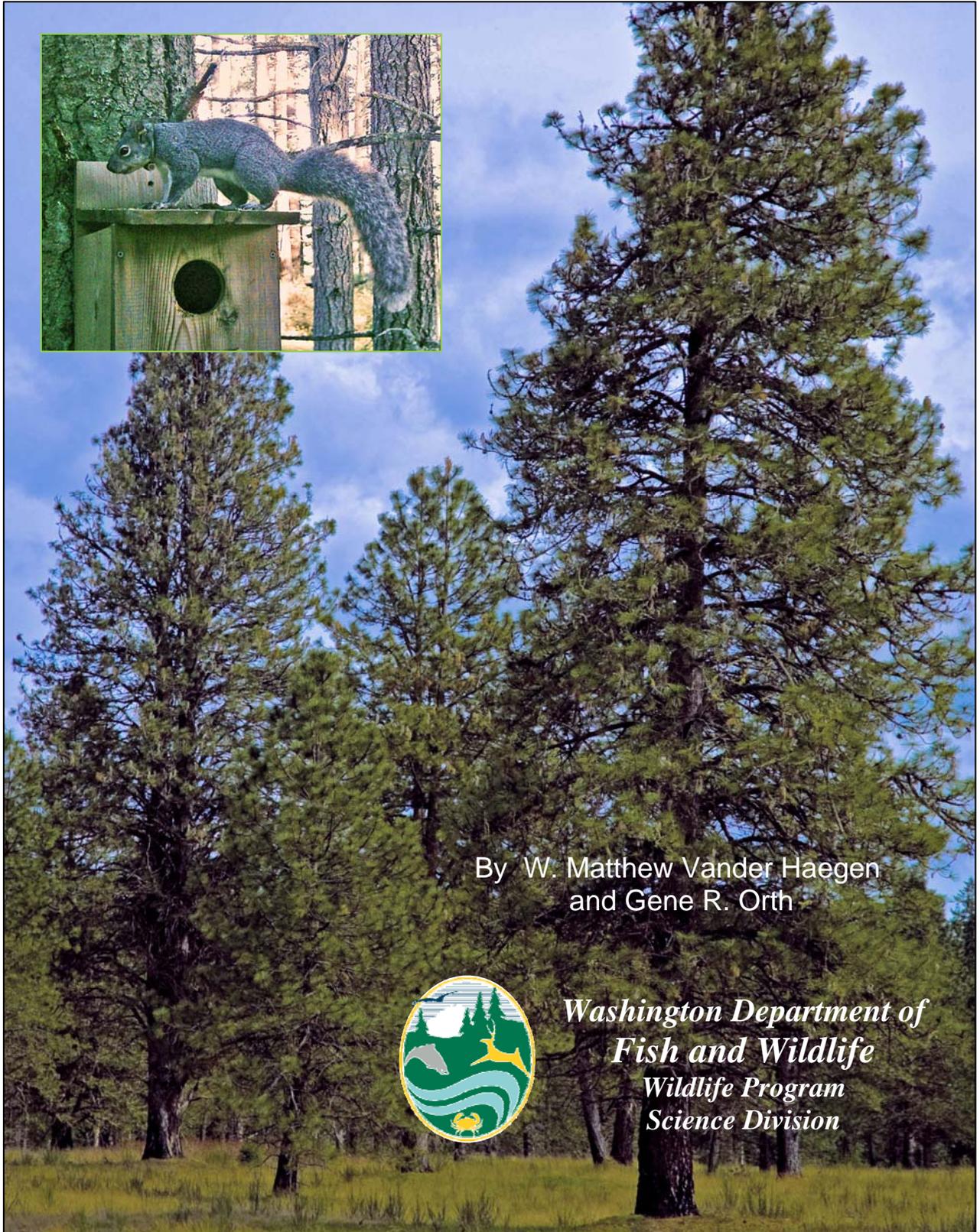


Western gray squirrel ecology and augmentation of the population in the South Puget Trough



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Cover photos : Ponderosa pine stand near Shaver Lake; translocated western gray squirrel (radio-collared) on nest box at release area in the Rainier Training Area (remote camera photo).

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Annual Progress Report

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EXECUTIVE SUMMARY

Western gray squirrel (*Sciurus griseus*) populations in Washington have declined over the last century and their range has diminished. Of the three disjunct populations of western gray squirrel remaining in Washington, the Puget Trough population faces the greatest risk of extinction. The majority of the Puget Trough population occurs on Joint Base Lewis-McChord (JBLM), an area of over 35,000 ha that contains some of the last patches of oak-pine forest in western Washington. The Recovery Plan for this State-threatened species lists augmentation of the population in the Puget Trough as a high priority. In 2007, Washington Department of Fish and Wildlife and the Department of Defense—Fort Lewis, engaged in a cooperative study of the ecology of western gray squirrels on the Fort and implemented a plan to augment this endangered population. Research on the resident population has focused on quantifying population parameters including survival, causes of mortality, and productivity, as well as habitat use and use of space. This information will be critical for assessing why the Puget Trough population has contracted over the last few decades and for focusing management efforts to allow the population to recover. Augmentation has focused on introducing animals from other populations in Washington and northern Oregon in order to increase the genetic diversity of the resident Puget Trough population and expand the occupied area.

From January through December 2010 we captured a total of 30 new resident western gray squirrels during routine and grid trapping. This brings to 121 the total number of resident western gray squirrels captured on the study area since October 2006. Of the squirrels captured in 2010, 15 were fitted with radio-collars and 15 were ear-tagged only and released. We collected 7152 telemetry locations of 80 radio-collared western gray squirrels in 2010 and we documented 179 new nests.

Annual survival of resident western gray squirrels was estimated at 0.55 for 2010; survival of translocated squirrels was similar at 0.54. Fifteen squirrels (residents and translocations) were depredated, 6 succumbed to disease, and 2 died of other causes. Nineteen of 25 resident females tracked through the breeding period attempted to rear young (5 of 6 that did not breed were yearlings); litter size varied from 1 to 4. Two females had a second litter after successfully rearing young; this finding represents the first documentation of 2 litters in a year for this species. All 10 translocated females tracked through the breeding period attempted to rear young; at least 5 were successful producing a total of ≥ 12 young.

We translocated 23 western gray squirrels from Klickitat County, WA and from Hood River and Wasco Counties, OR to JBLM in autumn 2010. As of 31 December, 8 animals from the 2010 release were known to be alive (fate of 4 was unknown because they were not radio-collared; fate of an additional 7 was unknown due to loss of their radio signal). Eight western gray squirrels (6 females, 2 male) from the previous augmentations retained working radio-collars and were known to survive through December 2010. Plans for 2011 include continued monitoring of radio-collared animals and intensified monitoring of reproductive success. Additional translocations will take place in fall 2011 as part of the species recovery effort.

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INTRODUCTION

The western gray squirrel (*Sciurus griseus*) inhabits oak/conifer forests in the western United States from southern California to north-central Washington (Verts and Carraway 1998). Throughout their range, western gray squirrels are most frequently associated with pines (*Pinus* spp.) that provide nesting cover and food, and oaks (*Quercus* spp.) that provide natal den sites and acorns for food (Verts and Carraway 1998). These tree genera also are associated with hypogeous fungi, another staple food of western gray squirrels. Populations of western gray squirrels are considered stable in much of California, where they are managed as a game species (California Department of Fish and Game 2000) and where their habitat contains numerous species of both oak and pine. From mid-Oregon north through Washington, oak/pine communities are simpler, containing primarily ponderosa pine (*P. ponderosa*) and Oregon oak (*Q. garryana*). Both species are intermittent producers of mast, likely making food resources less reliable than in more southern parts of the species' range. Although classified as a game species in Oregon, the western gray squirrel has shown evidence of declines in its population in the north-central part of the state (Foster 1992), and the Oregon Department of Fish and Wildlife lists the squirrel as “undetermined” on the State Sensitive Species List. While once hunted in Washington, the western gray squirrel has been protected since 1944 and was listed as threatened by the Washington Department of Fish and Wildlife (WDFW) in 1993 (Washington Department of Wildlife 1993).

Western gray squirrel populations in Washington have declined over the last century and their range has diminished (Washington Department of Wildlife 1993). Western gray squirrels currently exist in only 3 locations: the southern Puget Trough; north-central Washington (Chelan and Okanogan Counties); and south-central Washington (primarily Klickitat County). Of the three disjunct populations of western gray squirrel in Washington, the Puget Trough population faces the greatest extinction risk (Linders and Stinson 2006). Already at a low point in the early 1990s (Ryan and Carey 1995), available evidence suggested that the Puget Trough population has declined dramatically since then and may be dangerously low (Bayrakci et al. 2001). Causes for the decline in the Puget Trough population likely include habitat loss, habitat alteration, and increased mortality related to vehicle traffic (Ryan and Carey 1995).

The majority of the Puget Trough population occurs on Joint Base Lewis-McChord (JBLM; formerly Fort Lewis and the adjoining McChord Air Force Base), an area of over 35,000 ha that contains some of the last patches of oak-pine forest in western Washington (Linders and Stinson 2006). The Recovery Plan for this State-threatened species lists augmentation of the population in the Puget Trough as a high priority. In 2007, WDFW and the Department of Defense—Fort Lewis, engaged in a cooperative study of the ecology of western gray squirrels on the Base and implemented a plan to augment this endangered population (Vander Haegen et al. 2007). Research on the resident population has focused on quantifying population parameters including survival, causes of mortality, and productivity, as well as habitat use and use of space. This information will be critical for assessing why the

Puget Trough population has contracted over the last few decades and for focusing management efforts to allow the population to recover. Augmentation has focused on bringing animals from other populations in Washington and northern Oregon in order to increase the genetic diversity of the Puget Trough population and provide a demographic boost to this small population. This report summarizes the achievements of the project for 2010 and outlines planned work for 2011.

Objectives—Research

1. Document population parameters of the resident (and augmented) western gray squirrel population, including: survival rates, causes of mortality, and reproductive success.
2. Document movements of resident (and augmented) western gray squirrels, including home range, core use areas, seasonal movements, and juvenile dispersal.
3. Document habitat use at coarse and fine spatial scales.
4. Document patterns of nest use and nest tree selection.
5. Document interactions with non-native eastern gray squirrels (*S. carolinensis*) and differential patterns of habitat, nest, and space use (UW graduate study)

Objectives—Augmentation

1. Increase the genetic diversity of the Puget Trough population of western gray squirrels by introducing animals from other populations.
2. Increase the area occupied by western gray squirrels on JBLM.
3. Investigate the potential of non-DOD lands as reintroduction sites in the south Puget Trough and, if practicable, initiate reintroductions.

METHODS

Resident animals as well as animals captured for translocation were captured and handled using similar methods as described by Vander Haegen et al. (2005). Wire-mesh live traps were placed near the base of trees in likely habitat and pre-baited with English walnuts. Squirrels were forced out of the traps into a cloth handling cone (Koprowski 2002) that allowed us to weigh, measure, and inspect the animal. Most adult animals and juveniles of sufficient size (> 600g) were fitted with VHF radio-transmitter collars (Holohil Systems, Inc., Carp, Ontario) weighing approx. 15g and with a projected battery life of 18mo. Collars were made of multi-strand wire contained within plastic Tygon tubing and attached with a brass crimp. All squirrels were marked with numbered, metal ear tags (National Band and Tag Co., no.1005-3) attached to both ears.

We obtained animal locations using telemetry “homing”, a technique where the animal is approached using a telemetry receiver and Yagi antenna until a visual observation is achieved, or until the animal is determined either to be in a nest or otherwise hidden in a tree. On occasion, animal locations were derived using triangulation from 3 points. Animal and nest locations were recorded in data-logging

GPS receivers (Trimble Navigation Ltd., Westminster, CO) and were differentially corrected to improve accuracy (typically <5m).

Females were monitored intensively through spring and summer in order to document reproductive behavior. We captured all females periodically to check reproductive status (based on body mass, teat length, and presence of nuzzle marks). Nests suspected to contain young were monitored via remote still and video cameras; cavity dens were inspected with a remote video camera lowered into the cavity. We used both visual observation and remote cameras to obtain “emergence counts”, documenting the number of advanced-age young active around a natal den or nest. All mortalities were investigated in order to determine cause of death. Animals that died from no apparent cause were sent to the Washington Animal Disease Diagnostic Laboratory at Washington State University (WSU) for analysis.

RESULTS

Resident Captures

From January through December 2010 we captured a total of 30 new resident western gray squirrels during routine and grid trapping. This brings to 121 the total number of resident western gray squirrels captured on the study area since October 2006. Of the animals captured in 2010, 15 were fitted with radio-collars and 15 were ear-tagged only and released. A full account of animals handled on the study area since October of 2006 is presented in Table 1. As of 31 December we were monitoring 24 resident western gray squirrels (4 males and 20 females) on the study area.

Table 1. Number of western gray squirrels radio-collared or ear-tagged on Joint Base Lewis-McChord, by age, sex, and origin, October 2006-December 2010.

Origin/Marking	Adult_M	Adult_F	Juvenile_M	Juvenile_F	Total
Resident/Collared	25	41	2	11	79
Resident/Ear-tagged only	32	1	7	2	42
Augmentation/Collared	22	33	0	3	58
Augmentation/ Ear-tagged only	4	0	0	0	4

Telemetry Locations

We collected 7157 telemetry locations of 80 radio-collared western gray squirrels in 2010 and documented each location with a GPS receiver. For most locations the following information also was collected: date, time, accuracy, substrate (including nest use), activity, and general characteristics of the vegetation at the site. All telemetry locations of resident animals recorded in our database from October 2006 through December 2010 are displayed in Figure 1.

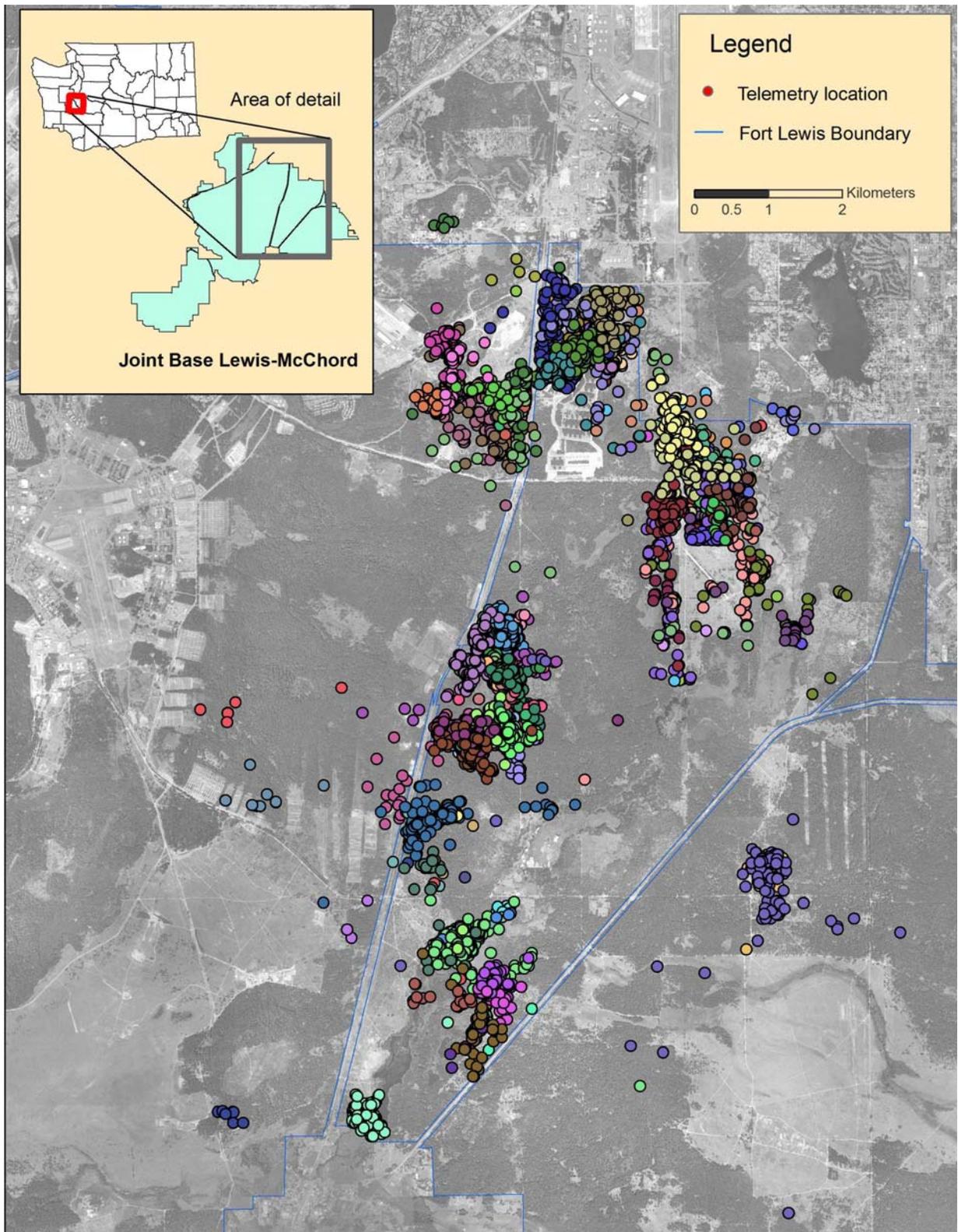


Figure 1. Telemetry locations of resident western gray squirrels on Joint Base Lewis-McChord, 2006-2010. Symbol colors are unique for each animal.

Nests

During 2010 we documented 179 new nests used by radio-collared western gray squirrels and recorded each location with a GPS receiver. For most nest locations the following information also was collected: date, time, accuracy, tree species and DBH, nest type, nest color and condition (indicators of current use). All 480 nest locations recorded in our database from October 2006 through December 2010 are displayed in Figure 2.

Most shelter and platform nests (n = 453) used by western gray squirrels on the study area were in Douglas fir (94 %) or ponderosa pine (4%); however, they also occurred in Oregon oak, Oregon ash (*Fraxinus latifolia*), and cottonwood (*Populus trichocarpa*) (all $\leq 1\%$). Cavity nests documented on the study area (n = 27) also were located primarily in Douglas fir (67%), but also were found in Oregon oak (15%), Oregon ash (15%), and big leaf maple (*Acer macrophyllum*) (4%).

Population Data

Annual Survival and Causes of Mortality.—Annual survival of resident western gray squirrels was estimated at 0.55 for 2010 (using known fate estimators in Program MARK). This is similar to survival estimated for 2009 and somewhat lower than estimates for 2007 and 2008 (Fig. 3); however, overlapping confidence intervals indicate no significant difference among years. Annual survival of translocated animals was estimated at 0.54 for 2010; point estimates for translocated animals were similar to those for residents in all years.

Twenty-three radio-collared western gray squirrels died during 2010. Fifteen were depredated, with most kills attributed to mammalian predators based on remains found at the kill sites. Three animals died from infection with *Francisella tularensis*, a bacteria and the causative agent for the disease tularemia. One of the tularemia deaths was a translocated squirrel and represents the first known loss of an augmented animal to this disease. The animal had been released in TA-4 in 2008 and had remained in that training area. Three animals died from other disease vectors or infections that could not be identified. Two translocated animals died from apparent physical trauma; 1 was observed foraging with an apparently injured hind-limb and was later found dead, its leg clearly broken; a second was killed by a car after moving into a developed area of the Base.

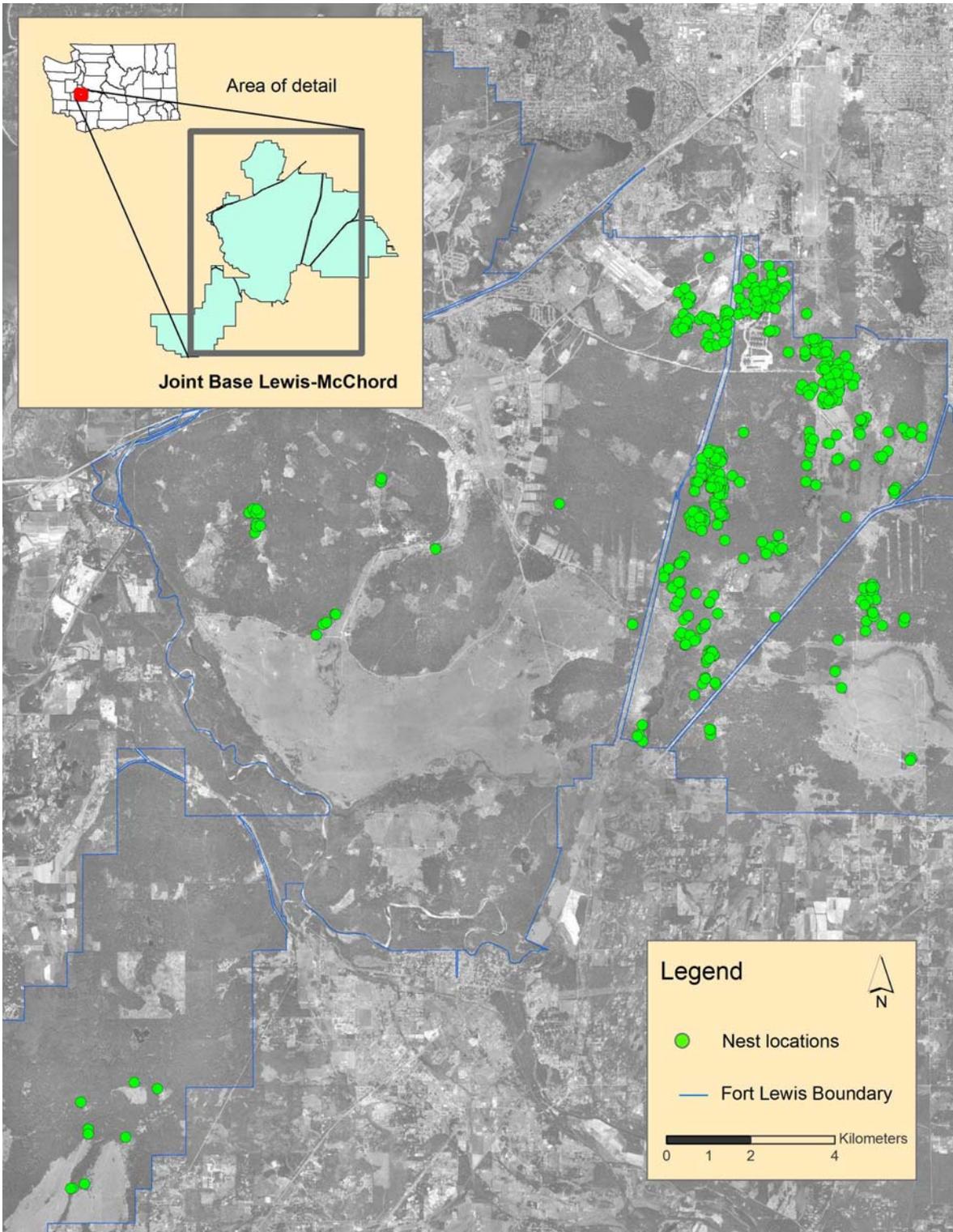


Figure 2. Nests of radio-collared western gray squirrels (both residents and translocated animals) on Joint Base Lewis-McChord, 2006-2010.

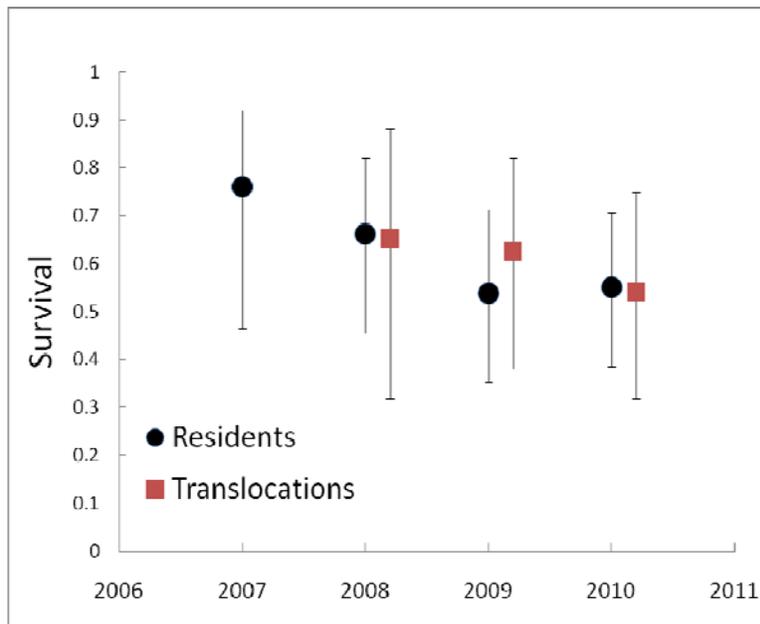


Figure 3. Annual survival rate (mean and 95% Confidence intervals) for resident western gray squirrels on Joint Base Lewis-McChord and for western gray squirrels translocated to the Base as part of the species recovery effort.

Reproduction.—Twenty-five resident females were monitored February-September 2010 for indications of breeding activity. Nineteen females showed definite indications of breeding, exhibiting enlarged teats, nuzzle marks, or both. Five of the 6 females that apparently did not breed were yearling females born in 2009. One yearling female did breed and successfully raised 2 young. Counts of young in complete litters were possible for 4 females and ranged from 1 to 4 (mean = 2.25, 1.26 SD). Complete counts of young per successful female (young raised to “emergence”; 6-7 weeks old) were possible for 9 females and ranged from 1 to 4 (mean = 2.1, 0.99 SD); these data include 2 litters for 1 female.

Two females attempted a second litter after successfully rearing young; this finding represents the first documentation of 2 litters in a year for this species. Both females had small first litters (1 and 2 young) and both reared 2 young in their second attempts. Both females had early litters, with young emerging in late-April or early May and young from second litters emerging or nearing emergence-age in late-July.

All 10 translocated females tracked during the breeding season in 2010 exhibited evidence of breeding activity (pregnancy and/or lactation). Five females were confirmed to have reared young to emergence age, producing a combined total of at least 12 young. A complete count of young per successful female was possible for 3 females and ranged from 1 to 4 (mean = 2.7, 1.53 SD).

Translocated Squirrels

2010 Release.—In the fall of 2010 we released 23 adult Western gray squirrels on JBLM as part of the State’s recovery effort for this population. Animals were captured on the Klickitat Wildlife Area in south-central Washington (n = 14) and on private lands in north-central Oregon near the town of Hood River (n = 9). Nine animals were released in TA-4 to supplement the 2009 releases in that area; 14 animals were released in the Rainier Training Area (RTA) at the southwest corner of the installation. The RTA release represents a reintroduction of this species to the area west of the Nisqually River (Fig. 4).

All squirrels received 2 injections of Ivermectin (2 weeks apart) prior to release to reduce the likelihood that they might introduce new ectoparasites to the release area. All animals were placed in separate wooden nest boxes secured to trees approximately 7 meters above the ground and provided with a dozen or so unshelled English walnuts. We removed the door on each of the nest boxes approximately 2 hours after releasing the squirrels into the boxes, allowing them free movement into their new habitat. Several squirrels continued to use the nest boxes for 1-2 weeks after release.

Of the 23 squirrels released in 2010, 8 (5 female, 3 male) were known to still be alive as of 31 December (Appendix A). Four animals were confirmed mortalities: 1 died within 12 days of release and appears to have starved; 1 was killed by a car after moving into a developed area of the base; and 2 apparently died of natural causes. The fate of 11 animals remains unknown; 4 because they were released without radio-collars and 7 due to loss of radio signal. We were unable to locate these missing animals during 2 aerial searches, suggesting that their radio-collars failed and that they may still be alive. It is also possible that these animals dispersed beyond our aerial search area or that their radio-collars were damaged by collision with a vehicle.

Previous releases.—Eight western gray squirrels (6 females, 2 males) from the augmentation efforts in 2007-2009 retained working radio-collars and were known to survive through December 2010. Additional animals from these earlier releases may have survived into 2010, but loss of their radio signals precluded a final determination.

Habitat Data

We sampled the vegetation structure and composition in female use areas and at nest sites in order to characterize western gray squirrel habitat on JBLM. Sampling was coordinated with graduate student Aaron Johnston and duplicated for female eastern gray squirrels for interspecies comparisons. We sampled the use areas for 18 female western gray squirrels and characterized the vegetation at 96 nest sites (74 stick nests and 22 tree cavities).

We estimated production of cones on Douglas fir and ponderosa pine trees for the primary squirrel study area. Methods and results are summarized in Appendix B.

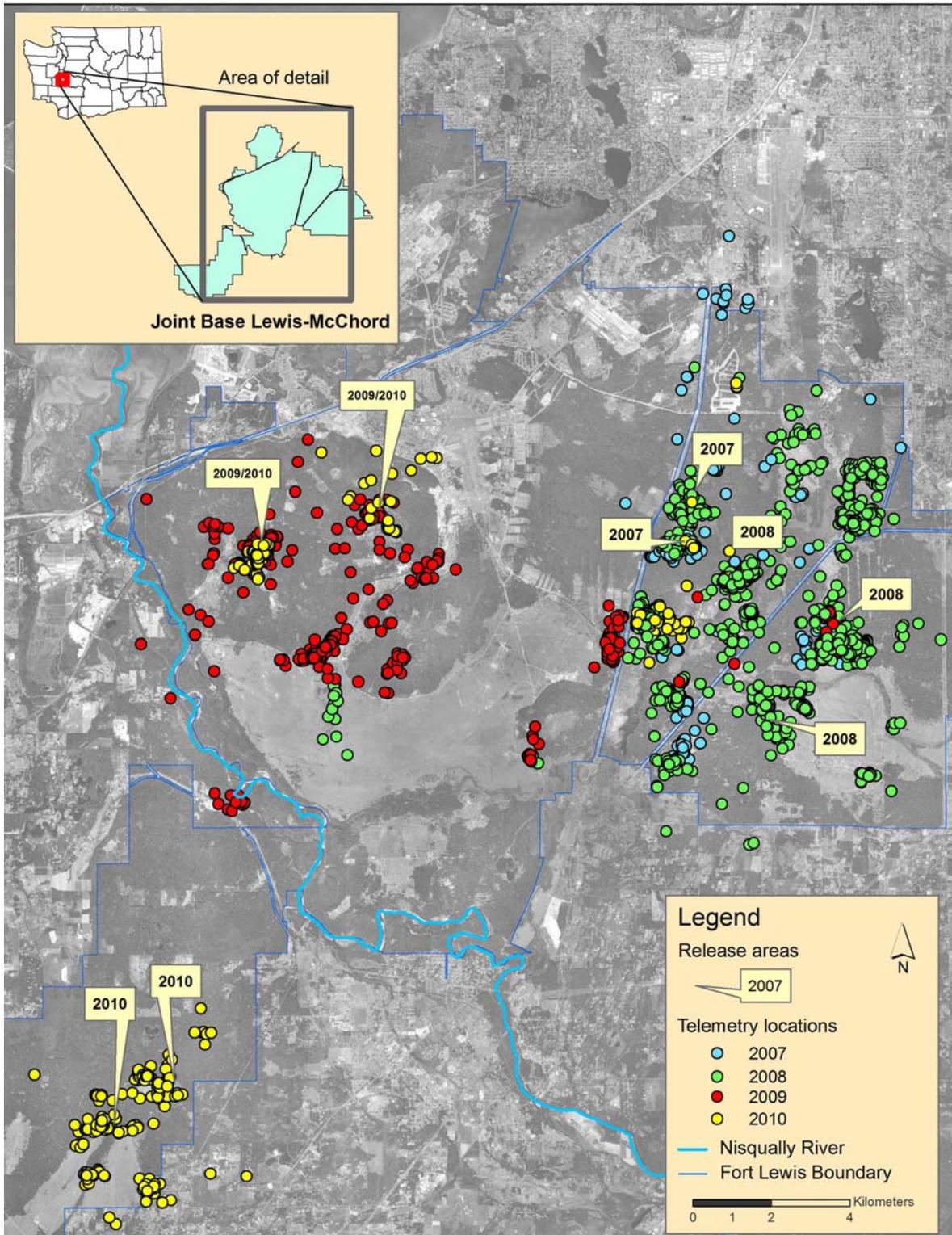


Figure 4. Release areas and subsequent telemetry locations (by release cohort) of translocated western gray squirrels on Joint Base Lewis-McChord, 2007-2010.

PLANS FOR 2011

Research

Monitoring of radio-collared squirrels will continue through 2011. We will capture and radio-collar additional resident western gray squirrels in order to maintain a suitable sample size for ongoing research on the ecology of the species on the study area. Areas of emphasis will include: documenting all natal nests and reproductive attempts through increased monitoring; continuing annual sampling of mast crop size; and completing the sampling of vegetation within animal home ranges to facilitate habitat use analyses. Further documenting the extent of tularemia in both the eastern and western gray squirrel populations will also be emphasized, with all suspicious mortalities sent for analysis.

UW graduate student Aaron Johnston will continue his assessment of eastern gray squirrel ecology on the study site, including monitoring of removal areas and assessment of survival and productivity. Aaron radio-collared a sample of Douglas squirrels (*Tamiasciurus douglasii*) on the study site early in 2011 and will collect movement data on these animals through autumn to see how their use of space might be influenced by the invasive eastern gray squirrel.

Field work for the western gray squirrel ecology study is scheduled to be completed in winter of 2011. We will begin capturing animals to remove radio-collars in December 2011 and plan to conclude by February 2012. With the conclusion of the ecology study, efforts will shift to monitoring the status of western gray squirrels on JBLM with a focus on areas where translocations took place.

Augmentation

Additional western gray squirrels will be released on the Base during fall 2011 as part of the recovery effort. Release areas will be selected in consultation with JBLM staff and likely will include TA4 and the RTA to supplement these earlier releases. Additional translocations to JBLM may be necessary in 2012 and beyond if monitoring suggests that the population is declining; however, at present we intend to pursue new release areas in suitable habitat off-Base beginning in 2012.

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APPENDIX A: Western gray squirrels translocated to Joint Base Lewis-McChord in 2010.

Animal number	Sex	Survival Period	Origin/Release Site/Release Date	Fate
3001	M	3 months +	WA/RTA/10 Sep	Lost signal, after relocating to Holden
3003	M	2 months	WA/RTA/10 Sep	Mortality, depredation
3005	F	4 months +	WA/RTA/10 Sep	RTA , active
3007	F	4 months +	WA/RTA/10 Sep	RTA , active
3013	F	3 months	WA/RTA/10 Sep	Mortality, found intact, no known cause
3014	M	2 months +	WA/RTA/10 Sep	Lost signal
3016	M	1 months +	WA/RTA/10 Sep	Lost signal
3018	F	4 months +	WA/RTA/ 12 Sep	RTA , active
3019	M	4 months +	WA/RTA/12 Sep	Johnson Marsh, active
3021	F	3 months +	WA/RTA/12 Sep	Lost signal
3026	F	4 months +	WA/RTA/12 Sep	RTA, active
3028	M	Unknown	WA/RTA/12 Sep	Unknown; not radio-collared
3029	M	4 months +	WA/RTA/12 Sep	RTA, collared on 3 Mar 11, active
3035	F	12 days	WA/RTA/12 Sep	Mortality, probable starvation
3045	M	4 months +	OR/TA 4/27 Sep	TA 4, radio-collared 16 Nov 10, active
3046	M	Unknown	OR/TA 4/27 Sep	Unknown; not radio-collared
3047	F	1.5 months	OR/TA 4/24 Sep	Mortality, road kill
3048	F	1week +	OR/TA 4/27 Sep	Lost signal
3049	F	1 week +	OR/TA 4/27 Sep	Lost signal
3050	M	Unknown	OR/TA 4/27 Sep	Unknown; not radio-collared
3051	F	4 months +	OR/TA 4/27 Sep	TA 4, active
3052	M	Unknown	OR/TA 4/1 Oct	Unknown; not radio-collared
3053	F	3 weeks +	OR/TA 4/1 Oct	Lost signal

APPENDIX B. Quantifying cone production on Joint Base Lewis-McChord.

In 2010 we began a pilot effort to quantify the availability of seed mast as a food resource for western gray squirrels on Joint Base Lewis-McChord. Our observations of radio-collared western gray squirrels on the Base from 2006-2010 indicate that squirrels regularly feed on the seeds of Oregon oak, ponderosa pine, and Douglas fir and that the intensity of use of these species by squirrels for food is related to the size of the annual mast crop. We focused our efforts in 2010 on sampling pine and fir seed crops; the U.S. Forest Service's Pacific Northwest Research Station annually samples the seed crop for Oregon oak on JBLM as part of their regional oak sampling project.

Methods

We used the JBLM Current Vegetation data layer to identify stands likely to include substantial pine or fir components. We limited our analysis to the eastern portion of the base, that area most intensively used by the resident western gray squirrels (Training Areas 8, 9, 10, 12, and the ammo storage unit north of TA-8). Our sampling included the pine stands in TA-6 because of their proximity to this high-use zone and the high number of pine trees in that area. As a first step in site selection, we include all stands that had "pine" or "fir" in their attribute description (Descript89) in the vegetation GIS data layer and that also were designated as either "savannah" or "woodland". We chose not include stands designate as "conifer forest" as we believed the tree spacing in woodland and savannah types would provide a better opportunity to view tree crowns and count cones; moreover, our observations indicate that squirrels frequently forage in these community types.

We sampled all 7 stands characterized as having a pine component and we selected a sample of 5 fir stands spaced north to south across the study area from the >50 fir stands available (we define stands here as contiguous polygons in the GIS layer; some stands comprised several vegetation mapping units identifiable in the GIS). We used ArcGIS to generate random points within each polygon, limiting the points to be within 50m of a road to aid in sampling logistics. We based the number of points generated for each stand on the stand's size and adjusted the number upwards for stands with small area. We used the random points to select an unbiased sample of trees to examine for cone production.

Sampling.—We visited the stands 22 July - 12 August 2010. We used a GPS unit (Trimble, Sunnyvale CA) to navigate to each random point and selected the nearest tree that met our criteria (minimum 50cm DBH; full, healthy crown; at least 50% of the crown visible for counting cones). If no suitable tree was observed within 50m of the point, that point was discarded and we moved on to the next random point. In mixed stands containing both fir and pine we selected one tree of each species at each point when available.

We counted cones visible from the ground by inspecting the crown from a distance approximately equal to one-half to two-thirds the height of the tree. We used binoculars

to scan each branch of the tree, counting unopened, new cones visible on one-half of the crown. In most instances we viewed the tree with the sun at our back to enhance visibility of cones. For our assessment of current-year production, we counted only unopened green cones on fir trees and unopened green or dark red/purple cones on pines. We also quantified the number of “old” cones on the tree using the same classification system; many fir trees and some pines had brown, open cones that appeared to be from previous years. We also searched the ground beneath trees containing new cones for “cone cores” and similar indications of foraging by squirrels.

A single observer sampled all trees in 2010. For each tree the observer recorded:

1. Tree species
2. DBH
3. Tree position relative to the stand (open, edge, or interior)
4. Cone class (see Table 2).

All sampled trees were marked with pink flagging tape and with an aluminum tag affixed to the bole of the tree with an aluminum nail at a height of approx 5 ft. Each tag was engraved with a unique tree number and the text “WDFW Cone”. The tags were placed on the side of the tree facing the nearest road to facilitate relocation; for trees not readily visible from a road, tags were placed on the north side of the tree.

Table 2. Classes ¹ used to quantify cone crops on Joint Base Lewis-McChord, 2010.

Ponderosa Pine

- 1= no cones visible
- 2=few individual cones scattered over the crown
- 3=cones more numerous and in clusters of 2 or 3 cones
- 4=cones in clusters of 3-5 and several clusters/limb.

Douglas Fir

- 1= no cones visible
- 2=few individual cones, usually near tree tops and limb ends
- 3=several cones per limb; cone-bearing limbs extending down most of crown
- 4=10-20 cones/limb; cone-bearing limbs extending down most of crown.

¹ Class descriptions from “Forestry Management Note MN-2001-1”, Potlatch Corporation, Lewiston ID. Classes 1 and 2 indicate no or light crop; ranks 3 and 4 indicate cones are readily visible

Results and Discussion

We sampled 53 Douglas fir trees and 50 ponderosa pine trees for cone abundance in 2010 (Fig. 5). We observed few trees of either species with new cones, suggesting low availability of seeds for western gray squirrels during fall and winter 2010 (Table 3). Only 1 Douglas fir tree had new cones, although the count on this tree was high at the maximum class 4. Many fir trees had a large number of brown, open cones from previous years; >90% of fir trees sampled had quantities of old cones that ranked as class 4 suggesting a large cone crop in 2009. Nine of the ponderosa pine trees sampled (18%) had new cones, but the crops on these trees all were class 2, indicating few cones were produced. Eight pines had a large number of brown, open cones from previous years (class 3 or 4). Our data suggest a crop failure for Douglas fir and a low crop for ponderosa pine on our sampling area in 2010. This is supported by the small number of observations of radio-collared western gray squirrels and eastern gray squirrels foraging on cones in late summer and fall of 2010 on JBLM.

Table 3. Tree position in the stand, diameter breast height, and cone-count class for Douglas fir and ponderosa pine trees sampled on Joint Base Lewis-McChord, 2010.

Species	n	Position			DBH			Class ¹			
		Open	Edge	Interior	Mean	SD	Max	1	2	3	4
Fir	53	11	41	1	82.9	20.7	133	52	0	0	1
Pine	50	37	13	0	71.6	15	105	41	9	0	0

¹ Classes are described in Table 2 (class 1= no cones visible; 2-3 = few cones; 4 = many cones)

We observed fresh cone-cores at the base of several pines in TA 6 and in TA 8 indicating that squirrels had foraged in the tree and consumed some cones before our surveys. The number of cores found was small (2-3), suggesting that early foraging activity had little effect on our cone counts. We also found 2 new cone cores beneath a fir tree in TA 8. New cones were not apparent in this tree or in any of the surrounding trees, suggesting that very small cone crops on firs may have gone undetected in our surveys. Identifying a small number of new cones on trees with a large number of open cones from the previous year may prove to be difficult.

Three pine trees in our sample had a small number ($\leq 5\%$) of dead, terminal branches indicated by red or brown needles. These trees occurred in pockets of similarly affected trees in Training Areas 6, 8, and 10 and were representative of the other pine trees in that part of the stand.

We intend to repeat this survey in 2011, revisiting the 103 trees permanently marked with aluminum tags. Additional stands were identified and additional random points were generated that would allow expanding the survey if time allows.

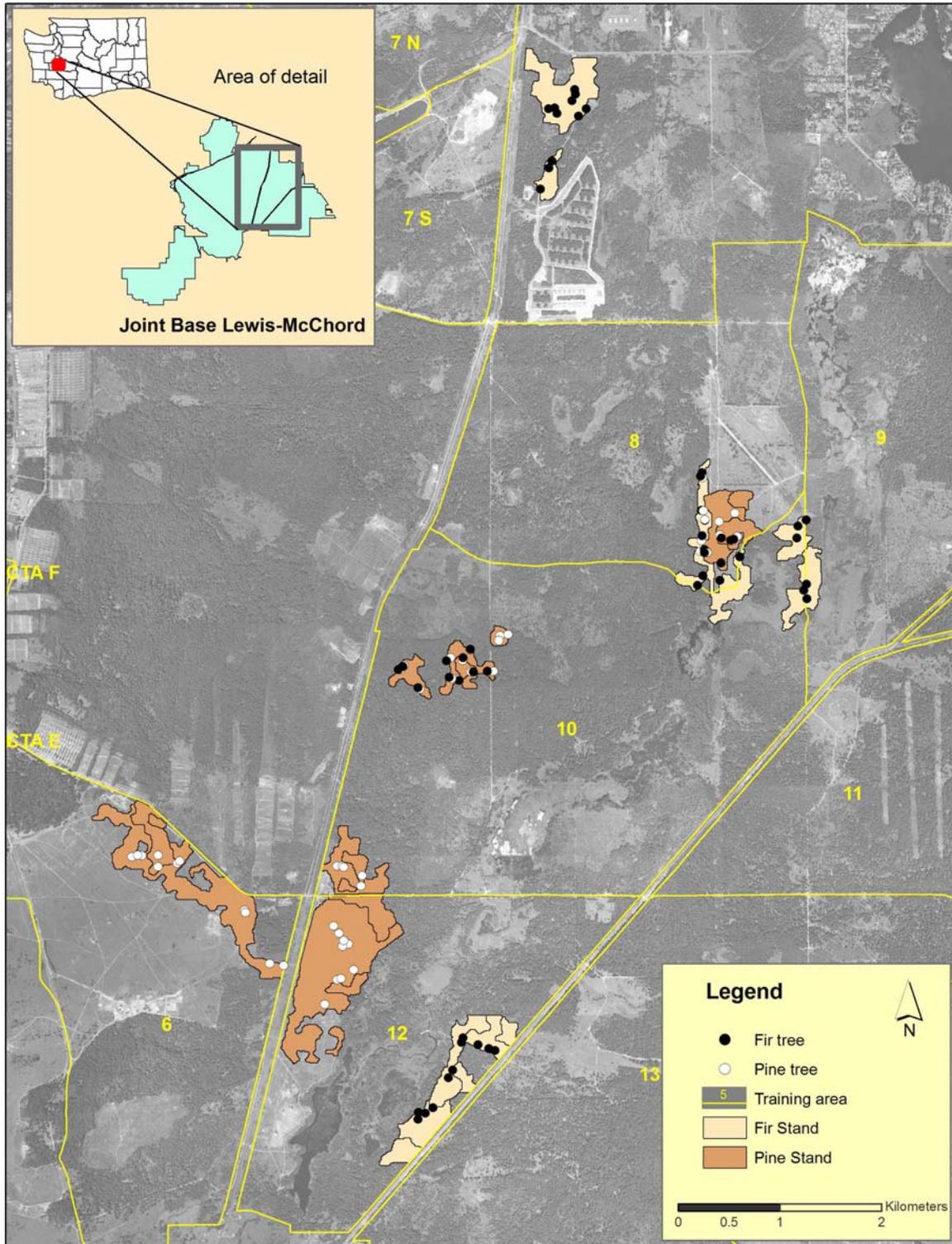


Figure 5. Location of stands and individual Douglas fir and ponderosa pine trees sampled for cones on Joint Base Lewis-McChord, 2010.