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Current Status of the Western Gray Squirrel Population in the Puget Trough, Washington

Abstract

The Puget Trough population of Washington's state-threatened western gray squirrel is centered in Oregon white oak ecotones adjacent to conifer forests and prairies on the Fort Lewis Military Reservation. Our goal was to determine the current status of western gray squirrels in this region. In 1998, we found five western gray squirrels in 538 hours of foot surveys in 133 oak sites. In 1999, we expanded our survey effort and included surveys on foot, surveys with simulated squirrel calls, live trapping, and bait stations with motion-sensitive cameras. No western gray squirrels were detected in any oak sites in 1999. One western gray squirrel was photographed in a ponderosa pine stand adjacent to oaks. The western gray squirrel population on Fort Lewis appears to have declined severely since low population numbers were reported in 1992-1993. Our ability to formulate mutually exclusive hypotheses underlying the decline of the western gray squirrel on Fort Lewis is limited by our lack of understanding of how these squirrels persist in highly-fragmented oak ecotones. Without intervention, however, the continued existence of this species in the Puget Trough may be doubtful.

Introduction

Western gray squirrels (*Sciurus griseus*) inhabit oak (*Quercus* spp.) woodlands in the western U.S. (Carraway and Verts 1994, Washington Department of Wildlife 1993). In recent years, oak woodlands have disappeared or been degraded due to agriculture and urban development, fire exclusion, and invasion by Douglas-fir (*Pseudotsuga menziesii*) and Scot's broom (*Cytisus scoparius*). Concern over the loss of oaks and declines in populations of western gray squirrels has grown. In Washington, the western gray squirrel was listed as threatened in 1993 and oak woodlands were listed as "Priority Habitat," habitat requiring special protection, in 1996 (Washington Department of Wildlife 1993, Washington Department of Fish and Wildlife 1999).

Western gray squirrels are currently found in three isolated populations in Washington State (Figure 1). The Puget Trough population is centered on the Fort Lewis Military Reservation in southern Pierce and northern Thurston counties (Washington Department of Wildlife 1993). This population exists because of protection given Oregon white oak (*Quercus garryana*) by the U.S. Army (Rodrick 1987, Washington Department of Wildlife 1993, Ryan and Carey 1995b). Western gray squirrels have been found on private lands adjacent to Fort Lewis and on McChord Air Force Base as well, but few squirrels have been recorded in recent years (Elizabeth Rodrick, Washington Department of Fish and Wildlife, Olympia, Washington, personal communication). A second population of squirrels is found in Chelan and Okanogan counties in the northern Columbia River basin. Very little is known about this population—it is believed to be low in abundance and highly fragmented. Squirrels have been observed in valleys within grand fir (*Abies grandis*)-Douglas-fir forests and in walnut orchards planted by early settlers (Barnum 1975). The third population ranges along the Columbia River Gorge and its tributaries along the east slopes of the Cascade Mountains into Yakima and Klickitat Counties in mixed Oregon white oak-Ponderosa pine (*Pinus ponderosa*) and mixed oak-pine-fir forests (Linders 2000).

The Fort Lewis population was intensively studied in 1992-1993 (Ryan and Carey 1995b). Eighty-one squirrels were observed during their study, most during surveys on foot. This was a relatively low number compared to historical anecdotal accounts. The primary causes for decline were believed linked with both habitat loss and mortality from motor vehicles. Our objectives for this study were (1) to reevaluate the current

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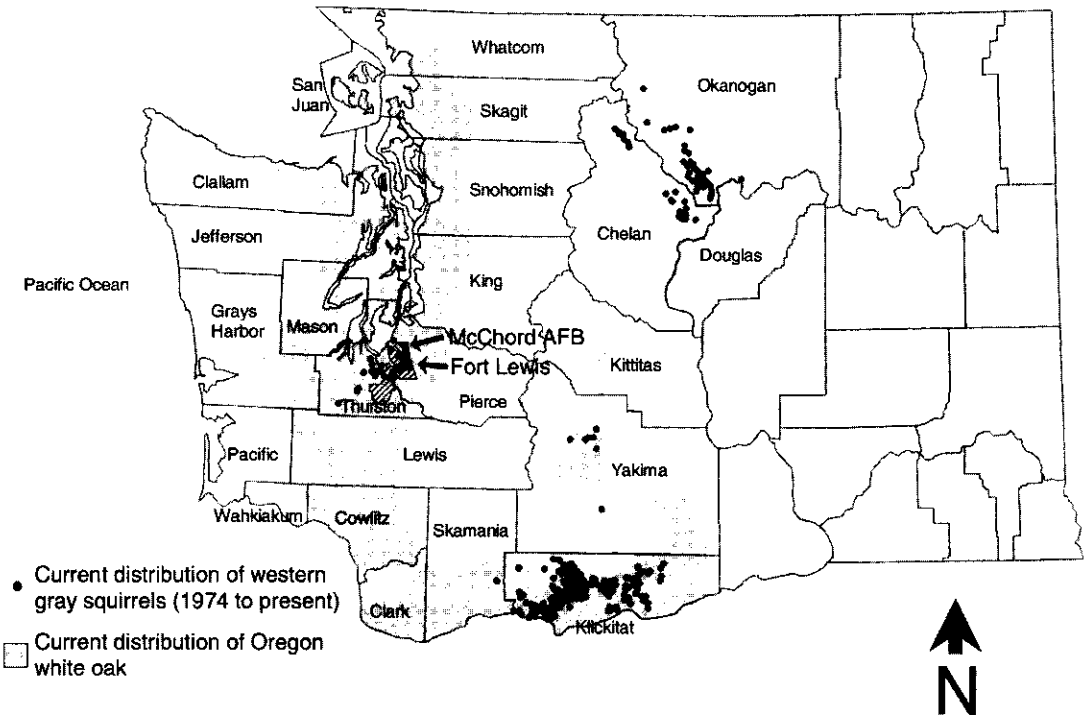

Figure 1. Current distribution of western gray squirrels (Rodrick 1999) and current distribution of Oregon white oak (Stein 1990) in Washington State.

population of western gray squirrels on Fort Lewis by duplicating the survey methods and intensifying the survey effort used during the 1992-1993 study, and (2) to evaluate additional survey methodology not tried during the earlier study.

Study area

The Fort Lewis Military Reservation is located in the southern Puget Trough physiographic province (Franklin and Dyrness 1988) in south Pierce and north Thurston counties in western Washington. The 34,400-ha reservation includes 22,160 ha of wooded lands, 7% (approximately 1,400 ha) of which contains a component of Oregon white oak. At present, pure oak stands on Fort Lewis are rare; most oaks occur in ecotones, transitions between upland Douglas-fir forests and prairies. Communities on Fort Lewis that border oak sites include prairies, wetland-floodplain forests, dry Douglas-fir forest, moist Douglas-fir-western red cedar (*Thuja plicata*)-western hemlock (*Tsuga heterophylla*) forest, and ponderosa pine woodlands.

We used Geographic Information System (GIS) maps to locate our oak sites; 573 oak patches ranging from < 0.2 to >44 ha existed on Fort Lewis in 1993 (Ryan and Carey 1995b). We initially selected all 133 oak sites > 2 ha and located outside of developed and artillery impact areas for study (Figure 2). As our study progressed, however, we reduced the number of sites to maximize opportunities for observing squirrels, generally selecting larger sites (Ryan and Carey 1995a, b) and those with historic (1992, 1993, and 1998; Figure 2) sightings of western gray squirrels (Table 1).

Each oak site was defined as a core area with a relatively continuous distribution of oaks. Boundaries were defined by prairie or treeless areas, major roads, and adjacent non-oak forests. If ecotone boundaries were unclear, a buffer was also included in the survey. Buffers consisted of areas with at least one large (diameter at breast height (dbh) >20 cm) live oak within one-half the mean diameter of the core area.

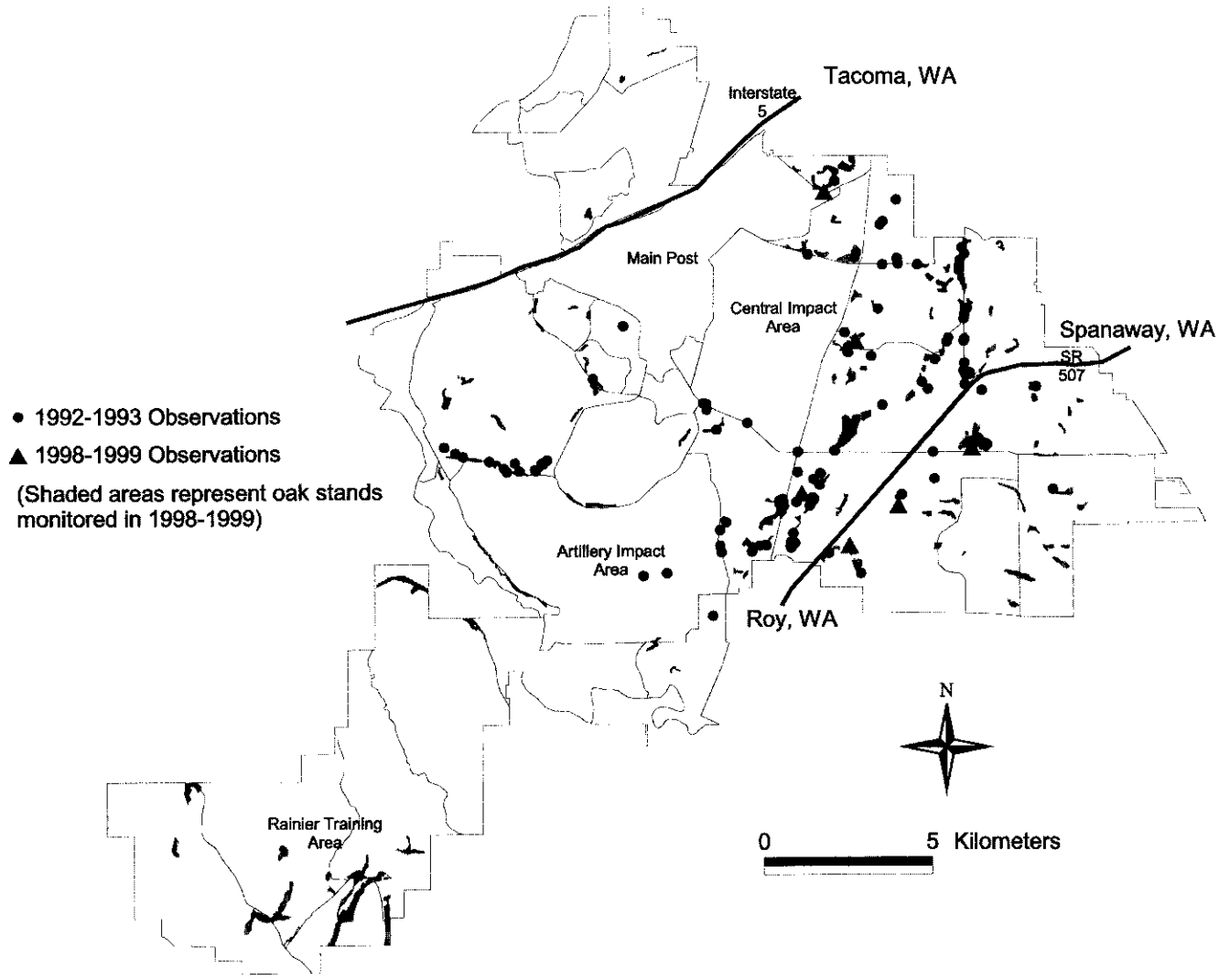

Figure 2. Western gray squirrel sightings on Fort Lewis Military Reservation, Fort Lewis, WA, 1992-1999. Thin lines represent training area boundaries on the reservation.

TABLE 1. Summary of methods used for monitoring western gray squirrels on the Fort Lewis Military Reservation, Fort Lewis, WA from 1998 to 1999.

Technique	Dates	Total number	
		Oak sites	Observers
Fall foot surveys	31 Aug-10 Oct 98	133	10
Trapping and trapping surveys	2 Feb-19 Mar 99	22	9
Spring foot surveys	22 Mar-10 May 99	33	7
Calling surveys	11 May-3 June 99	35	5
Bait stations/cameras	3 May-28 June 99	7	5
Telemetry, eastern gray squirrels	3 Mar-28 May 99	4	8
Telemetry, flying squirrels	24 Feb-28 May 99	4	7
Small-mammal trapping surveys	13 July-6 Aug 99	22	6

Methods

Foot Surveys

We walked over each site slowly and quietly, stopping every 15 m to look and listen for squirrels in a 15-m radius. Foot surveys were conducted between 30 min after dawn (approximately 0700) and 1500 hours, but were suspended during periods of high wind or heavy rain. Each site was surveyed three times (Ryan and Carey 1995b). Sites were surveyed only once by each observer to reduce observer bias. From August through October 1998 (fall surveys), we intensively surveyed all 133 sites. From March through May 1999 (spring surveys), we focused our effort on 33 sites; 22 sites with the highest potential for harboring squirrels (our trapping sites, see below) and an additional 11 sites with the most historic western gray squirrel sightings. Because all fall observations were made before noon and 1992-1993 data indicated that western gray squirrels were most active early in the day, spring surveys were only conducted from 0700 until 1230.

Calling Surveys

We used two hand-held, mouth-blown calling devices, Primo's "Squirrel Buster Deluxe"[3] hunting call and Haydel's "Mr. Squirrel" squirrel whistle, to attract squirrels and elicit squirrels to vocalize by imitating eastern gray squirrel (*Sciurus carolinensis*) and fox squirrel (*S. niger*) distress and alarm calls. Calls were used according to manufacturers' instructions. Moving quietly and wearing dull-colored clothing, observers called at approximately 80-m intervals throughout each site to ensure complete aural coverage. At each calling station, we called and listened for squirrels for approximately 3 min. Again, observers rotated between sites. Calling surveys were suspended during periods of high wind or heavy rain. In May and June 1999, two calling surveys were conducted in each of 35 sites; 17 of the 22 large sites trapped (the other five trapping sites were not surveyed because of a lack of historic gray squirrel observations) and in an additional 18 sites with historic western gray squirrel sightings.

Trapping

We live-trapped from February through March 1999. Site selection was based on maximizing our chances of western gray squirrel sightings and captures. We chose large oak sites (> 8.0 ha) or sites > 4.8 ha with historic western gray squirrel observations. Forty-four trapping arrays were placed in 22 sites. Each array consisted of eight stations spaced 40-m apart, primarily near trees or coarse woody debris, though occasionally in more open areas. Three traps were placed within a 3-m radius at each station: one small (12.7 x 12.7 x 40.64 cm), one medium (17.78 x 17.78 x 60.96 cm), and one large (15.24 x 15.24 x 66.04 cm) wire-mesh Tomahawk trap. Small sites were fitted with one array, while large sites held two to three arrays. Traps were opened on Monday mornings and closed on Friday mornings and were checked twice daily for two weeks. Due to cold, wet, winter conditions and the possibility of hypothermia, traps were covered with waxed milk cartons, and nest boxes and polyester batting were placed inside traps (Carey et al. 1991). We used

two baits: a peanut butter, molasses, and whole oat mixture (Carey et al. 1991), and whole walnuts. The peanut butter mixture was placed inside each trap and walnuts were placed both inside and outside each trap. Trapping stations were baited with whole walnuts outside each trap for at least three days prior to opening traps. Bait was replaced daily, if consumed, and fresh bait was added at the beginning of each week. Captured animals were examined and released according to Carey et al. (1991). Each individual was ear tagged upon first capture. We weighed, and determined the age, sex, and reproductive status of every squirrel at each capture; squirrels were then released from the station where captured.

Visual Surveys While Trapping

Eighteen visual surveys were conducted during our arboreal rodent trapping (February – March) and during forest floor small-mammal trapping (July–August; Wilson and Carey 2001) in each of the 22 trapped sites, 10 during morning checks and eight during afternoon checks. Technicians looked and listened for gray squirrels while walking along trapping lines and handling animals captured in traps.

Camera Surveys

Cameras triggered by infrared motion sensors (TrailMasters TM1500 active infrared trail monitor with automatic 35-mm cameras) were used to survey for western gray squirrels and to evaluate whether trap wariness influenced our trapping results. We established bait stations for remote camera surveys from May through June 1999. Arrays of 8-12 bait stations, with stations placed 40 m apart, were located in select oak ecotones and adjacent ponderosa pine and upland Douglas-fir communities. A total of 19 sites were surveyed with cameras. The nine oak sites (nine total arrays) selected were those with the most current and historic sightings of western gray squirrels. Three ponderosa pine sites (seven total arrays) adjacent to oak ecotones were selected because western gray squirrels regularly use ponderosa pine-oak-Douglas-fir habitat in south-central Washington (Linders 2000). We also expanded our camera surveys into adjacent Douglas-fir communities because they may be important as travel corridors between oak sites and water sources (Ryan and Carey 1995a, b), as an additional food source, and as available nesting sites. Twelve arrays were placed at seven Douglas-fir sites bordering oak ecotones with the greatest number of historic squirrel sightings. Ten walnuts were placed at each station. Stations were checked once or twice weekly, and missing walnuts were replaced. When walnuts routinely disappeared from ≥1 station in an array, we set up cameras to record animal activity. From May until June, five cameras were set up according to manufacturer's suggestions, and checked daily Monday through Friday, and bait was replaced as needed. Each camera was set to pause 30 sec between exposures when the infrared beam was repeatedly or continuously broken. To maximize photo coverage, cameras were rotated weekly among stations and sites. Arrays with little or no activity after four weeks were removed from the study.

Comparison of 1992-1993 and 1998-1999 Studies

We compared squirrel observations from 1992-93 and 1998-99 data in two ways. First, we compared data collected from foot surveys—the only survey method used in both studies. We then compared the numbers of both western gray squirrels and eastern gray squirrels detected regardless of method, oak ecotones surveyed, survey hours, or season.

Results

We observed five western gray squirrels, seven eastern gray squirrels, and five unidentified gray squirrels during 538 foot-survey hours in fall 1998 (Figure 2). Western gray squirrels were widely dispersed throughout the main reservation but not detected in the Rainier Training Area (south of the Nisqually River (Pierce-Thurston county line); Figure 1, 2). We found six eastern gray squirrels in five sites. Two eastern gray squirrels were observed in one site in which one western gray squirrel was also detected. All gray squirrels were found in oak ecotones 3-32 ha in size and bordering Douglas-fir communities and prairies. During spring 1999, seven observers spent 155 hr surveying for squirrels; no gray squirrels were detected. No western gray squirrels were detected during 259 hr of trapping surveys for arboreal rodents or during 108 hr of trapping forest-floor small-mammals. Additionally, no squirrels were observed during 35 hr of calling surveys.

We did not catch any western gray squirrels in 8,002 trap nights. We did catch nine adult eastern gray squirrels 35 times in four sites, three of these sites were in close proximity. We also caught 25 northern flying squirrels (*Glaucomys sabrinus*) and 12 Douglas' squirrels (*Tamiasciurus douglasii*).

Animals removed bait routinely from ≥1 stations at eight of nine oak, four of seven Douglas-fir, and two of three ponderosa pine sites. We set cameras for 140 camera days and photographed animals raiding bait stations on 164 occasions. One western gray squirrel was photographed in a ponderosa pine site (Figure 2). We estimated that eight eastern gray squirrels were photographed: five in oak sites, two in Douglas-fir sites, and one in a ponderosa pine site.

Comparison of 1992-1993 and 1998-1999 Studies

Ryan and Carey (1995b) made 156 observations of western gray squirrels during the 1992-1993 study—46 during foot surveys and 110 outside of foot surveys (behavioral studies, incidental observations by technicians and Fort Lewis personnel, and road kills). They saw 46 western gray squirrels during 330 hours of foot surveys (three visits each to 119 sites) between June 1992 and February 1993. These squirrels represented at least 38 individuals in 30 sites (Ryan and Carey 1995b).

We saw six western gray squirrels during our study. Of these, five were observed during 740 hours of foot surveys. These five individuals were all observed in the fall. Of all 1992-1993 observations, 96% were in 14 of the 36 sites surveyed during both studies.

The 110 western gray squirrel observations outside of foot surveys in 1992-1993 represented 43 individuals on 14 sites. In 1998 and 1999, we observed only one western gray squirrel outside of foot surveys and not within an oak site. In 1992-1993, observers saw one squirrel per 9 hr of survey time, compared to one squirrel per 117 hr of survey time in 1998, and no squirrels in 155 hr in 1999. Most western gray squirrels were observed from June through October during 1992-1993 foot surveys; September foot surveys were common to both studies—14 squirrels were detected in 1992, but only five in 1998.

Eastern gray squirrels were captured during both studies. In May and June 1993, four eastern gray squirrels were observed while surveying and two eastern gray squirrels were captured while trapping (Loreen Ryan, USDA Forest Service, Olympia, Washington, personal communication). During our study, we observed 36 eastern gray squirrels, all within 1 km of residential areas, although some observations were likely repeats of the same individual.

Discussion

Western gray squirrels have declined dramatically on Fort Lewis during the last decade. Fort Lewis is considered the last stronghold of the western gray squirrel in the Puget Trough (Washington Department of Wildlife 1993) and few squirrels have been observed outside Fort Lewis in recent years (Elizabeth Rodrick, Washington Department of Fish and Wildlife, Olympia, Washington, personal communication). Our data, coupled with previous studies (Ryan and Carey 1995a, b) and historic accounts (Buechner 1953; Larrison 1970; Tivel 1978; Rodrick 1987; Washington Department of Wildlife 1993), suggests that the end of a long term decline in the Puget Trough western gray squirrel population has been reached—only a few individuals remain, and the likelihood of extirpation appears high.

Techniques for Monitoring Western Gray Squirrels

Our efforts to locate western gray squirrels were substantially more comprehensive than previous studies—we used five different methods of detection, had larger sample sizes, and many more observers. Because we were monitoring a rare species, we also chose to expand our methodology to explore several techniques for locating squirrels.

Western gray squirrels are very wary and challenging to approach and therefore can be difficult for observers to detect. Where squirrels are relatively abundant, foot surveys can be effective, as they were in the 1992-1993 study on Fort Lewis (Ryan and Carey 1995b). Visual surveys conducted while trapping were likely not as effective as our foot surveys, partly because technicians were moving rapidly through sites, only along trap lines, and concentrating on checking traps more than detecting squirrels. However, we do advocate training

technicians to look and listen for squirrels while trapping, as it increases the effort expended in searching for squirrels with little added cost.

Trapping efforts have been successful in previous and ongoing western gray squirrel studies in Oregon, California, and southern Washington (Foster 1992; Gilman 1986; Cross 1969; Linders 2000). In 1998-1999, Mary Linders (University of Washington, Seattle, Washington, personal communication) found that she could recapture members of the Klickitat County squirrel population with predictable regularity. We used similar traps and trap placement techniques, although the addition of waxed milk carton trap covers and nest boxes, and polyester batting were unique to our trapping study. Previous western gray squirrel trapping efforts on Fort Lewis also had limited success (Ryan and Carey 1995b). Why western gray squirrels on Fort Lewis appear trap shy is unclear. Even with the use of camera surveys, we could not determine whether trap wariness influenced our trapping results because the population was so low. In contrast, trapping was very effective for eastern gray squirrels, and we regularly recaptured most individuals.

Bait stations and remote cameras proved to be an effective monitoring technique because we photographed all three diurnal squirrel species. Camera stations may be less intrusive than trapping and more cost effective than foot surveys, especially if large areas need to be monitored and squirrel numbers are low. Stations should be prebaited and checked twice weekly prior to setting up cameras. Cameras should be placed only at stations where bait is consistently disappearing. Calibration is necessary and problematic when cameras are frequently moved between stations. Cameras should be programmed to shoot a maximum of once every 30 sec to minimize exposure of an entire roll of film on one individual.

We were unsuccessful in using mouth-blown distress and warning calls to attract squirrels. Squirrels in low-density populations may rely more on secretive behavior than distracting or swamping predators with vocalizations. The calls we used were designed for eastern gray and fox squirrels, and did not imitate the precise tone or patterns of western gray squirrel vocalizations. It is also possible that the dialect imitated by the calls was not recognizable by our eastern gray squirrels. Studies have shown that different dialects (pronunciation and vocabulary differences) exist for the same bird species in different macrogeographic and even microgeographic regions (Mundinger 1982; Kroodsma et al. 1985); squirrels may also use different dialects and therefore calls may need to be developed specifically for western gray squirrels.

Telemetry studies would be the most useful technique for quantifying how western gray squirrels use fragmented habitat, especially how safely squirrels can move between oak ecotones considering the extensive road network on Fort Lewis. Telemetry would also be useful in measuring habitat quality, specifically quantifying important habitat components within oak ecotones, and assessing the relative importance of communities adjacent to oaks in providing year-round habitat for western gray squirrels. However, the benefits of knowledge gained from telemetry studies must be considered against the potential risk of mortality caused by handling squirrels when the population is very low.

Management Implications

As oak-dominated ecotones in the Puget Trough become increasingly rare and degraded, we would expect a corresponding reduction in western gray squirrels. If the Fort Lewis land base, especially total area in oak woodlands, is too reduced to sustain a viable western gray population, it may be necessary to expand squirrel management onto adjacent federal, state, tribal, and private lands in the Puget Trough. Additionally, the status of the western gray squirrel may be upgraded from state threatened to state endangered in the near future. Western gray squirrel management objectives and practices should take these possibilities into account.

Western gray squirrels are associated with mixed oak-conifer stands throughout their range (Asserson 1974; Gaulke and Gaulke 1984; Gilman 1986; Rodrick 1987; Foster 1992; Ryan and Carey 1995a, b; Carraway and Vertz 1994; Washington Department of Wildlife 1993). The ecology of oaks in the Puget Trough glacial outwash plains may be different from oak ecology in the river terraces and floodplains in southern Washington, Oregon, and California. In the Puget Trough, oaks most often occur in ecotones, between upland Douglas-

fir forest and prairie. Although oak ecotones can be highly varied in structural complexity and plant species composition which may be important in providing a year-round food source for squirrels (Ryan and Carey 1995a, b), many of the present Fort Lewis oak stands have a limited variety of mast-producing tree species.

The success of the western gray squirrel in Puget Trough may be ecologically linked to the success of the oak ecotones. It appears that simple protection of oak habitat on Fort Lewis was insufficient to preserve the Puget Trough population. Return of a viable western gray squirrel population to this region will require a concerted and well-planned strategy, and may require a broader participation of federal, state, tribal, and private landowners to ensure that an adequate and suitable habitat base is available.

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