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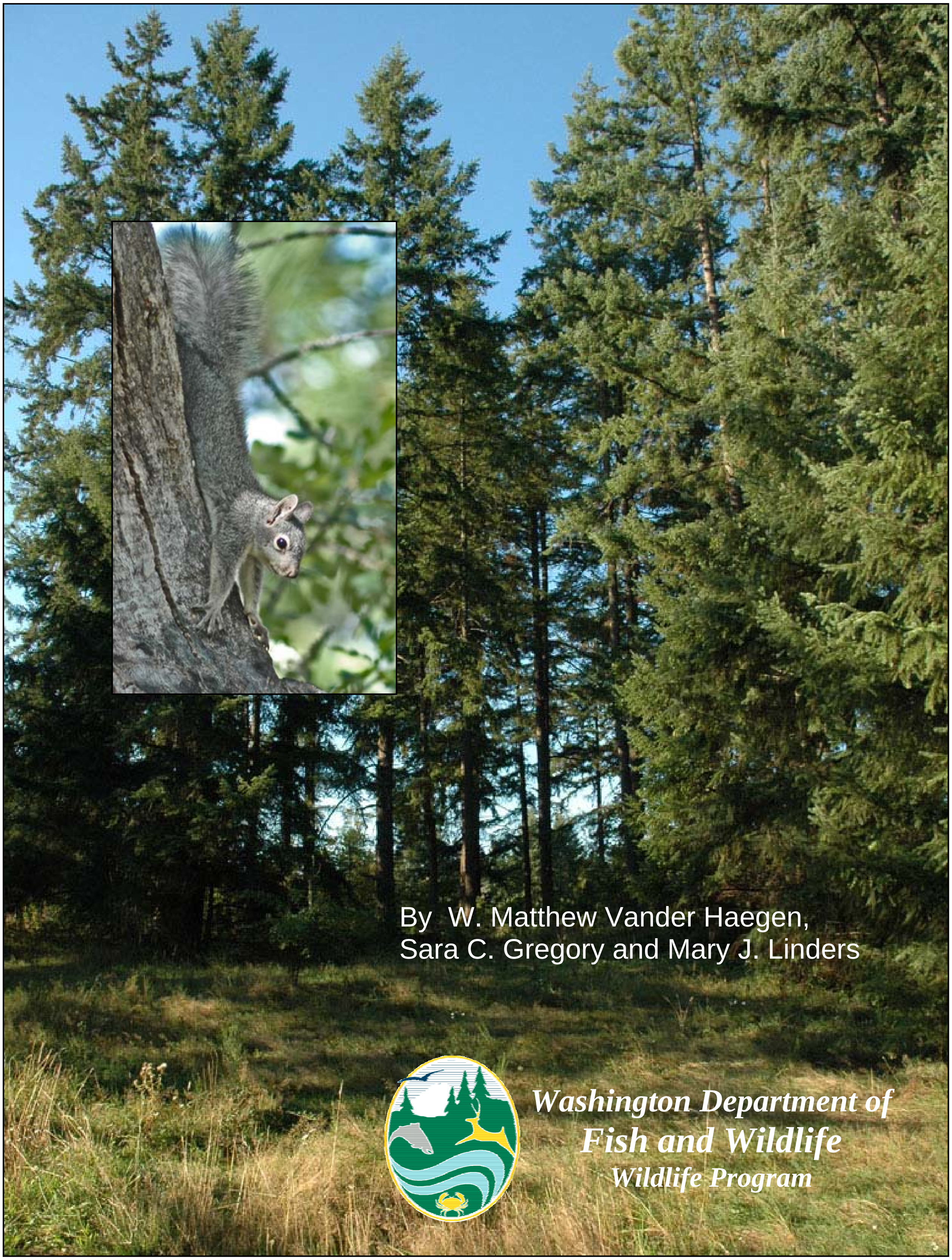
Implementation Plan for Augmentation of the Western Gray Squirrel Population, Fort Lewis, Washington



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Fish and Wildlife
Wildlife Program

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EXECUTIVE SUMMARY

The western gray squirrel is listed as threatened in Washington State and currently exists in 3 disjunct populations. Of these, the Puget Trough population faces the greatest extinction risk as a result of declining numbers and altered habitat. The majority of the Puget Trough population occurs on Fort Lewis, a 35,000 ha military reservation that contains some of the last patches of oak-pine forest in western Washington. The recovery plan for western gray squirrels in Washington lists augmentation of the population in the Puget Trough as a high priority. Augmentation is necessary both to increase the genetic diversity of the Puget Trough population and to expand the area of occupied habitat to provide a buffer against catastrophic loss due to disease, wildfire, or other causes.

An extensive review of tree squirrel reintroduction efforts suggests that translocations are a viable tool for recovery of tree squirrel populations. Based largely on established reintroduction protocols, augmentation of the western gray squirrel population on Fort Lewis will follow a detailed outline of preparation, implementation, and monitoring. There will be four general phases to the augmentation:

> Phase 1. Identify areas appropriate for release of new animals. Suitability of areas for release will be determined based on historic records for the species, locations of extant western gray squirrels, and current habitat conditions.
>
> Phase 2. Select source populations, numbers of animals to be translocated, and a timeline for translocation.
>
> Phase 3. Capture and relocate animals from the source population to the release location.
>
> Phase 4. Monitor translocated animals over a suitable period of time to assess the effectiveness of the augmentation. Concurrent with monitoring will be active research to assess demographic parameters, movement, and habitat use by western gray squirrels on the study area along with focused research on their spatial and behavioral interactions with non-native eastern gray squirrels.

Four potential release areas have been identified on Fort Lewis. Three of these currently have western gray squirrels or are adjacent to occupied habitat; the fourth is disjunct from occupied habitat but within the known dispersal distance for the species. Active habitat management on Fort Lewis has improved habitat conditions and continued improvements are planned.

Based on a range-wide assessment of western gray squirrel genetics and the size of the extant populations and their habitat, the preferred option for augmentation would be to obtain animals from both the Klickitat and North Cascades populations in Washington and from populations in northern Oregon. Obtaining animals from multiple source

populations will maximize the potential to introduce animals with sufficient behavioral plasticity and genetic diversity to prosper in south Puget Trough, while minimizing the demographic impact on source populations.

Numbers of animals translocated to Fort Lewis will vary by release unit. The initial release in the Squirrel Triangle Unit will consist of 12 animals. This unit has an extant population of western gray squirrels and the primary goal of the release is to augment the number of breeding females and add to the genetic diversity of the population. This first release is planned for fall of 2007 and will include animals from both the Klickitat and North Cascades populations. Subsequent releases (2008-2010) will occur in units with suitable habitat but no known extant populations; the number of squirrels released will be based on the area of suitable habitat.

Initial monitoring of translocated squirrels will be integrated with ongoing research of the extant western gray squirrel population. All translocated squirrels will be marked with ear-tags and fitted with radio-collars prior to release. Movements of translocated squirrels, their survival, causes of mortality, and reproductive effort will be documented. This intensive monitoring planned for the first 5 years of the project will allow rapid assessment of the fate of translocated squirrels, providing the opportunity for mid-course corrections of the augmentation strategy.

INTRODUCTION

Current Status

Of the three disjunct populations of western gray squirrel (*Sciurus griseus*) in Washington, the Puget Trough population faces the greatest extinction risk (Figure 1; Linders and Stinson 2006). The majority of the Puget Trough population occurs on Fort Lewis, a 35,000 ha military reservation that contains some of the last patches of oak-pine forest in western Washington. The squirrel was listed as threatened by the Washington Department of Fish and Wildlife (WDFW) in 1993; extensive surveys on Fort Lewis resulted in observations of 5 squirrels in 1998 and no squirrels in 1999 (Bayrakçi et al. 2001). Seven western gray squirrels were captured Feb-Apr 2006 during efforts to trap and remove invasive eastern gray squirrels (*S. carolinensis*) from core western gray squirrel habitat on Fort Lewis and an additional 18 animals have been captured as part of ongoing research in 2007 (WDFW unpublished data). Thus, western gray squirrels are still present on Fort Lewis, although their numbers are likely at precariously low levels. The recovery plan for western gray squirrels in Washington used average home range estimates from research in Klickitat County to calculate a hypothetical breeding population of 34 squirrels on Fort Lewis (Linders and Stinson 2007). This is at best a rough estimate; however, a population of this size would be vulnerable to catastrophic events. Thus, WDFW's Recovery Plan for the species lists augmentation of the population on Fort Lewis as a high priority (Linders and Stinson 2007). The goal of this project is to augment the western gray squirrel population on Fort Lewis and expand the area of occupied habitat to provide a buffer against catastrophic loss due to disease, wildfire, or other causes.

Translocation as a Tool

Trapping and relocation of wild animals is generally referred to by the term translocation. In 1987, The World Conservation Union (IUCN) defined translocation as "the movement of living organisms from one area with free release in another". Translocations include introductions, reintroductions, and augmentation. These activities are characterized as intentional rather than accidental, may involve captive-bred or wild individuals, and include movement of animals into any area within or outside of their native range. An introduction occurs when a species is released into an area where it did not occur historically. If the area of release is within a species' native range but does not contain other conspecifics because of human disturbance, the translocation is called a reintroduction. An augmentation occurs when animals are released into an area within their native range where conspecifics still exist (IUCN 1987). Reintroductions and augmentations are the most common types of translocations implemented to conserve species facing extirpation or extinction (Griffith et al. 1989).

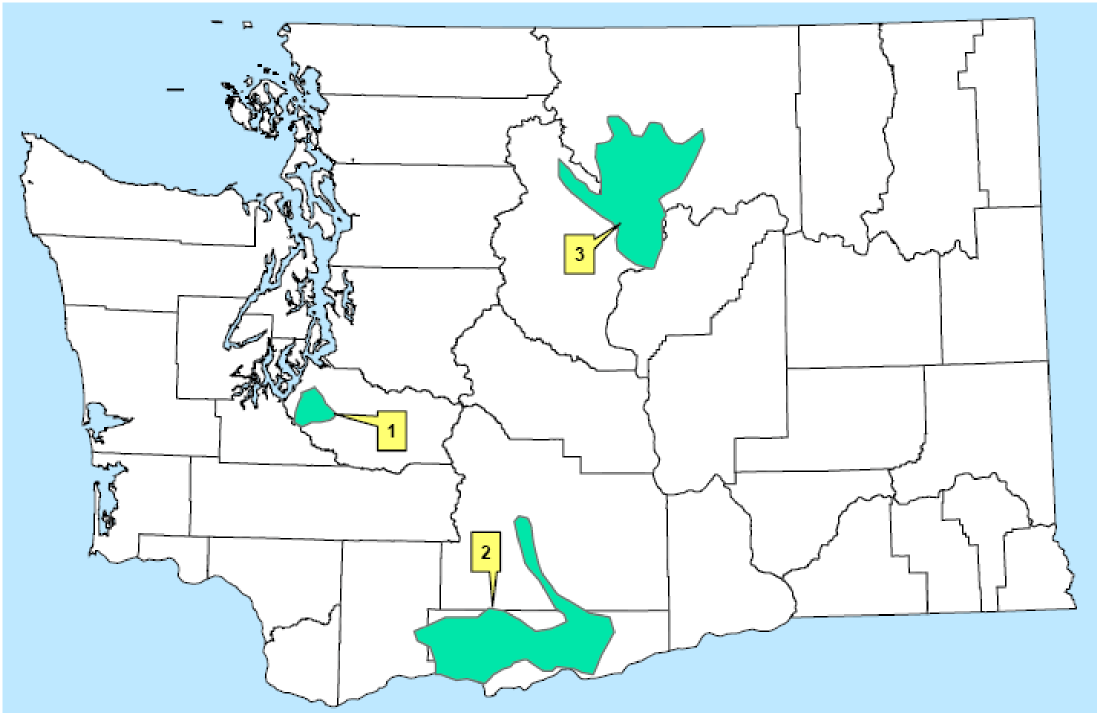

Figure 1. Current distribution of the western gray squirrel in Washington, 1) South Puget Trough, 2) Klickitat County, and 3) Chelan/Okanogan Counties (Linders and Stinson 2007).

Attempted Reintroductions of Sciurids

Delmarva fox squirrel.—Since being listed as a federal endangered species in 1967, the Delmarva fox squirrel (*S. niger cinereus*) has been re-introduced at 16 sites in appropriate habitat within its historical range (USFWS 1993). Eleven of these sites were in Maryland where a series of releases occurred between 1978-1992 at sites where Delmarva fox squirrels had been extirpated. The total number of animals released at each site ranged from 5 to 42 and the number of releases at each site varied from 1 to 3. All releases took place during the spring or fall and involved both adult and juvenile squirrels with male to female ratios ranging from 0.7 to1.3 (USFWS 1993, Therres and Willey 2002). Initially, translocated squirrels were kept at the release site in a holding cage containing food and water and nest boxes for a few days to 2 weeks before reintroduction. Subsequent reintroductions to supplement earlier releases did not include a holding period. Live-trapping at the 11 Maryland release sites during 1990-2001 revealed Delmarva fox squirrels at 9 sites and lactating females at 8 sites. In addition, Delmarva fox squirrels had expanded their range beyond the release area at 6 of these sites. Catch-per-unit-effort at the 9 sites where fox squirrels had successfully reestablished was comparable to areas with stable, naturally occurring populations. Thus, the majority of reintroductions in Maryland have been characterized as successful (Therres and Willey 2002). At the 2 sites where re-introduced fox squirrels failed to persist, managers cite different reasons for failure. At one site, habitat alterations from agricultural activities presumably prevented released squirrels from establishing. At the other site, only 5 animals were released into an extensive forest where they may have dispersed widely and failed to reproduce (G. Therres, Maryland Department of Natural Resources, personal communication).

From 1968-1971, 40 Delmarva fox squirrels were reintroduced at the Chincoteague National Wildlife Refuge (NWR) in Virginia. Though appearing healthy, 10 individuals died before or within a week after release (Deuser and Terwilliger 1987, USFWS 1993). Despite this initially high mortality, the remaining 30 squirrels founded a population that was estimated through mark-recapture methods at 180 animals in 2001 (USFWS 2003). All squirrels were released at Chincoteague NWR in November, December, or January. Although a hard release was used for this reintroduction (squirrels were released immediately after arrival at the release site), they received supplemental food for several weeks. In addition, the eastern gray squirrel, a potential competitor, was not recorded on the refuge until 1979.

The reestablished population at Chincoteague NWR served as a source population for another Virginia reintroduction at a site called Brownsville Farm. Twenty-four Delmarva fox squirrels were released during three events occurring in June 1982, September 1982, and May 1983. A soft release was employed for this reintroduction wherein squirrels were contained in a holding cage for 5-7 days before release. This was thought to reduce the 25% mortality (10/40) that occurred during the reintroduction at Chincoteague NWR as only one squirrel out of 25 died before release (Deuser and Terwilliger 1987). Squirrels were released into mature pine forests on Brownsville Farm and were provided with food and nest boxes to supplement existing resources. The reintroduction apparently failed as no Delmarva fox squirrels were sighted at Brownsville after 1984 despite trapping efforts. It is suspected that the animals from Chincoteague NWR lacked the genetic diversity necessary to found a sustainable population (Deuser and Terwilliger 1987). Eastern gray squirrels were present at Brownsville at the time of the Delmarva fox squirrel reintroductions.

As part of various reintroduction efforts up to 1990, the post-release movements of 83 Delmarva fox squirrels were documented via radio-telemetry (USFWS 1993). During the first 30 days post-release, individuals moved from 0.16 to 8.8km from the release site, although most animals returned to close to the release site. Three squirrels from one release moved 7.4km and remained at this new site, eventually establishing a population. At an experimental translocation in Maryland in 1991, 21 radio-collared squirrels were followed closely for at least 90 days after release in spring or fall (Bendel and Therres 1994). Although one individual moved close to 4km from the release site (later returning), most remained within 1km. In general at this site males moved farther than females and spring-released animals moved farther than those released in fall. One third of the released squirrels (7/21) died within 90 days, mostly due to predation (Bendel and Therres 1994).

Eurasian red squirrel.—Reintroductions of the endangered Eurasian red squirrel (*S. vulgaris*) have met with mixed results. In one translocation, eight animals [4 males (adults)/4 females (2 adults, 2 subadults)] were moved from a 3,900 ha forest of 32% pine and 17% oak in northern Italy where nest counts estimated the resident red squirrel population at 2,300. The squirrels were relocated 25km to a 3,500 ha area with less continuous forest; no other squirrels were present at the release site. Releases occurred during December 1986 and January, May, and August 1987, with no holding period and at a site with 46% pine, 26% oak and mast production that was comparable to the source site (Fornasari et al. 1997, Wauters et al. 1997a). Using radio-telemetry, it was determined that four of the eight squirrels died before reproducing; two during subfreezing temperatures 4 days following release, one that may have been ill upon capture two weeks following release, and another that survived for almost 3 months before it died of unknown causes. The four surviving animals founded a population estimated at 38 in 1990 that was thought to be expanding into areas beyond the release site by 1996 (Fornasari et al. 1997).

Another population of Eurasian red squirrels was successfully reestablished at an urban park in Antwerp, Belgium. In this reintroduction, 9 males (5 adults/4 subadults) and 10 females (7 adults/3 subadults) were collected from 3 different source sites in February, September, and October 1987 as well as January 1988. Habitat at two of the source sites was predominantly coniferous forest and one was mixed deciduous, similar to habitat at the release site. In addition, squirrels from one of the coniferous sites were accustomed to human presence. Squirrels were released immediately after arrival at the release site and monitored with radio-telemetry. Twenty nest boxes with nesting material were available at the park but it is not known if the released animals used them. Eight (3 males/5 females) squirrels survived to produce a stable population. Previous exposure to humans was a stronger predictor of the squirrels' survival in this urban setting than source site forest type or age (Wauters et al. 1997b).

A failed reintroduction of Eurasian red squirrels occurred in the fall of 1993 when 14 (7 male/7 female) radio-collared adults were released at a site that also contained a resident population of introduced eastern gray squirrels (Kenward and Hodder 1988). Although the squirrels spent 3-6 days in a holding cage and had access to feeders and nest boxes, they apparently were depredated by foxes within three months of release. Dissimilarity between source and release habitats may have contributed to the failure of this reintroduction (Kenward and Hodder 1988). Introduced eastern gray squirrels also were present at the site and are thought to be detrimental to naturally occurring populations of Eurasian red squirrels (Gurnell et al. 2004). The presence of the gray squirrels was presumed to have stressed the reintroduced red squirrels (as evidenced by post mortem adrenal condition, weight and disease) and decreased their ability to escape predation (Kenward and Hodder 1988).

Eastern gray squirrels.— Summer/fall translocation of 38 radio-collared eastern gray squirrels from urban-suburban Baltimore to a forested area resulted in the death or disappearance of 97% of the released animals. Presumed causal factors included aggressive behavior of resident eastern gray squirrels as well as unfamiliarity with the release site (Adams et al. 2004).

Western gray squirrels.— We know of only one attempted reintroduction of western gray squirrels. This effort occurred from 1972-1974 when 10 squirrels were released on the

Oak Creek Wildlife Area (OCWA) near Naches, Washington. The reintroduction plan and follow-up monitoring was not well documented; only one status report exists documenting 39 western gray squirrel sightings over 125 survey hours (Gaulke and Gaulke 1984). The last sighting of a western gray squirrel at the OCWA was in 1989 (Stream 1993, J. McGowan, WDFW, personal communication). Stream (1993) listed predation, competition with California ground squirrels (*Spermophilus beecheyi*), mast failure, and habitat degradation caused by large numbers of over-wintering elk (*Cervus elaphus*) as potential causes for the reintroduction's failure. The small number of animals released also likely was a factor.

Common Characteristics among Successful Translocations

Analyses of surveys of wildlife translocation efforts in North America, Australia, and New Zealand determined that high quality habitat, greater numbers of released animals, and placement of release site within the core of a species historical range were the most important determinates of translocation success (Griffith et al. 1989, Wolf et al. 1996, Wolf et al. 1998). Omnivorous mammals classified as game species that are capable of producing ≥3 offspring before 2 years of age may also benefit from translocation above animals lacking these attributes. Although genetic diversity should be monitored as part of the long-term assessment of a translocation's success, studies comparing translocated and resident Delmarva fox squirrels did not detect differences in genetic variation between the two populations studied (Moncrief and Dueser 2001, Lance et al. 2003).

Many of the characteristics of successful wildlife translocations are consistent with those cited above for squirrels. Potentially important factors for successful squirrel translocations included: appropriate habitat similar to that of the donor population, larger number of animals in numerous releases spaced over several years, proximity to extant populations, and releases in the fall of the year. Soft versus hard release seemed to make little difference. In true reintroductions where the species has been extirpated, two dozen squirrels released within a year is considered sufficient to ensure that animals survive in large enough numbers to reproduce and maintain genetic variability (USFWS 1993, Wauters et al. 1997, Therres and Wiley 2002). Recent modeling efforts using a range of population parameters from 6 species of tree squirrel suggest that as few as 15 animals may be sufficient to establish a lasting population under optimum conditions (Wood et al. 2007). Success of Delmarva fox squirrel reintroductions in Maryland (9 of 11 succeeding) and others where relatively small numbers of squirrels were released (Wood et al. 2007) suggests that translocations are a viable tool for tree squirrel recovery efforts.

AUGMENTATION METHODS

The previous section focused on reintroductions of wild animals and characteristics of successful reintroduction efforts. The augmentation of western gray squirrels planned for Fort Lewis differs from a reintroduction in that the species already occurs there and thus animals translocated to the site will most certainly interact with the extant population. This is a critical difference, in that the translocated animals will expand the genetic pool of the Fort Lewis population (a goal of the project), while individuals in the extant population will "expand" the effective size of the translocated population. That is, squirrels resident on or near the release site will mate with released individuals, reducing the need for translocating a large number of animals to avoid founder effects or poor demographic response possible in reintroductions involving small numbers. As releases are planned farther from sites occupied by squirrels, they take on more of the characteristics of reintroductions and a larger number of squirrels may need to be translocated.

Augmentation of the western gray squirrel population on Fort Lewis should follow a detailed outline of preparation, implementation, and monitoring (IUCN 1995). There will be four general phases to the augmentation:

> Phase 1. Identify areas appropriate for release of new animals. Suitability of areas for release will be determined based on historic records for the species, locations of extant western gray squirrels, and current habitat conditions.
>
> Phase 2. Select source populations, numbers of animals to be translocated, and a timeline for translocation.
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> Phase 4. Monitor translocated animals over a suitable period of time to assess the effectiveness of the augmentation. Concurrent with monitoring will be active research to assess demographic parameters, movement, and habitat use by western gray squirrels on the study area along with focused research on their spatial and behavioral interactions with non-native eastern gray squirrels.

Phase 1: Identification of release sites

General Suitability

Fort Lewis and the adjoining McChord Air Force Base were identified in the draft recovery plan as the most appropriate site for a western gray squirrel translocation. This site is within the species' historical range and currently supports a small population. These military bases also hold the largest contiguous acreage of mixed oak, pine, and fir in the south Puget Trough. Bayrakçi et al. (2001) cited habitat loss and incidental mortality by motorized vehicles as the primary causes of western gray squirrel population decline on Fort Lewis. Subsequent work on the genetics of western gray squirrels in the Northwest revealed extremely low genetic diversity in the Fort Lewis population (Warheit 2003), a condition associated with low productivity in some species. For population augmentation of the western gray squirrel on Fort Lewis to be successful, these risks need to be reduced (IUCN 1995, Fischer and Lindenmayer 2000). The Department of Defense has shown a willingness to support habitat improvements to address squirrel conservation. Ongoing restoration activities include reestablishing native plant species and opening the forest stands with prescribed burning and thinning (C. Fimbel and M. McKinley, TNC, personal communication). Reducing threats to western gray squirrels from motorized vehicle traffic may be more of a challenge. Potential solutions include reducing vehicle speed limits on key road through occupied squirrel habitat, educating drivers, and aerial bridges that would allow squirrels to cross between tree canopies on opposite sides of key roads.

The 22,160 ha of forest on Fort Lewis consist of 65% Douglas-fir (*Pseudotsuga menziesii*), 7% (1,400 ha) mixed oak (*Quercus garryana*) and 3% (775 ha) ponderosa pine (*Pinus ponderosa*); all species that provide important food and nesting resources for the western gray squirrel (Foster 1997, Bayrakçi et al. 2001). In addition, a variety of other food sources such as Oregon ash (*Fraxinus latifolia*), big-leaf maple (*Acer macrophyllum*), California hazelnut (*Corylus cornuta*), Indian plum (*Oemleria cerasiformis*), and serviceberry (*Amelanchier alnifolia*) are native to Fort Lewis. Growing conditions are best for oak and pine at the edges of prairies; historically, the suitability of these sites was maintained by quick draining soils and the historical regime of frequent fires set by Native Americans and other early inhabitants (Franklin and Dyrness 1973). During the last century, fire suppression has encouraged the encroachment of Douglas-fir as well as the aggressively invasive Scotch broom (*Cytisus scoparius*) onto prairies. Scotch broom has been negatively associated with squirrel presence on Fort Lewis (Ryan and Carey 1995). The lack of frequent fires also has created a closed forest structure that excludes species with lower shade tolerance such as oak and ponderosa pine (Hanna and Dunn 1997, Foster 1997).

In 2003, Fort Lewis together with The Nature Conservancy (TNC) began large-scale efforts to improve habitat in areas of known western gray squirrel occurrence. Since habitat enhancements began, almost 580 ha (1,430 acres) have been cleared of Scotch broom, planted with fruit-bearing native plants, or thinned to promote growth of oak and ponderosa pine (T. Zuchowski, Fort Lewis, personal communication). In 2005, Scotch broom was mowed across 142 ha (350 acres) of oak and pine forest. Douglas-fir also was removed from about 40 ha (100 acres) of prairie. Additionally, over 850 shrubs and trees known to be important food sources were planted including Oregon oak, big-leaf maple, serviceberry, and Indian plum. The goal of these plantings is to improve the forage options within areas of historical squirrel occurrence and encourage the creation of suitable corridors between core areas and subsequent movement of animals throughout Fort Lewis. Plantings will be maintained and supplemented with an additional 1440 plants during 2006 (M. McKinley, TNC, personal communication). Plans for timber harvests in squirrel habitat are accomplished with oak release and other habitat enhancements as a high priority. Wildlife biologists and foresters on Fort Lewis coordinate efforts to ensure that canopy connectivity as well as food and nest trees are left intact after logging. Efforts to control Scotch broom control continue, and the potential for chemical as well as manual control is being explored.

Eastern gray squirrels

The eastern gray squirrel is a potential competitor that, as mentioned above, has been implicated in the population declines of the Eurasian red squirrel. Although eastern gray squirrels are, on average, smaller than western gray squirrels, they are capable of rearing 2 litters/year (though this has not been documented in Washington) whereas western gray squirrels typically rear only one (Linders and Stinson 2006). Eastern gray squirrels are also more communal than western gray squirrels and related animals may cooperate to defend resources (J. Koprowski, University of Arizona, personal communication). There is little information on interactions between eastern and western gray squirrels, although in many locations where the eastern species has increased there have been apparent decreases in western gray squirrels. Theses qualitative observations have been primarily in urbanizing areas (e.g., south Puget Sound and northwest Oregon) and the relative effects on populations of western gray squirrels of habitat change and increasing human density versus increasing numbers of eastern gray squirrels is unknown. A relatively recent and expanding population of eastern gray squirrels on Fort Lewis poses a potential threat to successful recovery of western gray squirrels on the base; interactions between the two species and an assessment of this threat will be the subject of focused research (see RESEARCH section).

During 2006 a live-trapping effort was conducted within the core of western gray squirrel range on Fort Lewis with the goal of reducing the number of eastern gray squirrels; 32 eastern gray squirrels were captured and euthanized (TNC, unpublished report). Seven western gray squirrels also were captured during this effort, ear-tagged, and released at the capture location. Additional trapping efforts to remove eastern gray squirrels may continue over the course of this augmentation project, coordinated with ongoing research. Broader control efforts will be considered pending the outcome of planned research on the interaction between the two species.

Site Selection

We used knowledge of western gray squirrel habitat affinities, current and past distribution of the species on Fort Lewis, and consultation with Fort Lewis and TNC staff to identify potential release areas. In an earlier study, use of forest stands by western gray squirrels on Fort Lewis was assessed using walking surveys, focusing primarily on 313 oak stands outside of artillery-impact and developed areas (Ryan and Carey 1995). The vegetation where squirrels were seen most often was composed of 53% Douglas-fir, 34% oak, and 13% “other” tree species as well as an assortment of fruit-bearing shrubs (Ryan and Carey 1995). While this study provided an indication of western gray squirrels’ use of oak stands on Fort Lewis, it did not include surveys of forest types lacking oak and therefore was not comprehensive. Intensive research in Klickitat County using radio-telemetry also found western gray squirrels using stands dominated by conifers, generally including a component of Oregon oak and ponderosa pine (Linders 2000). Priority sites for augmentation are those adjacent to areas where western gray squirrels are known to occur and where adjacent habitat is available for squirrels to disperse as the population increases. Priority sites for reintroduction are those with adequate habitat, within the historically range of the species, and occurring within dispersal distance of occupied sites (3 km; Vander Haegen et al. 2005).

We have identified 4 areas for release of western gray squirrels on Fort Lewis (Figure 2). Each is dominated by Douglas fir forest but contains Oregon white oak and/or ponderosa pine and a variable amount of openings and transitional habitats. Table 1 lists each area

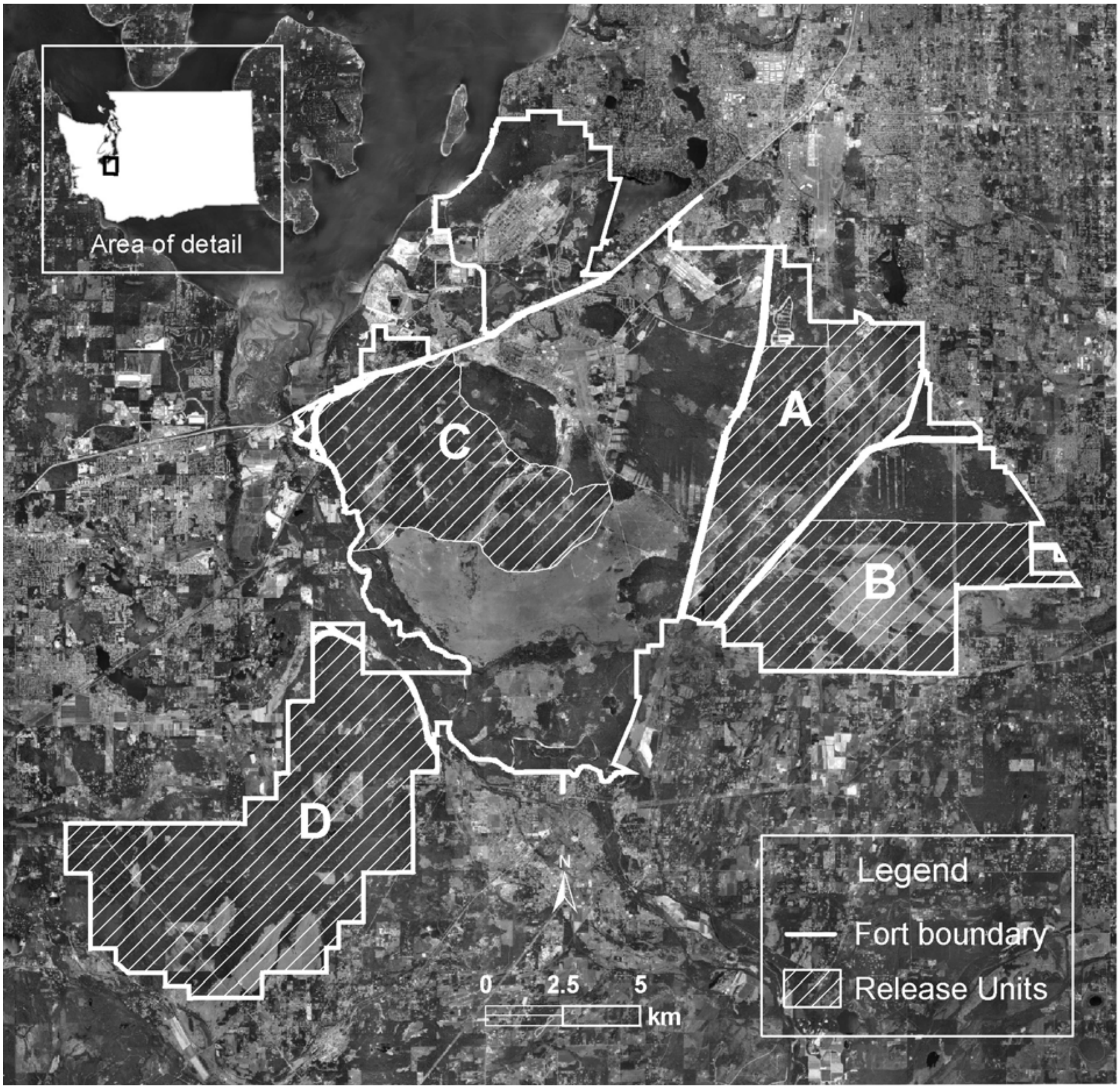

Figure 2. Fort Lewis military reservation showing the boundaries of release units identified for augmentation of the western gray squirrel: A) Squirrel Triangle Unit, B) 13th Division Prairie Unit, C) Training Areas 3-5 Unit, and D) Rainier Training Area Unit.

(hereafter “unit”) and its acreage in specific cover types including forested area within 250m of oak or pine. The Squirrel Triangle Unit holds most of the known western gray squirrels currently residing on the Fort and will be considered the primary release area for the augmentation effort. The other units are not known to currently have resident western gray squirrels and are considered secondary release areas. All units include several large training areas that are used for military training periodically each year. The areas currently occupied by western gray squirrels on the Fort occur primarily within training areas and we have no reason to believe there are significant negative effects from these activities.

Table 1. Size of proposed release units, area in hectares (acres) in ponderosa pine and Oregon white oak cover types, and area in western gray squirrel “habitat”, Fort Lewis, Washington.

Unit	Total Area	Pine	Oak	Habitat[a]
Squirrel Triangle	3663 (9052)	609 (1505)	257 (634)	2221 (5488)
13th Division Prairie	3707 (9159)	41 (101)	134 (330)	866 (2139)
Training Areas 3-5	3838 (9485)	0	69 (171)	881 (2177)
Rainier Training Area	7300 (18000)	[b]	[b]	[b]

[a]Amount of forest cover within 250m of pine or oak stands
[b]Not currently available.

Squirrel Triangle Unit—Nearly all of the western gray squirrels known to exist on Fort Lewis occur in the area known as the squirrel triangle (Appendix A). This 3663-ha unit has the greatest proportion of oak and ponderosa pine of any similarly sized area on the Fort and appears to have the most appropriate western gray squirrel habitat. Release of squirrels in this unit will be a true augmentation, as the translocated squirrels will likely be in immediate contact with extant western gray squirrels. Surveys for western gray squirrels using hair-tubes over a large part of this unit suggest that considerable habitat remains unoccupied.

13th Division Prairie Unit—This unit is adjacent to the Squirrel Triangle Unit but is not known to currently have western gray squirrels (Appendix A). Although larger in area than the Squirrel Triangle Unit, the Prairie Unit has less oak and pine cover types and thus less “suitable habitat”. There are historic records of western gray squirrels using this unit from the 1980s; the degree of use by eastern gray squirrels has not been determined.

Training Areas 3-5 Unit—This large unit has scattered oak stands but little pine (Appendix A). There is suitable habitat equivalent in area to that in the Prairie Unit, though there are few recent records of western gray squirrels. This unit is separated from the Squirrel Triangle Unit by the Central Impact Area (CIA) and part of the developed “cantonment” area (Fig. 2). The CIA is largely forested and is used currently by western gray squirrels and is not known to be a barrier to movement or dispersal. The cantonment area likely is a barrier; however, there is a corridor of forest at the southern boundary that should provide for dispersal movements between this unit and the CIA.

Rainier Training Area—The RTA comprises the southwest area of Fort Lewis and is separated from the remaining Units by the Nisqually river (Fig. 2). This large (>7000 ha) training area is mostly Douglas fir forest, but has oak woodland, prairie, and riparian components. The RTA is not known to contain western gray squirrels; however, there has been little survey effort and there appears to be considerable habitat. This unit is within dispersal distance of the Training Area 3-5 Unit; however, the potential for the Nisqually river as a barrier to dispersal between RTA and the rest of the Fort will have to be assessed.

Phase 2: Identification of Suitable Source Populations

There are 3 clear options for source populations for this augmentation effort: Klickitat County, the North Cascades, and Oregon. Each of these potential source populations has advantages and disadvantages that could affect the success of the augmentation (Table 2). The populations in Washington are most similar genetically but share a similar lack of genetic diversity (see *Genetics* below). Klickitat County is believed to have the larger population; however, all populations in Washington are listed as threatened.

There are several potential source populations within Oregon: the Willamette Valley; southwest Oregon (Douglas County area); and the Wasco County area across the river from Klickitat County. The genetics analysis suggests that of these, the 2 northern populations might be more suitable for augmenting the Fort Lewis population. The species is classified as a small game animal in Oregon, but there is concern that in some areas populations may be declining. Although habitat among the potential source areas differs, all have components that make animals from these areas suitable for translocation (see *Habitat* below).

Our preferred approach would be to obtain animals from multiple source populations, maximizing the potential to introduce animals with sufficient behavioral plasticity and genetic diversity to prosper in south Puget Trough.

Option 1: Animals from both Washington populations (Klickitat and North Cascades) would be used in the augmentation effort both to maximize the genetic diversity and minimize the demographic impact on source populations within the State.

Option 2 (preferred option): This option would supplement Option 1 with animals from the Willamette Valley or Wasco County populations in Oregon. Potential benefits of including Oregon squirrels in the augmentation would include: 1) increasing genetic diversity above that achievable by using Washington squirrels alone, and 2) decreasing the number of animals required from Washington source populations.

Option 3: This option would supplement Option 1 with animals from southwest Oregon, an area identified by Oregon Department of Fish and Wildlife (ODFW) as the core range of the species in Oregon (Marin Nugent, ODFW personal communication).

Table 2. Potential source populations for translocating western gray squirrels to south Puget Sound, Washington, and their relative advantages and disadvantages.

Potential source populations	Advantages	Disadvantages
North Cascades, Washington	+ Genetically similar + Association with riparian habitats	– Low genetic diversity – Habitat lacks oaks – Listed population
Klickitat County, Washington	+ Genetically similar + Larger population + Habitat similar and includes oaks	– Low genetic diversity – Mange known to occur – Listed population
Oregon (Willamette Valley)	+ Higher genetic diversity + Habitat most similar to Puget Trough + Population co-occurs in areas with eastern gray squirrels	– Mange known to occur
(Wasco County area)	+ Higher genetic diversity + Habitat similar and includes oaks	– Mange known to occur
(Southwest)	+ Largest population + Higher genetic diversity	– Genetically more similar to California populations – Mange known to occur

Genetics

Analyses of western gray squirrel genetics (microsatellite and control region sequences) suggest that populations in Washington are distinct from those in Oregon and California (Warheit 2003, 2007). The Columbia River presents a clear barrier that apparently has prevented interchange between the Washington populations and those farther south, perhaps for thousands of years. There is a notable geographic structure among the 3 Washington populations, with the south Puget Trough population somewhat (but not strongly) more similar to the North Cascades population than to the Klickitat population (Warheit 2003). Low genetic diversity apparent in the south Puget Trough population reinforces the need for augmentation, particularly from a population with greater diversity. Unfortunately, both the Klickitat and North Cascades populations also have low diversity compared to those in Oregon and California; if the augmentation takes place using only Washington squirrels, animals from both potential donor populations should be included to maximize the likelihood for improving genetic diversity (Warheit 2007).

The microsatellite data suggest that squirrel populations in Oregon and Washington are separate genetic entities, but the control region data suggest that a historical connection existed between these two areas, particularly with more northern Oregon populations (Warheit 2007). Squirrel populations in Oregon are more diverse genetically than those in Washington; however, translocating squirrels from Oregon has the negative potential of reducing range-wide genetic diversity (Warheit 2007). This could be minimized by using animals from the two northern Oregon populations (K. Warheit, WDFW, personal communication).

Habitat

Similarity between habitat occupied by source populations and habitat of the release site was an important factor identified in success of wildlife translocations. Western Oregon, particularly the Willamette Valley area, likely has the most similar habitat to that in the south Puget Trough region that includes Fort Lewis. Forests in both areas are dominated by Douglas fir, with grand fir (*Abies grandis*) and big-leaf maple common in more mesic areas (Franklin and Dyrness 1988). Both regions have scattered oak woodlands and occasional stands of ponderosa pine. Historically, ponderosa pine occurred more extensively in both areas, but much has been lost to conversion to other land use and through ecological succession (Franklin and Dyrness 1988, Hibbs et al. 2002). The Willamette Valley population is the only one of the 3 potential source populations that co-occurs with eastern gray squirrels over a significant part of its range.

Both potential source populations in Washington are on the east side of the Cascade Mountains with much drier climates than the Puget Trough. Western gray squirrel habitat in Klickitat County is dominated by ponderosa pine, Douglas fir and Oregon oak—all important species for squirrels on Fort Lewis. Habitat known to be occupied in the North Cascades is dominated by ponderosa pine and Douglas fir in the uplands, and hardwoods including alder (*Alnus rubra*), aspen (*Populus tremuloides*), and cottonwood (*Populus balsamifera*) in riparian zones (Franklin and Dyrness 1988); this region lacks an oak component. Riparian zones and their associated hardwood tree species seem to be of importance to western gray squirrels both in the North Cascades and the south Puget Trough.

Animal Health

An additional consideration in the selection of a source population is the presence of disease and parasites (Woodford and Rossiter 1994). Specifically, squirrels in the Klickitat population as well as those in Oregon and California are known to sometimes carry mites (*Notoedres centrifera*) that can cause mange (Cornish et al. 1999). Periodic outbreaks of mange have been documented in western gray squirrel populations in southern Washington, Oregon, and California, sometimes causing high mortality in local populations (Linders and Stinson 2006). Although outbreaks of mange have not been reported for the North Cascades and Fort Lewis populations, we do not know if *Notoedres centrifera* is endemic in these populations but simply has not been observed, or if the parasite is absent from these populations. Recent observations of mange-like hair loss in western gray squirrels on Fort Lewis suggest that the disease may be present; investigations to confirm this currently are underway. Unfortunately, testing healthy animals effectively for the presence of mites is rarely effective (K. Mansfield, WDFW, personal communication) and sampling western gray squirrel nests from both Fort Lewis and Klickitat for mites was inconclusive (WDFW unpublished data). Lacking a definitive means of detecting *Notoedres* mites, we will assume that they occur in all squirrel populations and take strong precautions to avoid moving afflicted squirrels into the Fort Lewis population. These precautions will include:

1. Translocating squirrels during fall, the season where mange (and therefore mite populations levels) were lowest in the Klickitat study (Vander Haegen et al. 2005).

2. Releasing squirrels that exhibit any indication of mange (or other health problem) at the capture site (not using them in the augmentation).

3. Treating all translocated squirrels with Ivermectin (an insecticide proven effective against mites in mammals) before releasing them on Fort Lewis. This single, prophylactic treatment will kill adult mites on the squirrel and may remain effective long enough to kill larvae from any eggs that may hatch (K. Mansfield, personal communication. Squirrels translocated from populations known to harbor mange mites (Klickitat County and Oregon) may be held in captivity for a short time to allow a second treatment.

Minimizing affects on the source population

The western gray squirrel is a listed species in Washington, thus care must be exercised to ensure that the cumulative effect of removing animals for translocation does not endanger the source population. Both the Okanogan and Klickitat populations occur over a large enough area that a short-term reduction in numbers in a small number of individual colonies should do no harm. Where possible, animals will be trapped in areas that are slated for development or timber harvest. Western gray squirrels in Oregon currently are a hunted species; though here, too, there are some areas with small populations where the cumulative effect of removing too many animals could be detrimental. If animals are trapped in Oregon for translocation we will coordinate our activities closely with regional managers from ODFW to ensure that appropriate source populations are selected.

Phase 3 – Capture and Translocation

Timing and numbers

We will capture animals for translocation during fall (September/October), when females have completed their breeding cycle for the year and when rates of mange infection are lowest (Vander Haegen et al. 2005). Fall trapping also will allow the translocated sample to include both adult and juvenile squirrels. A proportion of juvenile squirrels disperses from their natal area over the fall and winter and thus may be “programmed” to search for new areas to establish a territory. Moreover, including juveniles in the translocated sample (rather than all adults) may help minimize any short-term adverse effects on the source populations. Within tree squirrels, it is primarily the dominant males that successfully mate each year; new males introduced to the population may take some time to attain sufficient status to breed (J. Koprowski, Personal communication). Because females have a greater opportunity to contribute to the genetic makeup of a population each year we will bias the first year's release to females.

Numbers of animals translocated to Fort Lewis will vary by release unit. The initial release in the Squirrel Triangle Unit will consist of 12 animals. This unit has an extant population of western gray squirrels and the primary goal of the release is to augment the number of breeding females and add to the genetic diversity of the population. Based on available habitat in this unit (Table 1) and an estimated 40ha required by each animal (Linders and Stinson 2007), the Squirrel Triangle Unit should support a minimum of 55 western gray squirrels. Trapping efforts and hair-tube monitoring in this unit suggest that fewer than this number presently occur (WDFW and TNC, unpublished data). This conservative number for release should provide increased genetic diversity and boost reproductive output without significantly disrupting the social dynamics of the extant population. In the event that >50% of the animals translocated to this unit die or disperse permanently outside of the unit, additional animals will be released in the following year.

The 13th Division Prairie and Training Area 3-5 Release Units are peripheral to, or within dispersal distance of, the extant population of western gray squirrels on the Fort. These units are believed to have few if any resident western gray squirrels and thus translocations to these sites have elements of both a reintroduction and an augmentation. Based on available habitat in these units (Table 1) and an estimated 40ha required by each animal (Linders and Stinson 2007), each of these units should support a minimum of 22 western gray squirrels. The initial release of translocated squirrels in each of these units will consist of 10 males and 10 females. This number is within the estimated carrying capacity of the release sites and is within the range of successful release numbers presented in a recent modeling of tree squirrel reintroductions (Wood et al. 2007). If a significant proportion of the animals translocated to these units die or disperse permanently outside of the unit, additional animals will be released in the following year.

The Rainier Training Area Unit currently is disjunct from the known population of western gray squirrels on Fort Lewis. The large distance between RTA and the extant population of western gray squirrels (> 9km), along with the likely barrier presented by the Nisqually river, makes translocation of squirrels to this unit largely a reintroduction. The number of squirrels released on this unit will be based on analysis of available habitat. As with the other units, if a significant proportion of the animals die or disperse permanently outside of the unit additional animals will be released in the following year. Due to the isolated nature of the RTA, this effort may require multiple releases over several years in order to establish a breeding population.

Methods

Squirrels will be live-trapped and processed according to the methods discussed in Vander Haegen et al. (2005). We will use wire-mesh traps baited with whole walnuts. Trapping will begin during the early morning hours and conclude in late afternoon or when the desired number of animals has been captured. Animals will be held overnight and released at the release site the following morning.

Upon capture, animals will be sexed and assessed for reproductive condition. Any female exhibiting signs of caring for a litter (e.g. advanced teat development) will be released immediately at the trapping site. Healthy animals (adult and juvenile) weighing >600g will be eligible for translocation. These squirrels will be individually marked with numbered metal ear tags and fitted with a radio-transmitter affixed to a plastic, cable-tie collar (Vander Haegen et al. 2005). A tissue sample will be taken from one ear for genetics analysis. Following processing, squirrels will be returned to their individual traps and provided a few walnuts as food and an apple to help them keep hydrated. Each trap will be covered to keep animals calm and transported to the release site by truck. Trapping and translocation will continue on consecutive days until the target number of animals is obtained. If inclement weather (e.g., heavy rain or cold temperatures) develops, trapping will be postponed until conditions improve. Translocated squirrels will be released at the release site early in the morning to allow them time to adjust to their surroundings. Supplemental food in the form of walnuts may be provided during the first few weeks following release at the discretion of augmentation coordinators.

Phase 4 – Monitoring, Research, and Evaluation

Monitoring

The primary objective of monitoring is to determine the success of the augmentation. Because this is an augmentation and not simply a reintroduction, monitoring will involve both the extant population of western gray squirrels on Fort Lewis and the translocated animals. To achieve monitoring goals, efforts will be closely tied to concurrent research on the ecology of western gray squirrels on Fort Lewis. Key questions to be answered through monitoring and research include:

1. Are the translocated squirrels surviving to contribute to the population, either by mating with resident (extant) squirrels or by producing offspring on their own?

2. How are the resident western gray squirrels reacting to the translocated animals in terms of, a) maintaining their pre-augmentation spatial behavior and b) expressing expected rates of reproduction?

3. In secondary release sites (sites lacking an extant population), are translocated squirrels establishing home ranges and surviving and reproducing successfully?

Initial monitoring of the extant and translocated squirrels will be integrated with ongoing research of the extant western gray squirrel population. All translocated squirrels will be marked with ear-tags and fitted with radio-collars prior to release. Movements of all translocated squirrels, their survival, causes of mortality, and reproductive effort will be documented. This intensive monitoring planned for the first 5 years of the project will allow rapid assessment of the fate of translocated squirrels, providing the opportunity for mid-course corrections of the augmentation strategy.

Methods

Telemetry—All translocated squirrels will be fitted with radio collars and located 2-3 times/week. Locations will be derived primarily through homing and recorded with GPS; some locations, especially of animals in inaccessible areas, will be derived via triangulation from at least 3 points. Animals that cannot be located from the ground will be located using fixed-wing aircraft after obtaining clearance for entry into DOD air space (D. Clouse, US Army, personal communication).

Survival and Movements—The first few weeks after release likely will see extensive movements by translocated squirrels as they explore their new surroundings. Released animals will be tracked 4-5 days/week from the ground or from the air to document their movements and area of settlement and to monitor survival. Animals remaining in the same location for >1 week and not observed visually will be approached in order to determine status, including climbing to inspect nests if necessary. Once a squirrel has restricted its movements and appears to be establishing a home range, frequency of relocations will be reduced to 3 times/week in order to delineate its home range and core use areas.

Reproduction—Female squirrels will be monitored for indications of breeding activity (e.g., participation in mating chases, consistent use of a shelter nest or tree cavity). Nests or cavities suspected to be serving as natal dens will be inspected when the female is absent, using either a video probe or by climbing the tree and visually inspecting the nest. Nests with young will be monitored periodically using these methods and by using emergence counts to determine reproductive success (Vander Haegen et al. 2005).

Genetics sampling—Successful reproduction by translocated male and female squirrels can be assessed through monitoring the genetic makeup of young produced in the augmentation areas. Tissue samples will be obtained from all captured squirrels to allow DNA fingerprinting. A set of 21 variable microsatellite markers specific to western gray squirrels has been identified and will allow determination of familial relationships (WDFW unpublished data). DNA from juvenile and adult animals will be sampled through periodic trapping on study sites and targeted trapping in release areas. Parentage will be established when possible by comparing DNA of juveniles to that of all known adults.

Indirect monitoring—Hair tubes (baited hair-snags) have been used successful on Fort Lewis for assessing occupancy of sites by both eastern and western gray squirrels (TNC, unpublished data). This technique would be a cost-effective method of assessing both persistence and expansion of the augmented population on the Fort once the intensive telemetry monitoring has concluded. Live-trapping could be used periodically in newly established populations to document the presence of new individuals (either through emigration or recruitment); if techniques can be developed to derive DNA from hair-tube samples, tube sampling also could be used for this purpose.

Research

In addition to telemetry monitoring to determine the movements and fates of translocated squirrels, specific research questions will be addressed. These will include an assessment of population parameters of the extant population; habitat use by translocated and extant squirrels; selection of nest sites and patterns of nest use; home range and movements; and the interaction of western gray squirrels with introduced eastern gray squirrels.

Western gray squirrels—Resident western gray squirrels will be captured and radio-collared on the Fort prior to release of translocated animals. Animals of both sexes will be captured at multiple sites within the known range of the squirrel on Fort Lewis to provide information on movements and resource use across a variety of conditions present. Focal study areas will be identified and trapped each spring and fall in order to assess condition of the animals, estimate the abundance of squirrels on each site, and attach or replace radio-collars. Translocated western gray squirrels will be radio-collared prior to release on the study area and tracked in order to determine movements, survival, and reproduction as stated above. Animals that establish home ranges within the intensive study areas will be captured during semi-annual trapping efforts; those outside these areas will be trapped individually in order to assess condition and replace radio-collars. Specific research questions that will be addressed are presented in Appendix B and will be expanded in a separate research study plan.

Eastern gray squirrels—The ecological interactions between western gray squirrels and the introduced eastern gray squirrel will be the subject of graduate research through the University of Washington. The graduate student will focus on examining specific aspects of eastern gray squirrel ecology on sites with and without western gray squirrels, comparing these data with similar data collected on western gray squirrels on sites with and without eastern gray squirrels. Allopatric populations of the 2 species are known to occur in suburban areas and in the suburban/wildland interface at numerous locations in Oregon and California in addition to the study area on Fort Lewis. Specific research questions will be developed by the graduate student and may include questions related to relative use of space and other resources, differences in adult and juvenile dispersal, and differences in reproductive parameters and adult and juvenile survival. Research questions will focus on identifying the mechanisms of observed relationships as an aid to defining management actions to minimize detrimental affects of exotic squirrels on western gray squirrel populations. Areas identified for this research will not be subject to removal trapping of eastern gray squirrels for the duration of the study.

Evaluation

An important function of monitoring is to provide information that can be used to judge the success of an augmentation/reintroduction effort. This project includes components of both augmentation and reintroduction and will be considered successful if 1) translocated squirrels survive to breed within the area currently occupied by western gray squirrels on the Fort, expanding the genetic makeup of the population, and 2) translocated squirrels survive to establish a breeding colony in one or more areas not currently inhabited by western gray squirrels. This would comprise a range expansion and can be documented through telemetry monitoring of released animals or, subsequently, by hair-tube monitoring in conjunction with periodic trapping to obtain genetic samples. Contributions of translocated squirrels to the extant population on Fort Lewis can be documented by genetic fingerprinting of young captured on the site.

AUGMENTATION SCHEDULE

(Subject to annual review and amendment over the life of the project)

Year 1

- Release translocated animals in the Squirrel Triangle Unit. Specific areas for release would include those not currently known to include female home ranges.
- Animals for this initial release will be obtained from both the Klickitat and North Cascades populations.

Year 2

- Release translocated animals the13th Division Prairie Unit
- Augment the Year 1 release if fewer than half of the animals survived and remained within the reintroduction Unit.
- Animals for this and subsequent releases will come from multiple source populations.

Year 3

- Release translocated animals in the Training Areas 3-5 Unit
- Augment the Year 2 release if a significant number of translocated squirrels die or disperse outside the unit.

Year 4

- Release translocated animals into the RTA Unit (pending assessment of suitability)
- Augment the Year 2/Year 3 releases if a significant number of translocated squirrels die or disperse outside the unit.

Year 5

- Augment previous releases if necessary.
- Potential release on new, yet to be identified site on Fort Lewis or elsewhere in the South Puget Sound area.

MONITORING/RESEARCH SCHEDULE

Year 1 (2007)

- Research begins on ecology of western gray squirrels on Fort Lewis.
- Research begins on interaction of eastern and western gray squirrels.
- Monitoring of translocated squirrels via telemetry (initial release site).
- Exploratory monitoring of potential release sites via hair-tubes.

Years 2-3

- Research continues on ecology of western gray squirrels on Fort Lewis.
- Research continues on interaction of eastern and western gray squirrels.
- Continued monitoring of translocated squirrels via telemetry (initial and subsequent release sites).
- Exploratory monitoring of potential release sites via hair-tubes.

Years 4-5

- Research continues on ecology of western gray squirrels on Fort Lewis.
- Continued monitoring of translocated squirrels via telemetry (initial and subsequent release sites).

Years 5+

- Monitoring of release areas via hair tubes.
- Monitoring of suitable habitat adjacent to know occupied areas for indication of range expansion.

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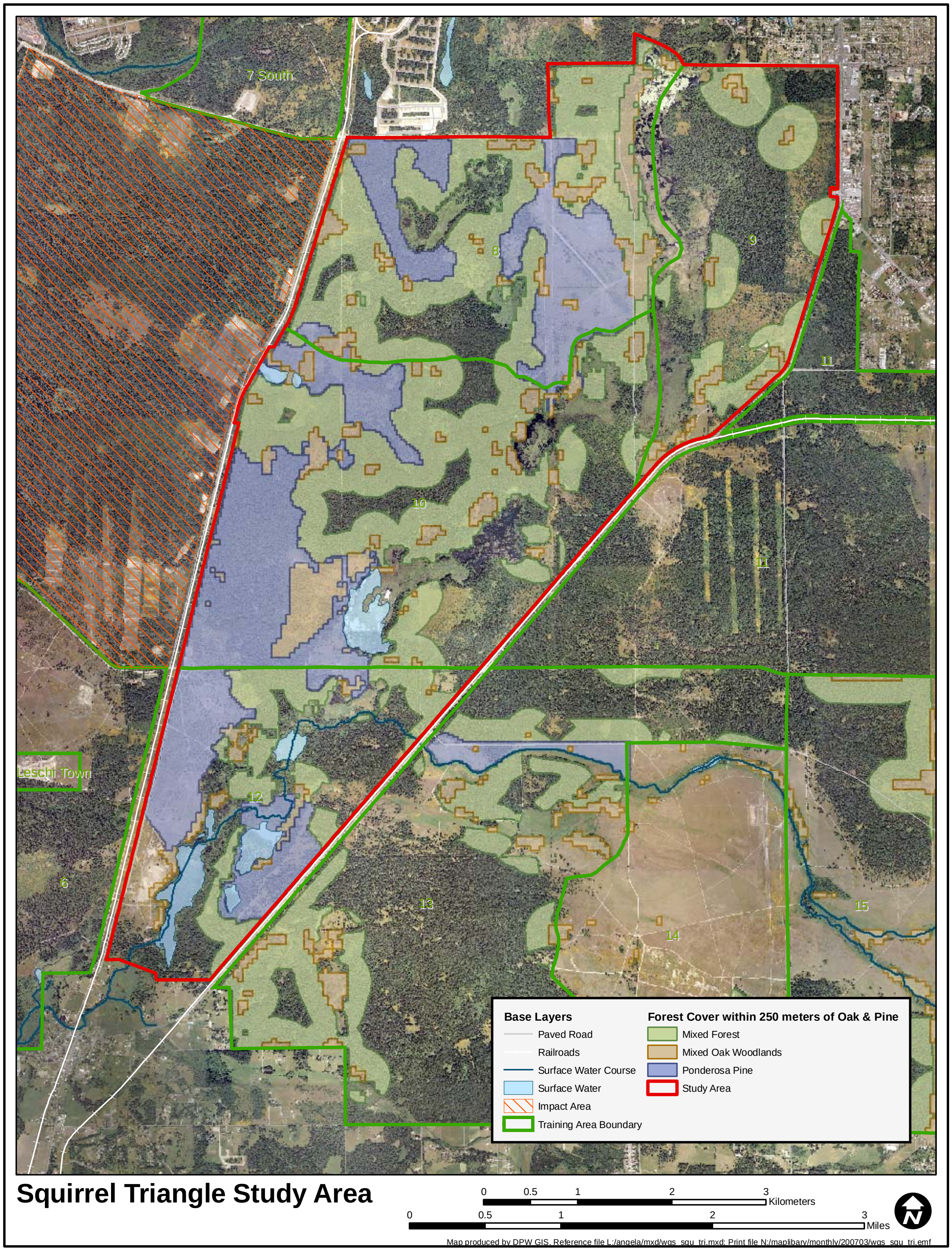
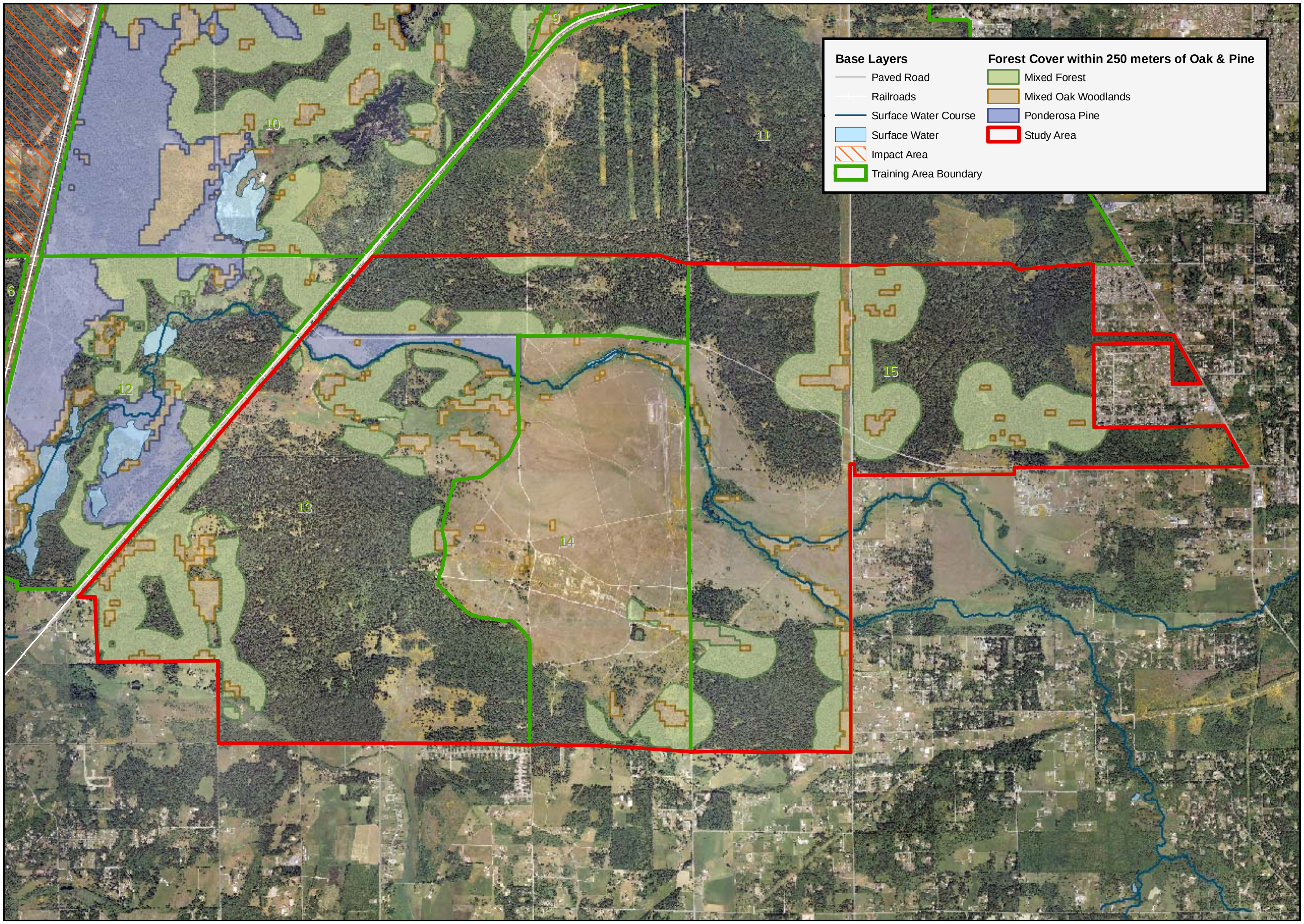
APPENDIX A

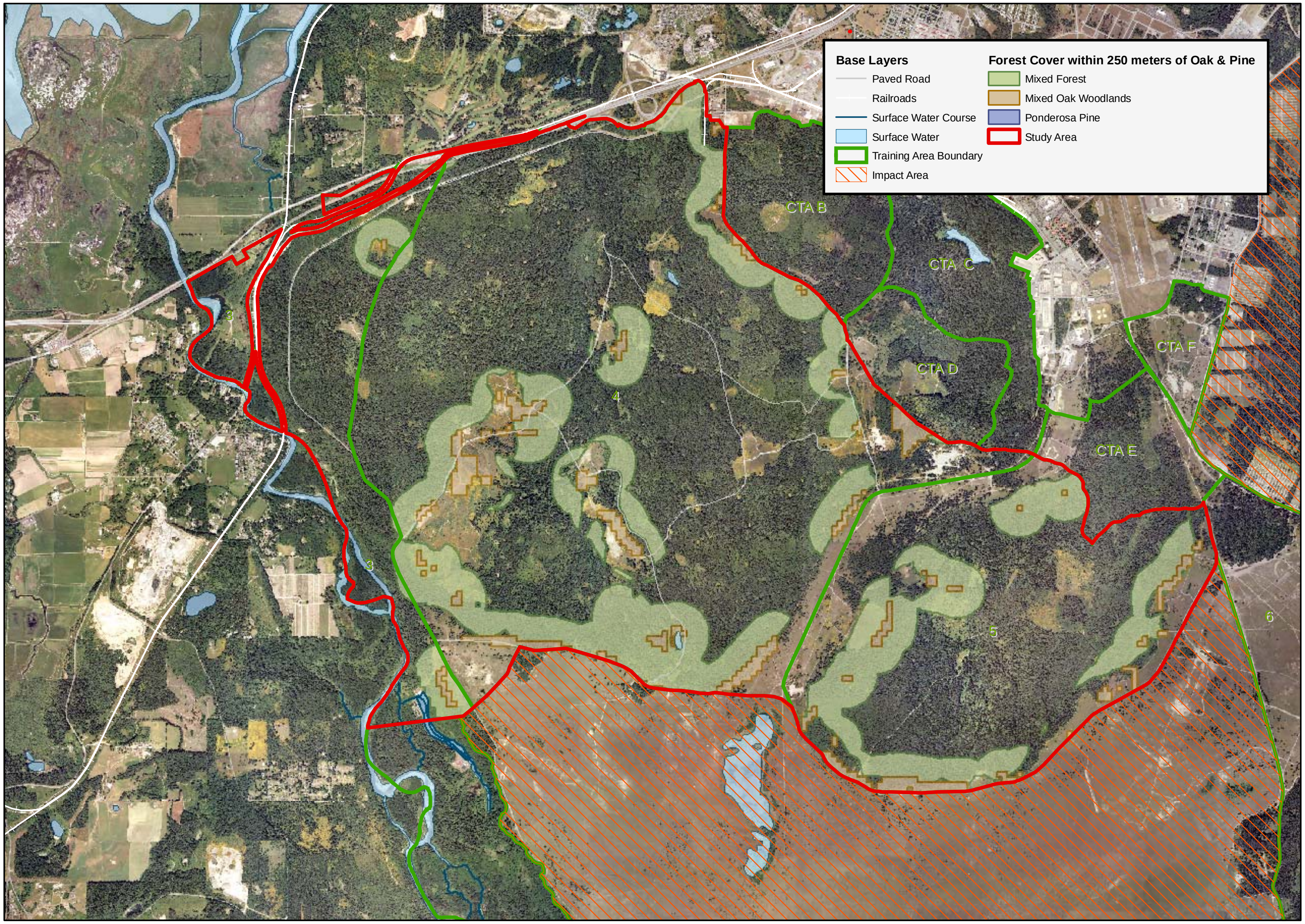
Overview maps of 3 proposed release sites.





13th Division Prairie Study Area

Map produced by DPW GIS. Reference file L:/angela/mxd/wgs_13thDiv.mxd; Print file N:/maplibary/monthly/200703/wgs_13thDiv.emf



Training Areas 3 - 5 Study Area

APPENDIX B

Planned Western Gray Squirrel Research on Fort Lewis

Research Questions

a. Spatial Measures
    i. What is the average (with measures of variance) annual home range and core area size of male and female squirrels?
    ii. What are the average seasonal home range and core area sizes of male and female squirrels?
    iii. What proportion of juveniles disperse (>1km) from their fall use areas and what is the average dispersal distance?
b. Survival
    i. What is the average annual adult survival rate of male and female squirrels and what is the pattern of mortality over the calendar year?
    ii. What are the key sources of mortality for adult and juvenile squirrels?
c. Productivity
    i. What proportion of adult and first-year females give birth?
    ii. What is the average litter size of female squirrels?
    iii. What is the average annual productivity of female squirrels?
d. Nest use
    i. What are the physical characteristics of arboreal nests used by squirrels?
    ii. Do trees selected by squirrels for nesting differ from those available on the forest stand?
    iii. What is the average number of nests used by an individual squirrel annually?
e. Habitat use
    i. Do squirrels select for specific forest types among those available on the study area?
    ii. Do squirrels select for particular forest stand characteristics among those available on the study area?
f. Comparisons with other populations
    i. Do spatial measures differ between the Fort Lewis population of western gray squirrels and the Klickitat population?
    ii. Do survival and mortality measures differ?
    iii. Do productivity measures differ?
    iv. Do nest characteristics and patterns of nest use differ?
    v. Do general patterns of habitat selection and characteristics of forest stand selection differ?

g. Comparisons with western gray squirrels translocated to Fort Lewis
    i. Do spatial measures differ between the extant and translocated western gray squirrels on Fort Lewis?
    ii. Do survival and mortality measures differ?
    iii. Do productivity measures differ?
    iv. Do general patterns of habitat selection and characteristics of forest stand selection differ?