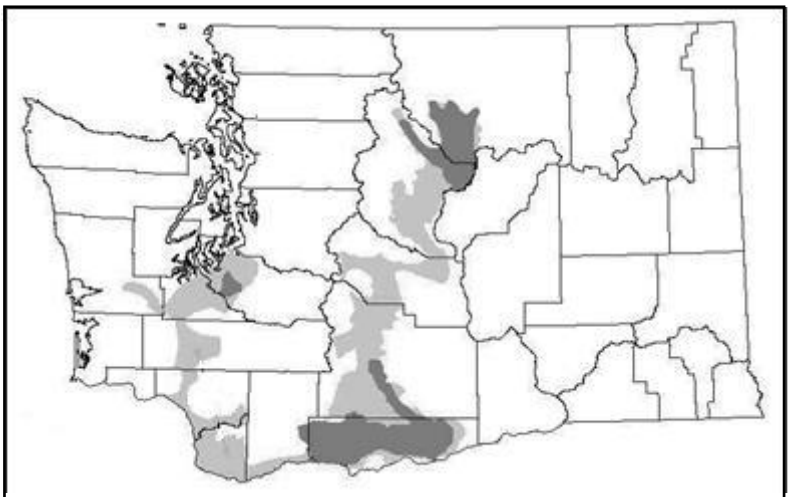

Figure 1. Historic (light) and current (dark) range of the Western Gray Squirrel in Washington.

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*).

[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.

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 – 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.

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

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 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

[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.

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

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

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*).

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 1 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.

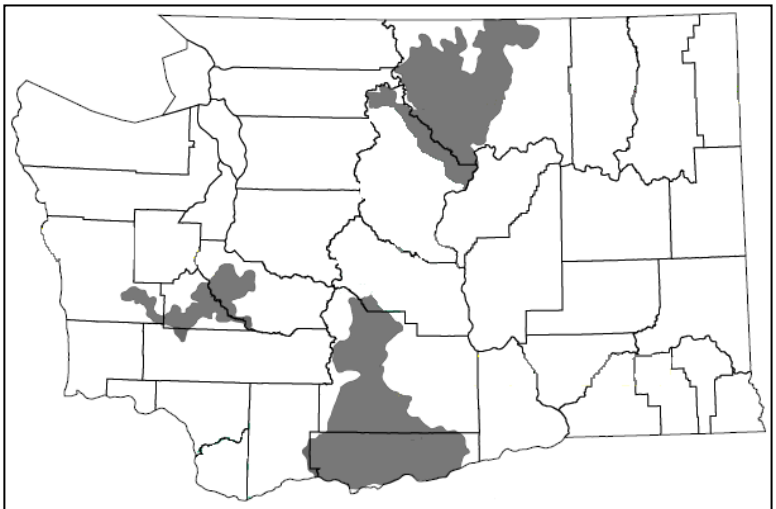

Figure 2. Recovery areas for Western Gray Squirrel in Washington.

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.

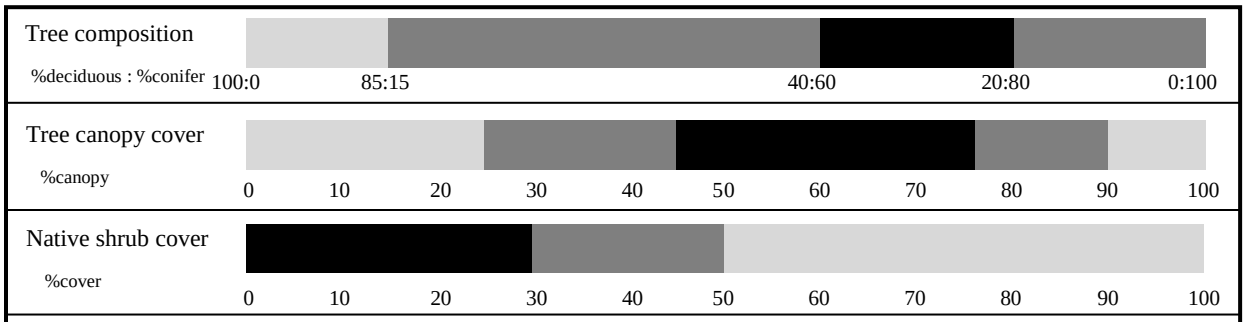

Figure 3. Key components affecting squirrel habitat quality throughout Washington. Tree composition refers mainly to the upper canopy in a stand. Ranges shaded black are considered suitable for primary habitat; black or dark grey areas are both appropriate as secondary habitat; and ranges shaded light 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 2), 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 3) 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

[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.

areas should be conserved for this reason as well as for their known significance as wildlife habitat (*37*). Trees 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.

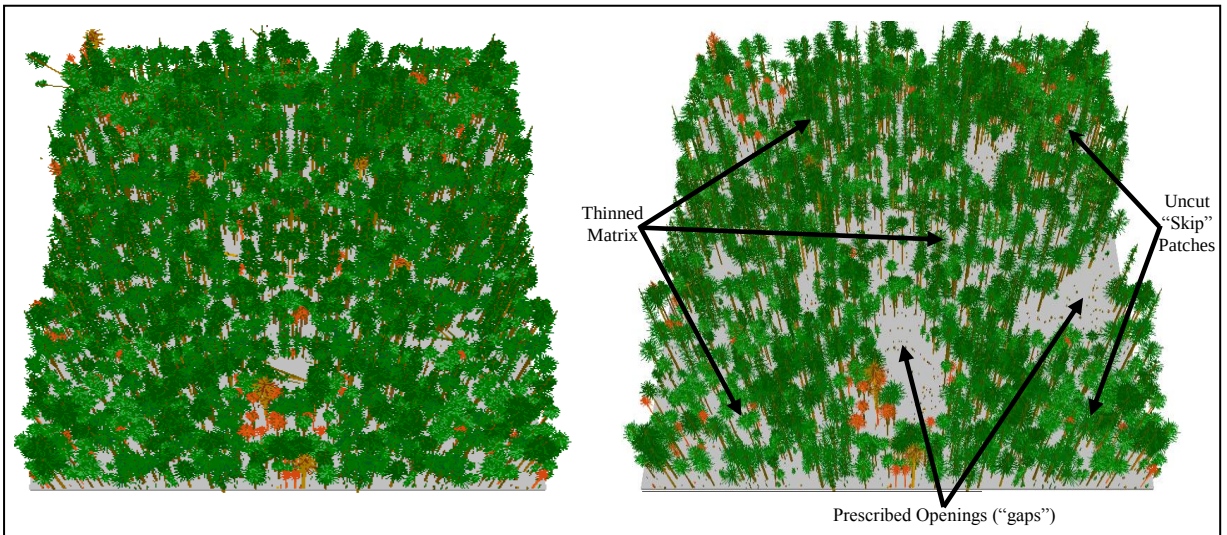

Figure 4. This example shows what a variable density thinning might look like within a 20 acres harvest unit. Small openings (gaps) and unthinned patches are part of a planned thinning which was designed to retain key features necessary to sustain Western Gray Squirrel.

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 3).
- 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 2). 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 3). Asking for assistance from knowledgeable individuals and organizations (see Appendix 3 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 3.

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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APPENDICIES

Appendix 1. 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 (≥75%) tree composition.	conifer-dominated (≥75%) 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.		

Appendix 2. 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 3. 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 2.
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.