Western Gray Squirrel (*Sciurus griseus*)

Conservation Status—The western gray squirrel is classified as an ISSSSP Sensitive Species in Washington, and is an Oregon Conservation Strategy (OCS) Species as well as a game animal (ODFW 2006), however the species has no federal special status. In Washington, the western gray squirrel is designated as a state threatened species (WDFW 2009). Factors limiting western gray squirrel populations include habitat loss and fragmentation (Ryan and Cary 1995a; ODFW 2006), predation by domestic cats (Verts and Carraway 1998), competition from introduced squirrel species (Ryan and Cary 1995a), changes in woodland structure due to fire suppression (ODFW 2006), and road-related mortality (Ryan and Cary 1995a, Verts and Carraway 1998).

Distribution— The geographic range of the western gray squirrel extends from the coastal mountains near the Mexico-California border, north along the Sierra Nevada range and along the coast to the southern Cascades (Verts and Carraway 1998). In Oregon, the western gray squirrel occurs throughout the Willamette Valley, southwest Oregon, the Columbia Gorge, foothills of the western Cascades, and lower elevations of the eastern Cascades (Verts and Carraway 1998).

Ecology—In western Oregon, western gray squirrels are strongly associated with *Quercus* woodlands and conifer forests in which Oregon white oak co-occurs (Verts and Carraway 1998). Dalquest (1948) stated that the occurrence of western gray squirrels in Washington is primarily regulated by the spatial distribution of Oregon white oak, the only true oak (*Quercus* spp) that occurs in the state. In contrast, Ryan and Carey (1995b) failed to detect western gray squirrels in pure stands of Oregon white oak at Fort Lewis, Washington, but found that the frequency of stand use was correlated with the species-richness of trees and shrubs that produce large seeds and fruits.

The geographic distribution and life history characteristics of true oaks probably prevent western gray squirrels and other vertebrates from becoming overly dependent upon acorn crops as a food source in the Willamette Valley. Oregon white oak is the only acorn-producing species across most of the Valley (scattered populations of California black oak occur in Lane County) and its acorn production exhibits high inter-annual variation in abundance and synchronicity across large geographic areas (Coblentz 1980, Ryan and Carey 1995a, Peter and Harrington 2009). High yields of mast may only occur once every 3 to 6 years (Ryan and Carey 1995b), thus posing a significant limit to any wildlife species that specializes in feeding upon acorns. Coblentz (1980) speculated that a poor mast crop in the Willamette Valley during 1978 affected the abundance of western gray squirrels in the region.

Besides acorns, the diet of western gray squirrels in Oregon is composed of seeds from Douglas fir (*Pseudotsuga menziesii*) Sitka spruce (*Picea sitchensis*), grand fir (*Abies grandis*) and pines (*Pinus* spp); as well as berries, leaf buds, and tree sap (Bailey 1936; Maser et al. 1978). Hypogeous fungi (i.e., truffles) may comprise a large proportion of their diet during spring and summer (Cross 1969, Stieneck and Browning 1970). The mutualistic relationship with ectomycorrhizal fungi is essential to the growth of Oregon white oak, thus by dispersing mycorrhizal inoculum, small mammals play a crucial role in the regeneration of oak trees (Frank et al. 2008). Western gray squirrels were not one of the species tested in the southern Oregon study by Frank et al. (2008), but squirrels seem likely dispersers of mycorrhizal inoculum among Willamette Valley oaks given the prominence of truffles in their diet.

Western gray squirrels at Fort Lewis exhibited a preference for woodland patches >8 ha in area than smaller patches (stands ranged between 0.4 – 48 ha) and for woodlands within 0.6 km of water (Ryan and Carey 1995b). Larger woodlands probably offer more abundant resources and a greater number of travel routes for arboreal species; therefore the preference for larger patches by squirrels in Washington is also likely to hold for Willamette Valley populations, although this hypothesis remains untested. Ryan and Carey (1995b) did not offer any underlying reason for the increased frequency of squirrel occurrence they observed near watercourses. Three explanations seem possible: 1) there maybe a greater diversity and abundance of food plants in riparian areas than in uplands, thus riparian areas are capable of supporting greater population densities of squirrels, 2) trees and shrubs along water courses may provide travel corridors across otherwise impermeable landscapes, and/or 3) western gray squirrels may have a high physiological demand for water, which requires individuals to visit drinking water sources frequently. All three explanations seem plausible to us, but so far remain unexamined.

There is little information about the reproduction of western gray squirrels from Oregon. Pregnant females have been collected from Benton County (Verts and Carraway 1998) and southwest Oregon (Cross 1969) during March. Foster (1992) found females in estrus from January to March and in June in northeast Oregon. Females typically produce only one litter per year in the Pacific Northwest (Ryan and Carey 1995a). Western gray squirrels use tree cavities as dens and also construct stick nests, called dreys. Dreys are usually constructed near the stem and in the upper-third of the tree. Conifers and hardwoods are used for denning (Foster 1992).

Cross (1969) reported that summer home ranges of female western gray squirrels in southwestern Oregon ranged between 2.1 – 26.1 ha (3.3 – 42.0 ac; n = 3) and between 3.2 – 13.7 ha (5.1 – 22.0 ac; n = 3) for males. In a northeast Oregon study, Foster (1992) reported that home ranges of females ranged between 2.6 - 9.9 ha (4.2 to 16.0 ac; n = 3) and between 4.6 – 7.8 ha (7.4 - 12.6 ac; n = 4) for males. Winter home ranges are almost always smaller in area than summer home ranges (Cross 1969, Ryan and Carey 1995a, Linders et al. 2004).

Habitat Management/Restoration—In the Willamette Valley, Oregon white oaks and California black oak (in Lane County only) are perhaps the single most important habitat element of gray squirrels. Acorns and hypogeous fungi specifically associated with oaks are crucial components of their diet. Branches of mature oaks also are also the most available substrates for cavity nests used by gray squirrels on some landscapes. Annual acorn production varies greatly, so maintaining a diversity of food plants will ensure a consistent supply of food during all seasons.

In Washington, the western gray squirrel is listed as a state threatened species and is afforded special protection during forestry operations (Vander Haegen et al. 2004). The following guidelines have been established in Washington to protect gray squirrels (Vander Haegen et al. 2004):

- Protect all squirrel nests and nest trees
- Maintain a no-cut buffer within 50 feet of each nest tree
- Retain at least 50% canopy coverage within 400 feet of each nest tree
- Maintain habitat connectivity among nests, water sources, and foraging habitat by retaining/creating arboreal travel corridors.
- Retain all oaks whenever possible
- Avoid logging, road building, or other noisy activities within 400 ft of all nest trees during the western gray squirrel breeding season (1 March – 30 September).

Vander Haegen et al. (2004) found that likelihood of occupancy was much greater at sites where operators complied with the above guidelines than at sites where guidelines were not followed. Although Oregon forestry operators are not restricted in stands occupied by gray squirrels, the Washington guidelines offer a reasonable, voluntary approach to protecting the species during oak restoration treatments or timber harvests.

Non-Habitat Limiting Factors— Predators of western gray squirrels include the northern goshawk (*Accipiter gentilis*), red-tailed hawk (*Buteo jamaicensis*), great-horned owl (*Bubo virginianus*), bobcat (*Lynx rufus*), common gray fox (*Urocyon cinereoargenteus*; Ingles 1947), coyote (*Canis latrans*; Cross 1969) and domestic cat (*Felis catus*; Verts and Carraway 1998). Ingles (1947) stated that he did not believe predators were a significant factor limiting gray squirrel populations in California, but we did not find research comparing rates of mortality among different sources anywhere across the geographic range of the species.

Western gray squirrels compete against a large number of other native species for food and den sites, including the scrub jay (*Aphelocoma coerulescens*) and Steller's jay (*Cyanocitta stelleri*, Verts and Carraway 1995), Lewis woodpecker (*Melanerpes lewis*; Cross 1969, Foster 1992), acorn woodpeckers (Ingles 1947, Cross 1969), Douglas' squirrel (*Tamiasciurus douglasii*), and California ground squirrel (*Spermophilus beecheyi*; Ingles 1947). Ingles (1947) speculated that competition with Douglas' squirrels limited the upper elevational range of western gray squirrels in the Sierra Nevada range of California. In Oregon, western gray squirrels potentially compete against two introduced squirrels: the eastern gray squirrel (*Sciurus carolinensis*), and eastern fox squirrel (*Sciurus niger*; Verts and Carraway 1995, Weston 2005). The former species is more adaptable to urban areas and able to produce two litters a year when food is abundant (Foster 1992; Ryan and Carey 1995), characteristics that are likely to permit the eastern gray squirrel to displace the western gray squirrel across extensive areas of the Willamette Valley in the future.

Vehicles were recognized as a major source of mortality as early as the mid-1940's (Ingles 1947). Of 81 western gray squirrels studied at Ft Lewis, 13 were killed on roads (Ryan and Carey 1995b). The importance of road mortality to population viability has not been investigated, but because of the demonstrated high mortality in some areas, road mortality is an important threat to consider for conserving this species in the Willamette Valley, especially near urban or high-use recreation areas.

Outbreaks of notoedric mange maybe a significant source of mortality during some years. Cornish et al. (2001) reported that no squirrels initially captured in Klickitat County, Washington during winter 1998 appeared to have mange, but 59% of squirrels captured in the same study area during August 1998 – July 1999 had contracted the disease; 42% of affected squirrels died. Squirrels may have been predisposed to contracting mange because of poor nutrition that was a consequence of acorn crop failure. Transmission of the disease may have been inadvertently facilitated by repeated trapping using contaminated equipment (Cornish et al. 2001).

Human Disease—In California, the western gray squirrel has been implicated as the primary vertebrate reservoir of Lyme disease (*Borrelia burgdorferi*), which is can be transmitted to humans through infected ticks of the species *Ixodes pacificus* and *Dermacentor occidentalis* (Lane et al. 2005). Nevertheless, infection rates among ticks in California and Oregon remains low (5-6%; Stafford 2007). Western gray squirrels in northern California also were found to have the highest rate of exposure among rodent species tested for *Anaplasma phagocytophilum*, an emerging and potentially fatal disease in humans and wildlife. Gray squirrels also host ticks that are capable of transmitting the *A. phagocytophilum* to humans (Nieto and Foley 2008).

Survey Methods— Bayrakgi et al. (2001) compared four different methods for determining presence or density of western gray squirrels: 1) visual surveys along transects, 2) calling surveys, 3) trapping, and 4) infrared camera stations. The authors reported that visual surveys were effective in their study, but may be less so on landscapes where population densities are very low. Calling surveys were ineffective for detecting squirrels. However, the investigators used recordings of eastern squirrels which may have failed to elicit responses from western gray squirrels. Bayrakgi et al. (2001) did not capture a single western gray squirrel after 8,002 trap nights. However, other investigators have had better success (Cross 1969, Linders 2000). The expense, permitting process, and technical expertise required for mammal live trapping precludes the use of these methods for most effectiveness monitoring efforts. Bayrakgi et al. (2001) found that baited camera stations were useful for detecting the presence of gray squirrels and more cost-effective than visual surveys.

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