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Periodic Status Review for the Western Gray Squirrel

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The Washington Department of Fish and Wildlife maintains a list of endangered, threatened, and sensitive species (Washington Administrative Codes 232-12-014 and 232-12-011). In 1990, the Washington Wildlife Commission adopted listing procedures developed by a group of citizens, interest groups, and state and federal agencies (Washington Administrative Code 232-12-297). The procedures include how species listings will be initiated, criteria for listing and delisting, a requirement for public review, the development of recovery or management plans, and the periodic review of listed species.

The Washington Department of Fish and Wildlife is directed to conduct reviews of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing by the Washington Fish and Wildlife Commission. In addition, as was the case with this western gray squirrel periodic status review, the Department may initiate a review of a species if a petition is received from an interested person setting forth specific evidence and scientific data to suggest that a species may be in need of reclassification. The periodic status reviews are designed to include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification. The agency notifies the general public and specific parties who have expressed their interest to the Department of the periodic status review at least one year prior to the five-year period so that they may submit new scientific data to be included in the review. The agency notifies the public of its recommendation at least 30 days prior to presenting the findings to the Fish and Wildlife Commission. In addition, if the agency determines that new information suggests that the classification of a species should be changed from its present state, the agency prepares documents to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act.

A petition to reclassify the western gray squirrel as endangered was accepted by the Department on March 27, 2014, and information was received from the public to inform the review through March 28, 2015. The draft periodic status review for western gray squirrels was reviewed by species experts and state and federal agencies. This was followed by a 90-day public comment period through December 29, 2015. All comments received were considered during the preparation of the final periodic status review. The Department intends to present the results of this periodic status review to the Fish and Wildlife Commission for action at an upcoming meeting.

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Draft Washington State Periodic Status Review for the Western Gray Squirrel

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EXECUTIVE SUMMARY

The western gray squirrel is one of three native tree squirrel species in Washington. It was historically distributed in low elevations from Pierce County southward to Clark County, through the Columbia River gorge, and in low to mid-elevations along the eastern Cascade Mountains from Klickitat to Okanogan counties. Current distribution in the state is now primarily limited to three geographically discrete areas: the Klickitat region (Klickitat, southern Yakima, and southwestern Skamania counties); the North Cascades (Okanogan and Chelan counties); and the southern Puget Trough (Joint Base Lewis-McChord and small areas off-base in Pierce and Thurston counties).

Although not well documented, western gray squirrels were probably once uncommon to locally common across much of their range in Washington. The species was in decline by the late 1800s and was considered rare by 1970. The first statewide population estimate was derived for the period from 1994 to 2005, with the population likely numbering between 468 and 1,405 squirrels (937 ± 50%). This included estimated population sizes of 705 squirrels in the Klickitat region, 190 squirrels in the North Cascades, and 42 squirrels in the southern Puget Trough. Populations have not been formally assessed since then, but the southern Puget Trough population has likely increased due mainly to translocations of squirrels to Joint Base Lewis-McChord (JBLM) in 2007-2012 and the North Cascades population may have been negatively impacted by several massive wildfires in 2014 and 2015. Minimal information exists to determine whether or not a major change in squirrel abundance or distribution has occurred in the Klickitat population since 2005, but some habitat alteration has occurred and has perhaps caused a corresponding change in the population.

Important known threats to western gray squirrel populations in Washington are habitat loss, degradation, and fragmentation; small population size and isolation; disease; and highway mortality. The factors most linked to habitat loss for western ground squirrels include land conversion, logging, wildfire, and fire exclusion. Climate change is both a current and potential future threat through impacts to squirrel habitat and mortality from forest fires.

Because of the species' relatively small total population size, continuing threats, and a lack of information suggesting that any of the three populations have either reached the downlisting goals of the recovery plan or substantially declined since 2005, it is recommended that the western gray squirrel remain a state threatened species in Washington. Ongoing surveys will provide the information needed to better clarify current western gray squirrel population levels and this information will be available to assess the status of the species for the next scheduled periodic status review.

INTRODUCTION

Washington supports a diverse native and non-native squirrel fauna comprised of 19 species of tree squirrels, ground squirrels, marmots, chipmunks, and flying squirrels. The western gray squirrel (*Sciurus griseus*) is one of five tree squirrels found in the state, three of which are native. Western gray squirrels have been considered rare in Washington since at least 1970 (Lauckhart 1970) and became a state threatened species in 1993. The Washington population is not federally listed.

This periodic status review summarizes the biology, population status, threats, and recent management activities for western gray squirrels in Washington and assesses whether the species should retain its current protected status or if it deserves reclassification under state law. A more detailed review of the species' biology, past status, population stressors in the state, and required recovery actions appeared in Linders and Stinson (2007).

SPECIES BACKGROUND

Description, taxonomy, and legal status. The western gray squirrel is the largest of three native tree squirrel species in Washington. It has gray pelage on the back and flanks contrasting with pure white on the belly and throat (Carraway and Verts 1994, Verts and Carraway 1998). It also features a long bushy tail that is primarily gray with white-frosted outer edges. The species has prominent ears that can occasionally be reddish-brown on the back in winter (only visible upon close inspection) and are the only part of the animal's pelage that may have any brown. The large size, bushy tail, and gray pelage lacking any brown on the body or tail distinguish western gray squirrels from other squirrels in Washington. Vocalizations include a hoarse "chuff-chuff-chuff" barking. Three subspecies are recognized, with *S. g. griseus* present in Washington.

Figure 1. Western gray squirrel (*photo by Joseph V. Higbee*).

Western gray squirrels are not protected under the federal Endangered Species Act. Under state laws, the species is classified as threatened in Washington and as a "vulnerable sensitive species" in Oregon.

Distribution. The species is distributed from north-central Washington southward through western Oregon, California, and the west-central edge of Nevada to northern Baja California in Mexico (Linzey et al. 2008, Escobar-Flores et al. 2011). In Washington, it was historically distributed in low elevations from Pierce County southward to Clark County, through the Columbia River gorge, and in low to mid-elevations along the eastern Cascade Mountains from Klickitat to Okanogan counties (Figure 2; Linders and Stinson 2007). Current distribution in the state is now primarily limited to three geographically discrete areas: the Klickitat region (Klickitat, southern Yakima, and southwestern Skamania counties); the North Cascades (Okanogan and Chelan

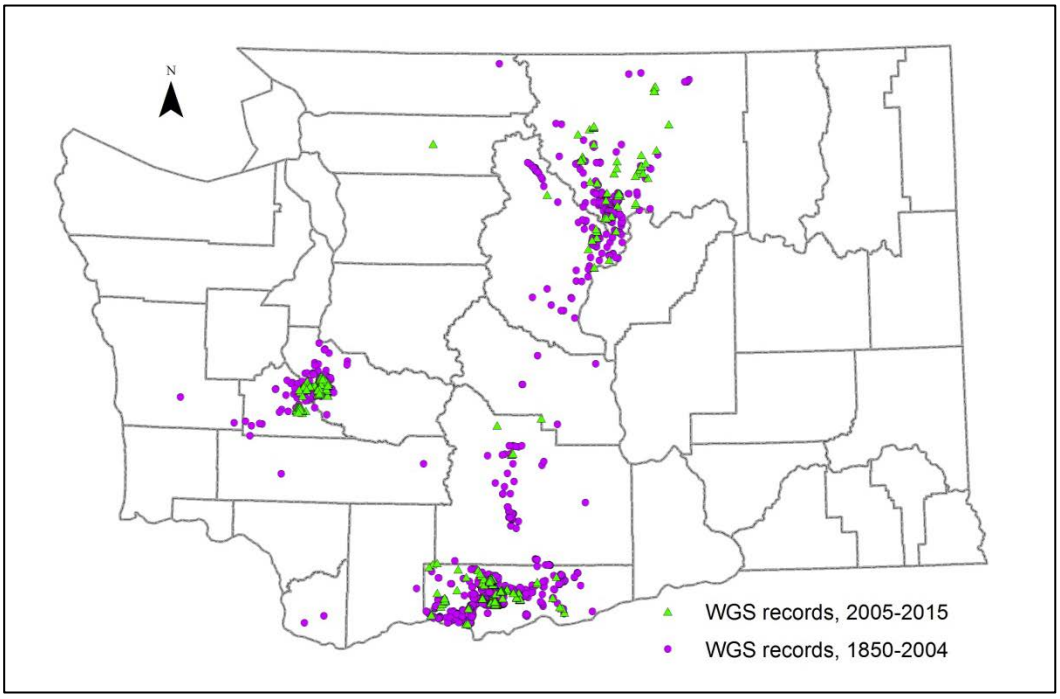

Figure 2. Western gray squirrel occurrences (squirrels and nests) in Washington from 1850-2004 and 2005-2015 (WDFW WSDM database).

counties); and the southern Puget Trough (Joint Base Lewis-McChord [JBLM] and small areas off-base in Pierce and Thurston counties) (Figure 2; Linders and Stinson 2007). Small scattered populations may also remain in parts of Clark, central and northern Yakima, and Kittitas counties. Elevational range in Washington extends primarily from near sea level to 1,300 m (4,265 ft), with a few additional records reaching 2,140 m (7,030 ft; WDFW Wildlife Survey Data Management [WSDM] database).

Behavior. Western gray squirrels are generally arboreal and solitary, and are adept at traveling through the tree canopy (Ingles 1947, Cross 1969, Foster 1992). Animals also commonly forage and move about on the ground, usually near trees. Western gray squirrels avoid large forest openings, instead using arboreal routes for escape, cover, and access to nest trees. The species is mainly diurnal, with daily activity levels highest in the hours just after sunrise. Activity occurs year-round, but is greatest in autumn when extensive feeding and caching of food takes place. Western gray squirrels are considered secretive and wary by nature, but individuals have partially habituated to human activity in some locations.

The species uses two main types of nests (stick nests and tree cavities) for resting, sleeping, and rearing young. Stick nests (dreys) can be either large rounded covered shelters for winter use or rearing young, or broad platforms for seasonal or temporary use (Ingles 1947, Cross 1969, Linders 2000). Both are constructed with sticks, twigs, leaves, and moss, and lined with grass, moss, lichens, and shredded bark. External dimensions of stick nests are 43–91 cm (17–36 in) in diameter and up to 46 cm (18 in) in height (Grinnell and Storer 1924, Ingles 1947, Foster 1992). Stick nests are usually built adjacent to the trunk in the top third of the canopy (Foster 1992). When available, tree cavities are often selected by females for giving birth and rearing young. Individual squirrels occupy

multiple nests over the course of a season, with an average of 5.9 nests used per animal in Klickitat County (Linders 2000) and 14.3 nests used per animal in Okanogan County (Gregory 2005). Breeding females sometimes use more than one nest when rearing a litter (Gregory 2005). Many nests are used by multiple squirrels throughout a season.

Habitat requirements. Forest stands occupied by western gray squirrels must provide adequate nest sites, food, and escape cover. Favored stands consist of clumps of trees that form a dense upper canopy intermingled with areas of lower canopy cover and small canopy gaps (Linders and Stinson 2007, Linders et al. 2010). Higher quality habitat commonly includes transitional, conifer-dominated areas that merge with open patches of oak and other deciduous trees. Mature, large-seeded mast-producing trees provide abundant food and sites for nest construction, with ponderosa pine (*Pinus ponderosa*) and Oregon white oak (*Quercus garryana*) especially important in Washington (Linders 2000, Gregory 2005, Hamer et al. 2005). Larger trees (i.e., >38 cm [16 in] diameter at breast height) typically offer greater food and cover. Additional features of higher quality habitat include an interconnected canopy that can be used for arboreal travel (Ryan and Carey 1995a, 1995b, Linders 2000, Gregory 2005) and fairly sparse ground cover. Animals spend most of their time in relatively small areas of higher quality habitat (known as primary habitat or core use areas) but make use of surrounding areas of lower quality (i.e., secondary) habitat (Linders et al. 2010). Squirrels may also visit isolated, open-grown trees to obtain seeds or when traveling across open expanses (Linders et al. 2010).

Western gray squirrels in the Klickitat region favor conifer-dominated forests over mixed Oregon white oak-conifer and pure oak, and usually occur in areas with a conifer overstory and an open understory (Linders 2000, Linders et al. 2010). Occupied stands are usually dominated by a multi-layered canopy of ponderosa pine and often have an upper canopy taller than 14 m (Linders et al. 2010). A sparse understory of oak with little or no shrub or ground vegetation also characterizes most occupied stands. Nest trees are typically located in the interior of forest stands, have crowns connected to adjacent trees, and usually have dominant or co-dominant crowns (Linders 2000). Nests in one study in Klickitat County were placed most frequently in ponderosa pine (72%), Douglas-fir (*Pseudotsuga menziesii*; 16%), and Oregon white oak (12%; Linders 2000). Mature trees are preferred for nesting.

In the southern Puget Trough, western gray squirrels primarily inhabit upland areas dominated by conifers with little shrub cover (Johnston 2013). Squirrel use has also been reported to be higher in mixed conifer-Oregon white oak stands dominated more by Douglas-fir than oak (Ryan and Carey 1995a). Riparian areas and stands of pure oak are used substantially less. Core areas of western gray squirrel home ranges are typically characterized by high canopy cover and connectivity (Johnston 2013). Large trees are preferred for nesting, with 92% of shelter and platform nests and 58% of cavity nests placed in Douglas-fir (Johnston 2013). Oregon white oak, ponderosa pine, Oregon ash (*Fraxinus latifolia*), black cottonwood (*Populus balsamifera*), and bigleaf maple (*Acer macrophyllum*) are also used for nesting.

In the North Cascades, where Oregon white oak is absent, western gray squirrels occur mostly in mixed conifer-deciduous forests comprised mainly of Douglas-fir and ponderosa pine with smaller amounts of species such as lodgepole pine (*Pinus contorta*), black cottonwood, bigleaf maple, and trembling aspen (*Populus tremuloides*) (Stuart 2012). Within these stands, nesting areas are characterized by large trees, high levels of dwarf mistletoe (*Arceuthobium* spp.) infection, high canopy cover and

connectivity, and a high percentage of live trees (Stuart 2012) as well as by high trunk basal areas and high tree species diversity (Gregory et al. 2010) and sparse shrub and herbaceous cover (Hamer et al. 2005). Large ponderosa pine and Douglas-fir trees with crowns connecting to adjacent trees and containing mistletoe brooms are most often used for nesting (Hamer et al. 2005, Gregory et al. 2010, Stuart 2012).

In general, habitat connectivity is essential for western gray squirrels and facilitates movement between habitat patches, predator avoidance, access to mates, and juvenile dispersal (Linders et al. 2010). Almost any habitat containing trees can provide connectivity. However, movement corridors are more likely to be used when they have an irregular or complex canopy structure and when they are composed of mature trees. Given the linear character of riparian areas, these often serve as important travel corridors, especially in areas where dry uplands support limited tree cover.

Reproduction and breeding behavior. Western gray squirrels attain sexual maturity at 10-12 months of age (Fletcher 1963, Swift 1977). The species has an extended reproductive season, with mating occurring from December to late June or July, and some young being reared until September (Swift 1977, Foster 1992). Typically, one litter is born annually (Linders 2000, Gregory 2005), although in rare instances females may successfully rear a second litter (Vander Haegen and Orth 2011). Pregnancy and nursing last about 44 days and 56 days, respectively (Swift 1977).

In Washington, most females are pregnant by February or March, with litters born from March to July. The last litters are usually weaned by late August (M. Linders and M. Vander Haegen, unpubl. data in Linders et al. 2010). Litter size ranges from one to five young, with an average of 3.3 $\pm$ 0.7 (SD) in Klickitat County (Vander Haegen et al. 2005) and 3.0 $\pm$ 0.5 on JBLM (95% CI; Johnston 2013).

Diet and foraging behavior. Primary foods of western gray squirrels include hypogeous fungi (truffles and false truffles), pine nuts, acorns, other seeds, green vegetation, and fruit, with hypogeous fungi comprising more than half of the annual diet at some locations (Stienecker and Browning 1970, Stienecker 1977, Linders and Stinson 2007). Hypogeous fungi are widely present in the diet in Washington, with at least 21 genera consumed in the North Cascades (Stuart 2012) and at least 14 genera eaten in the southern Puget Trough (Johnston 2013). The most frequently consumed genera in these areas are *Rhizopogon*, *Geopora*, and *Melanogaster*. Other foods eaten in the southern Puget Trough include Douglas-fir seeds, ponderosa pine seeds, Oregon white oak acorns, maple (*Acer* spp.) samaras, hazelnut (*Corylus* sp.) nuts, hawthorn (*Crataegus monogyna*) berries, Himalayan blackberry (*Rubus armeniacus*) berries, epigeous fungi, black cottonwood catkins, and Douglas-fir bark (Johnston 2013). Other foods in Washington include the immature catkins of aspen, larval and adult rain beetles (*Pleocoma* sp.), the cambium of Douglas-fir, ponderosa pine, and maples (Bowles 1921, Scheffer 1923, 1952, Gaulke and Gaulke 1984), and Oregon white oak flowers (S. Van Leuven, pers. comm.). Western gray squirrels forage both in trees and on the ground. Foods such as acorns and hypogeous fungi are often cached underground for later consumption in seasons when food is less abundant.

Movements. Home ranges of western gray squirrels vary in size, shape, and amount of overlap with other individuals based on sex, age, season, and the availability of food, nest cavities, and other resources. Average home range sizes vary among the three populations in Washington and are significantly larger in males (74-460 ha) than in females (18-80 ha) (Linders 2000, Linders et al. 2004,

Gregory 2005, Stuart 2012, Johnston 2013). These sizes are larger than those reported in Oregon and California, suggesting poorer habitat quality in Washington (Linders et al. 2004). Some studies have reported that western gray squirrels in Washington exhibit low home range overlap and nearly exclusive core areas, with same-sex overlap lower in females (4.7-7.0%) than in males (15-17%; Linders 2000, Gregory 2005; Vander Haegen, pers. comm.). However, other studies have documented substantially higher same-sex overlap (≥26%; Stuart 2012, Johnston 2013).

During the breeding season, males expand their movements to search for females, whereas female movements remain similar or become more restrictive compared to the non-breeding season (Linders 2000, Linders et al. 2004, Stuart 2012). Both sexes have smaller home ranges during the winter (Linders et al. 2004, Stuart 2012). Animals may shift their home range locations seasonally in response to changes in the availability of food or nests, or may permanently disperse to establish new home ranges (Linders and Stinson 2007). Vander Haegen et al. (2005) reported that 20% of juveniles dispersed away from natal home ranges during their first fall, moving an average distance of 2,862 ± 213 (SD) m. Stuart (2012) recorded a maximum movement of 15.4 km by an adult male.

Population demographics. Population densities of 0.25-4.3 animals/ha have been recorded in California (Carraway and Verts 1994), but are generally much lower in Washington (e.g., 0.23 ± 0.08 [SE] animals/ha in Klickitat County; Vander Haegen et al. 2005). Substantial population fluctuations can occur in response to changes in food supply, weather, disease, hunting, predation, and logging of mast-bearing trees (see citations in Linders and Stinson 2007). The size of one population in southern Oregon varied nine fold during an 8-year period (Carraway and Verts 1994).

Vander Haegen et al. (2013) reported a maximum life span in the wild of at least 8 years. Survival is variable among years and seasons depending on food availability and disease outbreaks. In Klickitat County, average annual survival was higher among females (62 ± 13% [SD]) than males 55 ± 14% (Vander Haegen et al. 2013). Survival is probably lowest among juveniles younger than 5 months of age. At JBLM, similar annual survival rates existed between females (60%, 95% CI 0.503, 0.697) and males (62%, 95% CI 0.454, 0.757) (Johnston 2013). Survival has been reported as fairly similar between breeding and non-breeding seasons (Vander Haegen et al. 2013) or lower during fall-winter than in spring-summer (Stuart 2012). Equal sex ratios have been recorded in Klickitat County (Linders 2000), which is believed typical of most tree squirrel species (Gurnell 1987, Steele and Koprowski 2001).

Sources of direct mortality include predation, disease, automobiles, and sport hunting (Ingles 1947, Vander Haegen et al. 2013). Numerous predators are known to kill western gray squirrels, including raptors and small and mid-sized carnivores (Carraway and Verts 1994, Linders and Stinson 2007). In Klickitat County, predation by bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and other species accounted for 63% of all mortality (Vander Haegen et al. 2013). Similarly, more than half of the squirrel deaths at JBLM and in the North Cascades were attributed to predation (Vander Haegen and Orth 2009, 2011, Stuart 2012).

Disease is another important cause of mortality in Washington and was responsible for 37% of western gray squirrel deaths in a study in Klickitat County from 1998 to 2005 (Vander Haegen et al. 2013). Most (77%) of this mortality was due to notoedric mange caused by the mite *Notoedres centrifera* (Vander Haegen et al. 2013). Mange was present in all years in this population and was usually most prevalent in spring. During occasional years with severe outbreaks, more than half of

the population can be infected, which can result in greatly reduced squirrel abundance (Cornish et al. 2001, Linders and Stinson 2007). To date, mange has been recorded in only two animals in the North Cascades (Stuart 2012) and not at all at JBLM (M. Vander Haegen, pers. comm.). Mild winter temperatures and nutritional stress brought on by mast crop failures, drought, or degraded habitat likely plays a role in causing severe outbreaks of mange (Cornish et al. 2001, Vander Haegen et al. 2013). Tularemia, a bacterial disease common to rodents and lagomorphs, was a mortality factor for western gray squirrels on JBLM between 2007 and 2011, when 10 radio-tagged squirrels died from the disease (M. Vander Haegen, pers. comm.).

Automobiles can be an important source of mortality in some western gray squirrel populations (Ingles 1947). In Washington, mortality from automobiles regularly occurs at JBLM in Pierce County (Ryan and Carey 1995b, Johnston 2013), in Klickitat County (Linders and Stinson 2007), and in the North Cascades (Bartels 1995, 2000, Stuart 2012). Highway mortality has also occurred at Oak Creek Wildlife Area in Yakima County (Gaulke and Gaulke 1984).

POPULATION STATUS AND TREND

Global. The pre-breeding season population size of western gray squirrels in California was estimated at approximately 18 million animals by 2000 (California Department of Fish and Game 2002 in USFW 2004). Population trends in many parts of California are probably relatively stable. The species is hunted in most of the northern two-thirds of California, with up to 50,000 squirrels harvested annually (CDFG 2011). Population data are lacking for Oregon. The species showed some evidence of decline in recent decades, particularly in the north (Foster 1992, Weston 2005), but recent observations suggest abundance has perhaps stabilized and that distribution has expanded eastward in some areas of the state (T. Thornton, pers. comm.). Hunting is still allowed in Oregon, but harvest levels are unrecorded. The species is uncommon and not hunted in Nevada (USFWS 2004). Population status in Mexico is unknown.

Washington past. Relatively little information is available on the historical abundance of western gray squirrels in Washington (Linders and Stinson 2007). The species was noted as uncommon in the southern Puget Trough during late 1800s due to hunting, but increased substantially after about 1910 (probably because of legal protection and increased forest availability) and was described as "extremely numerous" in 1921 (Bowles 1921). Booth (1947) remarked that squirrels in western Pierce County were more common than in Klickitat County. Records indicate that western gray squirrels remained fairly widespread in Pierce and Thurston counties into the 1970s (Barnum 1975; WDFW WSDM database), although land development caused declines in some areas in the 1950s or earlier (M. Johnson, pers. comm. in Rodrick 1986). Squirrels were last recorded in southern Thurston County during the late 1970s (WDW 1993). By 1985-1986, the southern Puget Trough population appeared to be restricted to JBLM (Rodrick 1986).

Western gray squirrels were uncommon to locally common in the southern Cascade Mountains in the 1930s and 1940s (Booth 1947, Scheffer 1957). Anecdotal reports indicate that outbreaks of mange decimated numbers in Klickitat County in the 1930s (Linders and Stinson 2007) and in Yakima County in the 1940s-1950s (Stream 1993). The species was considered uncommon in parts of Klickitat County during the 1970s (Barnum 1975; D. Morrison, pers. comm. in Linders and Stinson 2007).

Observations are sparse for the North Cascades population, but a hunting season for the species was closed in 1929 after one year apparently because squirrels were insufficiently abundant (Linders and Stinson 2007). Hard winters and indiscriminate shooting may have kept numbers relatively low during the 1960s (Stream 1993, WDFW files).

The western gray squirrel was included in a 1970 brochure of rare mammals in Washington, when it was described as most numerous in oak woods, but scarce elsewhere in its range (Lauckhart 1970). Barnum (1975) stated that the species had become increasingly rare and that remaining populations were restricted to a few isolated locations in the state.

Washington present. Linders and Stinson (2007) summarized survey efforts conducted for western gray squirrels in Washington from the early 1990s to 2005 and estimated the number of animals in each of the three main populations and statewide. Based on the amount of potential habitat, distribution of squirrel occurrences, home range sizes, and extent of home range overlap among individuals, they estimated hypothetical population sizes of 705 squirrels in the Klickitat region, 190 squirrels in the Okanogan region, and 42 squirrels in the southern Puget Trough for the period of 1994-2005. They placed the statewide population as likely numbering between 468 and 1,405 squirrels (937 ± 50%). This represents the only population estimate for Washington to date. Linders and Stinson (2007) also established a recovery objective for downlisting the Washington population from threatened to sensitive, as follows: total populations of 3,300 adult squirrels in the Southern Cascades Recovery Area (i.e., the Klickitat region), 1,000 adult squirrels in the North Cascades Recovery Area, and more than 300 adult squirrels in the Puget Trough Recovery Area, plus the existence of management plans, agreements, regulations, and/or other mechanisms that effectively protect the habitat values for populations. Linders and Stinson (2007) did provide population objectives for uplisting to endangered status or delisting.

Limited new information on western gray squirrel abundance in the state has become available since 2005, however, no revised size estimates have been derived for any of the three main populations. In the southern Puget Trough, WDFW conducted a translocation project from 2007 to 2012 to augment the squirrel population on JBLM, releasing 93 animals from other populations in Washington and Oregon (Vander Haegen and Orth 2009, 2011; M. Vander Haegen, pers. comm.). Ongoing habitat enhancement of oak communities has also likely benefited this population. Additionally, recent research indicates that home range overlap on JBLM may be greater than previously reported (Johnston 2013), which can indicate larger population size. Based on recovery efforts and new information, this population is presumed larger now than in 1994-2005 and likely occupies a greater area, including a few individuals living outside of JBLM in both Pierce and Thurston counties (Vander Haegen and Orth 2011; M. Vander Haegen, pers. comm.). However, the population is still considered vulnerable because of its small size, limited geographic range, and isolation from other populations (M. Vander Haegen, pers. comm.).

Three recent data sources indicate that until June 2014 the North Cascades population was probably larger than estimated by Linders and Stinson (2007). Stuart's (2012) telemetry data suggested smaller home ranges and greater overlap among squirrels than noted by Gregory (2005), indicating that available habitat in some areas supported more animals than previously believed. Surveys conducted along the Methow and Okanogan Rivers in 2010-2013 slightly expanded the known distribution of the species (Yamamuro et al. 2011, Pacific Biodiversity Institute 2012). Genetic analyses also suggested that the region had a larger effective population size than previously thought (i.e, 500-

1,000 squirrels), although this estimate has not been validated with field data (Stuart 2012). However, in July 2014, the Carlton Complex fire, which at 103,723 ha was the largest wildfire in Washington's history, burned about 30% of modeled western gray squirrel habitat in the population's range, including some of the most densely occupied habitat (Morrison 2014; M. Vander Haegen, pers. comm.). This was followed in 2015 by more major fires (Chelan Complex, Okanogan Complex, and Wolverine fires) that burned substantial additional squirrel habitat. Impacts of the fires to the squirrel population and its habitat have not yet been assessed. Sizeable areas of habitat burned in these fires at high or moderate intensities, which would have undoubtedly killed squirrels and significantly altered their habitat, while other areas burned at lower intensities and had fewer negative effects on the species.

Relatively little additional information on the size or trend of the Klickitat population has been obtained since 2005. In Klickitat County, where most of this population occurs, an estimated 12% (209 km^2 [51,644 acres]) of the 1,759 km^2 (434,650 acres) of potentially suitable habitat for western gray squirrels was altered between 2005 and 2014, primarily by timber management activities that reduced canopy cover below levels suitable for western gray squirrels (WDFW, unpubl. data). It is important to note that this estimate may not equate to a net loss of habitat considering that (1) the harvested forest represented an unknown amount of squirrel habitat, (2) other forest stands may have grown into habitat for the species, and (3) forest management on some sites may have improved their value as habitat. Thus, the total net change in habitat in the county since 2005 is unknown. Other trend information includes the results of periodic trapping on a 1-km^2 grid in good quality habitat on the Klickitat Wildlife Area, which suggest that squirrel abundance has remained relatively stable there since 2000 (M. Vander Haegen, pers. comm.). No further major outbreaks of mange have occurred in the population since 1999 (M. Vander Haegen, pers. comm.). Overall, no extensive evidence exists to determine whether or not a major change in squirrel abundance or distribution has occurred in the Klickitat population since 2005, although some habitat change has happened and has perhaps caused a corresponding change in squirrel numbers.

In conclusion, no new population estimates have been derived for western gray squirrels in Washington since the 1994-2005 estimate of Linders and Stinson (2007). However, numbers may have changed in all three regional populations since then, with a probable increase in the southern Puget Trough resulting from translocations and other conservation efforts at JBLM, a possible decrease in the North Cascades caused by major forest fires in 2014 and 2015, and a possible change in the Klickitat region due to habitat alteration. A major statewide survey of western gray squirrel abundance is being conducted from 2015 to 2017 (see Management Activities) and upon completion will provide distribution and relative abundance among ecological systems for the three populations. These new estimates of population extent and relative abundance will be available for the next periodic status review for this species.

FACTORS AFFECTING CONTINUED EXISTENCE

Adequacy of existing regulatory mechanisms. As a state threatened species, western gray squirrels are protected from intentional killing and intentional destruction of nests (RCW 77.15.130). Currently, there is no Forest Practices Rule in effect for this species, therefore Washington Department of Natural Resources (WDNR) and WDFW take a voluntary management approach with forest land owners to protect western gray squirrels. WDFW biologists screen forest practices applications (FPAs) for likely western gray squirrel presence and conduct follow-up surveys to

confirm presence or absence. While demonstrating squirrel occupancy of habitat currently relies upon finding stick nests, there are drawbacks to this method, including (1) telemetry has revealed that some stick nests may not be detected during surveys, (2) occupancy surveys may fail to identify forest stands used only for foraging or those only having cavity nests, and (3) some sites inhabited during periods of moderate to high population densities may be temporarily unoccupied during periods of lower abundance, and therefore be deemed unoccupied at the time of a survey.

At sites that are confirmed to be occupied by squirrels, biologists work with landowners to educate them about the species and its habitat requirements, and how WDFW's Priority Habitats and Species (PHS) recommendations (Linders et al. 2010) can be incorporated into their harvest planning and land management goals. The biologist then works with the landowner to develop a management plan that the landowner can agree with and is willing to implement, while providing as much protection as possible for the squirrel and its habitat. The level of habitat protection may vary depending on the landowner's harvest goals. This plan is shared with the WDNR, who may help with implementation of the plan. In a study of 10 timber harvest sites in Klickitat County, Vander Haegen et al. (2004) found that operators did not always implement all of the recommended protection measures specified in their forest practices permits and concluded there was a strong need for improved implementation of these habitat protection measures. In 2014, seven of 31 management plans did not achieve the ideal level of habitat protection recommended by biologists (primarily leaving only nest trees without adequate connectivity between nest trees). This especially pertained to small forest landowners who tend to be more financially constrained on the amount of trees they are able to leave in place. WDNR and WDFW are performing additional outreach to small forest landowners on the importance of their participation in providing habitat conservation for the squirrel, and in contributing towards a successful voluntary management approach. In 2013, the Forest Practices Board requested that WDFW and WDNR provide annual reports on the status of western gray squirrels, management plans developed for their protection, and the success of the current voluntary management approach. After further information is available, the Forest Practices Board will assess whether or not additional protection measures may be necessary.

Under Washington's Growth Management Act, counties and cities are required to develop critical area ordinances that identify fish and wildlife habitat conservation areas and use the best available science to regulate development that would impact those areas (RCW 36.70A.050 and 36.70A.172). Counties vary in critical area definitions, implementation, and levels of protection offered, but generally development proposals impacting the habitat of a listed species can be conditioned to avoid, minimize, or mitigate impacts. For projects involving the cutting of oaks and other large trees used by western gray squirrels, effective mitigation is difficult because of the long time needed before replacement trees produce mast in significant amounts and develop cavities suitable for nesting. Pierce, Thurston, Okanogan, Chelan, Klickitat, and Yakima counties have critical area ordinances that apply where western gray squirrels or their habitat are known to occur.

Federal protective measures for western gray squirrels in Washington vary among agencies. The species is recognized as a "sensitive species" by the U.S. Forest Service, but this classification provides no protection for animals and little protection for their habitat. Western gray squirrels may receive some consideration in U.S. Forest Service plans, but there is no requirement to avoid or minimize direct or indirect impacts to the species' habitat. The Columbia River Gorge National Scenic Area, which is jointly administered by the Columbia River Gorge Commission and the U. S. Forest Service, protects confirmed western gray squirrel nests and requires WDFW-approved plans

for development or logging where the species is present. At JBLM, policy or guidelines for management of the species is contained in the base's *Integrated Natural Resources Management Plan* (DOA 2007). Although no training restrictions exist for areas occupied by western gray squirrels, JBLM Range Regulations prohibit the intentional harassment of all wildlife species and the base has been a proactive leader in western gray squirrel conservation.

At least two final or draft habitat conservation plans (HCPs) that receive approval by the U.S. Fish and Wildlife Service include western gray squirrels or their habitat. Through a WDNR HCP, some aspects of oak woodland habitat (e.g., trees >20 inches [51 cm] in diameter and maintenance of 25–50% canopy cover) are protected in southern Cascades planning units to offset squirrel habitat losses during certain WDNR operations (WDNR 1997). An HCP being developed by Thurston County is anticipated to cover western gray squirrels and portions of their habitat within the county.

Habitat loss, degradation, and fragmentation. Conifer-hardwood forests in Washington have changed dramatically over the past century and continue to be negatively impacted by land conversion, logging, wildfire, and fire exclusion (Chappell et al. 2001a, 2001b). All three western gray squirrel populations are affected by various forms of land development (e.g., building and road construction, land clearing), resulting in habitat loss and fragmentation for the species. Along the eastern Cascade Mountains, development is often concentrated in the riparian forests of valley bottoms occupied by squirrels (USDA Forest Service 1996). Urbanization continues to occur in the southern Puget Trough on the lands surrounding JBLM and reduces opportunities for western gray squirrel colonization outside the base. On JBLM, some loss of habitat still occurs near areas of previous development, but is typically offset by habitat restoration activities elsewhere on the base.

Logging may degrade western gray squirrel habitat by destroying nests and potential nest sites, fragmenting the tree canopy that squirrels use for travel and escape cover, and reducing or eliminating food sources (Vander Haegen et al. 2004, Linders and Stinson 2007). Most logging in the Klickitat and Okanogan regions involves either partial cuts in dry forests, in which large trees are generally removed, or clearcuts in more mesic forests in which almost all trees are removed (Linders and Stinson 2007). Some level of thinning harvest may improve forest conditions for squirrels by increasing sunlight to remaining trees and increasing mast production, but over-thinning can reduce canopy closure and inhibit arboreal travel. Among the three squirrel populations, timber management activities have been greatest in the Klickitat region, which may have resulted in a net reduction of habitat for the species during the past decade.

Fire exclusion from Washington's dry forests increases tree density, litter depth, and fuel loading, thereby heightening the risk of large catastrophic fires (Agee 1993, Graham and Jain 2005) that can threaten western gray squirrels and their habitat. At more mesic sites, fire exclusion can lead to invasion by Douglas-fir and grand fir (*Abies grandis*), which can overtop and suppress shade-intolerant oaks and pines (Agee 1993, Ryan and Carey 1995a), as well as exotic vegetation such as Scotch broom (*Cytisus scoparius*). Regular burns of lower intensity can help restore forests to more natural conditions, thus providing many potential benefits for western gray squirrels. Benefits include reducing the density of forest understories, creating more open park-like conditions in forests, enhancing the survival and size of remaining trees, increasing seed production, and reducing the potential for large destructive fires (Agee 1993, Fitzgerald 2005).

In December 2013, WDFW began comprehensive tracking of FPAs that might be associated with western gray squirrel habitat. More than 90 FPAs were received in 2014 (G. Bell, pers. comm.). There has been a noticeable upward trend in FPAs related to forest health improvements (e.g., thinning, fuels reduction) or harvest. In Okanogan County, FPAs have increased substantially since the Carlton Complex fire (12 post-fire FPAs in 2014) as landowners have attempted to salvage log burned stands or thin forests outside the perimeter of the fire (G. Bell, pers. comm.). A similar increase can be expected in response to the recent 2015 fires.

Small population size and isolation. Small isolated populations of western gray squirrels, such as those found in Washington, face higher risks of extirpation from stochastic events (e.g., disease outbreaks, fluctuations in mast production) and declining genetic diversity that can result in inbreeding depression and reduced fitness. Washington populations are known to have lower genetic diversity than populations in Oregon and California (Warheit 2003). By the early 2000s, the southern Puget Trough population was considered most at risk from genetic concerns because of its small size, but a translocation program conducted in 2007-2012 may have partially alleviated this concern (Vander Haegen 2012).

Disease. Notoedric mange has had a significant impact on western gray squirrels in Washington since at least the early 1930s (Linders and Stinson 2007), especially in the Klickitat population, where disease is the second most common cause of mortality after predation (Vander Haegen et al. 2013). Mange outbreaks are occasionally severe in the Klickitat region and have caused declines in squirrel abundance, but have not been reported in the other two populations. Outbreaks likely result from periods of nutritional stress caused by mast crop failures, drought, or degraded habitat (Cornish et al. 2001, Linders and Stinson 2007) and may be related to mildness of the winter (Vander Haegen et al. 2013). Outbreaks have not been observed in the Klickitat population since 1999, but remain a recurring threat in this region (Vander Haegen et al. 2013).

Highway mortality. Squirrels in all three Washington populations have experienced significant roadkill mortality (Linders and Stinson 2007). Animals often cross roads to access foraging sites or when seeking mates, which can expose them to vehicles on a regular basis (Linders and Stinson 2007). Immature squirrels may be most vulnerable, especially when dispersing from natal home ranges (Gaulke and Gaulke 1984, Ryan and Carey 1995b). The risk of road-kill mortality is expected to increase in the future as Washington's human population, and hence traffic volume, continue to grow.

Climate change. The impacts of climate change on western gray squirrels in Washington are unclear, especially in the long-term. Altered fire regimes caused by climate change have probably already affected the occurrence and intensity of forest fires in the state, with impacts likely to increase in the future (Littell et al. 2010). Major fires have the capability of damaging large areas of western gray squirrel habitat and directly killing squirrels in the North Cascades and Klickitat regions, as demonstrated by the large Carlton Complex, Chelan Complex, Okanogan Complex, and Wolverine fires that occurred in Okanogan and Chelan counties in 2014 and 2015. Additionally, warmer temperatures associated with climate change could increase the exposure of squirrels to disease (Steel et al. 2011). Despite these concerns, one recent modeling exercise suggests that western gray squirrels could significantly expand their range in eastern Washington as climate change alters forests over the next century (Johnston et al. 2012).

Other human-related or natural factors. Introduced eastern gray squirrels (*S. carolinensis*) and eastern fox squirrels (*S. niger*), and native California ground squirrels (*Otospermophilus beecheyi*) and Columbian ground squirrels (*Urocitellus columbianus*) may compete for food and habitat with western gray squirrels in parts of their range in Washington (Linders and Stinson 2007; J. Ransom, pers. comm.). These species are expanding their ranges in Washington and overlap in places with western gray squirrels in the southern Puget Trough or in parts of Okanogan, Chelan, Yakima, Klickitat, and Skamania counties. Recent research at JBLM detected few competitive interactions between western and eastern gray squirrels largely because of differential habitat use (Johnston 2013). This pattern may not hold true in other locations where western gray squirrels and introduced squirrels may occupy the same habitats. Introduced wild turkeys (*Meleagris gallopavo*) are another potential competitor of western gray squirrels. Although there are no data on the potential impacts of turkeys on western gray squirrels, the two species overlap extensively in the Klickitat and Okanogan regions and are known to consume some of the same foods (Linders and Stinson 2007).

Other factors may have the potential to negatively affect western gray squirrels in Washington, but have not yet been confirmed to have important impacts to populations. These include disturbance from military training exercises at JBLM, poorly managed grazing practices, incidental hunting mortality, and introduced pathogens or insects that harm squirrel habitat (Linders and Stinson 2007, Linders et al. 2010).

MANAGEMENT ACTIVITIES

Management recommendations. WDFW updated its PHS management recommendations for western gray squirrels in 2010 (Linders et al. 2010). These revisions included a shift in emphasis from protecting individual nest locations and maintaining forest canopy connectivity between nest trees to a broader landscape-level approach that focuses on protecting key habitat features important for western gray squirrels.

Management plans for forest practice applicants. WDFW Habitat Program staff regularly review FPAs that may adversely impact western gray squirrels or their habitat (see Adequacy of Existing Regulatory Mechanisms). For willing landowners with squirrels on their lands or proposed harvest sites, staff work with landowners to develop management plans that incorporate PHS recommended habitat protection measures for squirrels. Landowners that voluntarily accept a plan, agree to minimize harvest activities that alter habitat and that may disrupt the squirrels' breeding and rearing of young. The level of protection agreed to in these management plans, however, varies depending on the landowner's forest management goals and financial constraints.

Surveys. WDFW and partners continue to survey for western gray squirrels to better determine current distribution in Washington. Surveys are primarily conducted using hair-snag tubes to confirm presence of the species. The largest survey between 2007 and 2014 was done by the Pacific Biodiversity Institute in the Methow watershed of Okanogan County in 2010-2012. This citizen science project resulted in the deployment of tubes at 463 sample locations and detections of squirrels at 44 locations, including five new areas (Pacific Biodiversity Institute 2012). WDFW conducted smaller surveys at other locations in 2010-2012. These included sites with squirrel habitat along the south shore of Lake Chelan in 2010 and 2011 (106 tube locations, squirrel detections in multiple new drainages; Gallie 2010); along the north shore of Lake Chelan and the Entiat River

valley in 2012 (37 tube locations, no detections); in the Okanogan watershed (no detections); and in the Nile Creek drainage in Yakima County in 2011.

In 2015, WDFW initiated a major survey of western gray squirrel distribution and relative abundance among ecological systems in the Klickitat and North Cascades populations, as well as in the east-central Cascades where remnant subpopulations may exist. Field sampling will rely on hair-snag tubes placed along transects through squirrel habitat. The surveys will continue in 2016 and 2017, and will be expanded to include the southern Puget Trough.

Southern Puget Trough population augmentation. WDFW, in cooperation with JBLM, conducted a translocation project from 2007 to 2012 to augment the base's western gray squirrel population, releasing 93 animals from Klickitat and Okanogan counties and from Hood River and Wasco counties, Oregon (Vander Haegen and Orth 2009, 2011, Vander Haegen 2012). Goals of the project were to increase the population's size, genetic diversity, and area of occupation. The project is considered successful, with breeding populations established on two new areas of the base, squirrels expanding to nearby off-base areas, and translocated animals showing normal levels of survival and reproductive success, and probably interbreeding with resident squirrels.

Research. Several research projects have been conducted since 2007 and have provided valuable information on the species' conservation and management in Washington. In the North Cascades, Stuart (2012) studied distribution, life history, and response of western gray squirrels to fire fuel treatments during 2008-2011. Core areas and nest sites were located in both treated and untreated sites, indicating that previous fuel treatments retained adequate habitat to support squirrel populations in this area. Stuart (2012) recommended that during fuels reduction treatments, desirable habitat features such as patches of large trees with mistletoe and moderate levels of canopy cover and connectivity should be retained to protect habitat for squirrels. The study also found similar genetic heterozygosity and allelic richness between the Methow Valley and Stehekin subpopulations.

Two intensive studies of western gray squirrel ecology were conducted on JBLM from 2006-2012. The first quantified population parameters including survival, causes of mortality, productivity, and resource selection (Vander Haegen and Orth 2009, 2011), while the second examined potential competition between western and eastern gray squirrels (Johnston 2013). The latter study noted high dietary overlap for most food resources between the two species, but found little distributional overlap in terms of habitat use. Western gray squirrels occurred primarily in coniferous uplands with little understory vegetation, whereas eastern gray squirrels used riparian areas with deciduous trees and dense understory. Johnston (2013) concluded that coexistence of western and eastern gray squirrels appears possible where distinctly different upland and riparian habitats occur.

Other management activities. Habitat restoration, done in part to benefit western gray squirrels, has been conducted at several locations. At JBLM, restoration of oak communities is underway and involves the removal of Douglas-fir trees overtopping oak stands, mowing of Scotch broom, and planting of oak seedlings. At the Klickitat Wildlife Area, forest understory vegetation has been thinned as resources allow to reduce the threat of large wildfires and eliminate excessive ground cover for squirrels. Fire fuel reduction treatments have also been conducted by the National Park Service at Stehekin.

CONCLUSIONS AND RECOMMENDATION

Western gray squirrels have declined substantially in Washington since the late 1800s and are now largely limited in distribution to three separate areas: the Klickitat region, the North Cascades, and the southern Puget Trough. Population estimates have not been updated since 1994-2005, when Linders and Stinson (2007) estimated 937 ± 50% (low of 468, high of 1,405) squirrels in the state, including 705 animals in the Klickitat region, 190 animals in the North Cascades, and 42 animals in the southern Puget Trough. Since 2005, abundance has probably increased in the southern Puget Trough because of translocations, although this population remains insecure because of its small size and limited geographic area. The North Cascades population has possibly declined since 2005 due to habitat alteration and mortality caused by the major wildfires of 2014 and 2015. No information exists to fully determine if major changes have occurred in the Klickitat population during the past decade, but some habitat alteration has occurred which may have caused a corresponding change in squirrel distribution or abundance. The species continues to be most threatened by habitat loss, degradation, and fragmentation; small population size and isolation; disease; and highway mortality. For these reasons and because no information is available to suggest that the three populations have either reached the downlisting goals of the recovery plan (Linders and Stinson 2007) or have substantially declined since 2005, it is recommended that the western gray squirrel remain listed as a state threatened species in Washington.

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