Western Gray Squirrel Distribution in the Upper Methow Valley, Washington 2010-2012 Report

Pacific Biodiversity Institute

This page is intentionally blank.

Western Gray Squirrel Distribution

in the Upper Methow Valley, Washington

2010-2012 Report

December 2012

Pacific Biodiversity Institute
P.O. Box 298
Winthrop, Washington 98862
509-996-2490

Recommended Citation

Pacific Biodiversity Institute. 2012. Western Gray Squirrel Distribution in the Upper Methow Valley, Washington. 2012 Report 46 p.

ACKNOWLEDGEMENTS

Pacific Biodiversity Institute would like to thank the Washington Department of Fish and Wildlife Aquatic Lands Enhancement Account (ALEA) Volunteer Cooperative Grants 09-1351, 10-1353, and 12-1304, The Methow Valley Interpretive Center, The Craig and Jean Olson Foundation and Pacific Biodiversity Institute Special Projects Grant for funding our project. Many volunteers helped with data collection: John Alexios, Joyce Bergen, Marjorie Barker, Sharon Clark, Hannah Edwards, Alan Fahnestock, Jane Gilbertsen, Alan and Karen Gillespie, Jim and Cathy Habermehl, Dorothy and Ed Hudson, Michael Hutchins, Don Johnson, Patricia Leigh, Larry Lund, Paula Macrow, Jason Miller, Matt Moen, Stephen Nourse, Craig Olson, Sam and John Owen, Melanie Rowland, Patricia Sears, Jason Smith, Lorah Super, Dave and Ann Tate, Morgan Allen-Tate, Patricia Thomas, Asako Yamamuro, Vicky and Ed Welch, Dan Weinstein and George Wooten. Katy Stuart was also key in providing information on western gray squirrels in the lower Methow Valley.

TABLE OF CONTENTS

List of Figures

INTRODUCTION

The western gray squirrel (*Sciurus griseus*) is listed as Threatened in the state of Washington, however very little is known about its northern range. It currently inhabits mixed oak and conifer forests in Washington, Oregon, and California. To aid in conservation and recovery efforts, it is necessary to determine fundamental information such as the species distribution. Historically in Washington, western gray squirrels inhabited the Columbia River gorge and low- to mid-elevations on the east and west sides of the Cascade Mountains in Washington (Figure 1; Dalquest 1948; Ingles 1965). Currently, the western gray squirrel is known to exist in only three isolated remnant populations in Washington: 1) Puget Trough, 2) South Cascades, and 3) North Cascades.

Causes of threatened status

Habitat loss has been determined to be the largest factor contributing to declines in the Washington population of western gray squirrels. Habitat losses have occurred from urbanization (Rodrick 1986), logging removing large, mast producing trees and eliminating an interconnected canopy (Noss et al. 1995; Vander Haegen et al. 2004), fire exclusion (Kertis 1986), and overgrazing (Weaver 1961). Additionally, road-kill deaths (Ingles 1947; Verts and Carraway 1998; Weston 2005), mange (Bryant 1921; Shannon 1922), and competition with non-native squirrels (Byrne 1979) have also led to western gray squirrel population declines. *Sciurus niger* and *Sciurus carolinensis* are introduced tree squirrels which compete with the western gray squirrel for resources (Byrne 1979). An additional threat to population recovery of the three remnant populations is low genetic diversity (Warheit 2003).

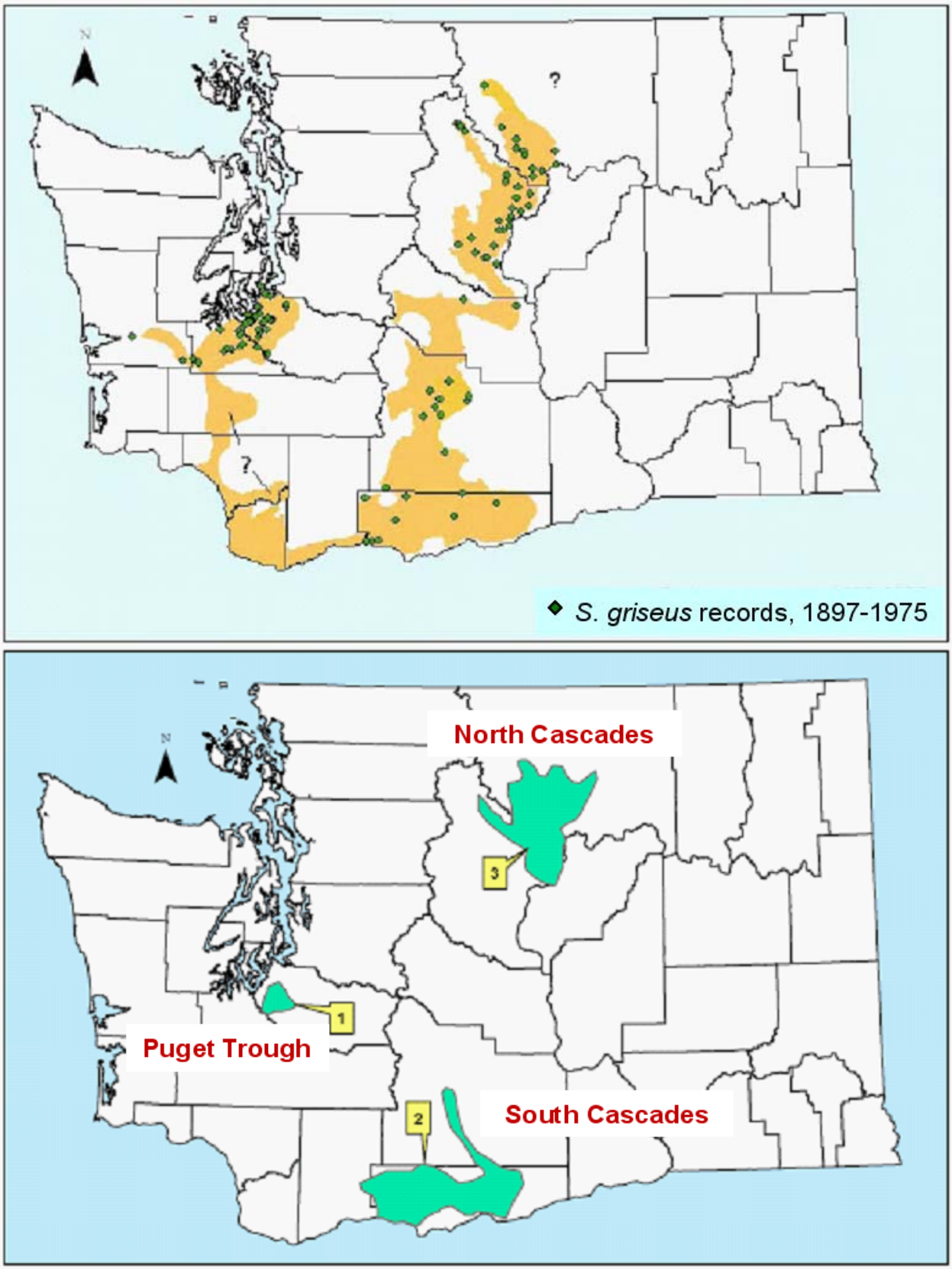


Figure 1. (upper map) Historical and (lower map) current western gray squirrel distribution in Washington state.

Ecological importance

Western gray squirrels are the largest native tree squirrel in Washington and are ecologically important as fungi dispersers, tree seed dispersers, and food for predators. One major food source for western gray squirrels is hypogeous fungi which are mycorrhizal and increase water and nutrient uptake with roots of associated trees (Stienecker and Browning 1970; Asserson 1974; Maser et al. 1981). Western gray squirrels disperse fungal spores as they defecate. Western gray squirrels also tend to be scatter hoarders which leads to them aiding tree seed dispersal by burying individual pine and fir cones and acorns away from the parent tree (Smallwood et al. 2003). Predators of western gray squirrels include red-tailed hawks, northern goshawks, golden eagles, coyotes, bobcats, fishers, and house cats (Carraway and Verts 1994; Zielinski et al. 1999; Vander Haegen et al. 2005).

Western gray squirrel species description

Western gray squirrels (*Sciurus griseus*) are mammals of the order Rodentia, suborder Sciurognathi, and family Sciuridae. *S. griseus* has uniformly silvery-gray fur on its back and white fur on its belly. It also has large ears and a long, plumose tail (Bailey 1936; Hall 1981). *S. griseus* has a body length (not including the tail) of 265-323 mm and a tail length 240-309 mm (Crase 1973; Ingles 1965; Nelson 1899). Mass may be between 520-942 g (Crase 1973; Hall 1981; Ingles 1965).

Western gray squirrel behavior

S. griseus is mostly arboreal and tends to be wary (Cross 1969). Spherical stick nests (shelter nests), platform stick nests, and cavity nests are used by western gray squirrels as predator protection and shelter (VanderHaegan et al. 2004), in addition to being a location to raise young. *S. griseus* spherical stick nests consists of a few concentric layers with the largest sticks on the outside and sequentially smaller and insulating layers lining the inside (Merriam 1930; Cross 1969). Western gray squirrels tended to select larger diameter trees, interconnected canopies, and trees with mistletoe when making nests in Black Canyon in the lower Methow Valley, Washington (Gregory et al. 2010). Western gray squirrels are active year round. Their activity peaks a couple hours after sunrise (Cross 1969), and is documented to change seasonally in the North Cascades area during winter months (per comm. Katy Stuart). When disturbed, western gray squirrels may "freeze" in place. If the danger does not seem high, they may bark, "chewnnk-chewnnk-chewnnk", while foot-stamping and tail-flicking (Cross, 1969; Ingles 1947). However they are more known to be a quiet and passive squirrel species, often times not making any sounds; this is evident in comparison to the vocal red squirrel (*Tamiasciurus hudsonicus*) who inhabits similar habitat in Washington State (pers comm. Katy Stuart). Typically, western gray squirrels eat cones by cutting them off the tree, letting the cone fall, then retrieving the cone on the ground. Then, the squirrel will carry individual cones to a branch, hold the cone in its forefeet, and remove conescales to eat the pinenuts (Grinnel and Storer 1924). They are typically known to eat ponderosa pine and Douglas fir seeds in the North Cascades region (pers. comm. Katy Stuart; Gregory 2005).

Gaps in knowledge of the North Cascades population of western gray squirrels

The North Cascades population and ecosystem differ from the populations and habitats other remnant populations of western gray squirrels in Washington State. The North Cascades population inhabits the northern-most extent of the western gray squirrel's range, which lacks oaks, is a primarily dry forest ecosystem, and experiences harsher winters (Gregory et al. 2010). The least is known about the North Cascades remnant population of western gray squirrels

compared to the Puget Trough (Fimbel & Freed 2008; Ryan & Carey 1995; Vander Haegen et al. 2007; Vander Haegen and Orth 2009) and South Cascades populations (Cornish et al. 2001; Linders et al. 2004; Vander Haegen et al. 2004; Vander Haegen et al. 2005). The South Cascades population occurs where oak and pine forests merge (Linders and Stinson 2007); the Puget Trough population occurs in areas primarily of Oregon white oak and Douglas-fir (Linders and Stinson 2007). Acorns make up much of the western gray squirrel diet in the South Cascades and Puget Trough (Verts and Carraway 1998). The North Cascades ecosystem lacks oaks and the western gray squirrels occur in ponderosa pine and Douglas-fir forests (Bartels 1995; Gregory 2005; Hamer et al. 2005). The North Cascades population of western gray squirrels experiences a much harsher winter than either the Puget Trough or South Cascades population (Table 1). The northern habitat of the North Cascades population (our focal region) is colder and snowier in the winter than the southern region of the North Cascades, Puget Trough, or the South Cascades ecosystems.

Within the North Cascades population, the southern extent of the western gray squirrel population has received attention over the last decade (Gregory 2005; Hamer et al. 2005; Gregory et al. 2010; Bartels 1995; Bartels 2000), however little is known about the western gray squirrels inhabiting the northern portion of the North Cascades. The Methow Valley is located in this area. It is composed of approximately 75 percent coniferous forest and 14 percent shrub steppe. As part of the coniferous forest, four percent of the Methow Valley is ponderosa pine forest which may provide the best western gray squirrel habitat. The upper Methow Valley has an average minimum temperature of -12.0 °C in January and an average maximum temperature of 30.4 °C in July. This region also has an average annual precipitation of 36 cm and an average total annual snowfall of 180 cm (104-yr averages; Western Regional Climate Center 2010). The southern area of the North Cascades population, where the majority of previous work has been conducted (lower Methow Valley), has an average minimum temperature of -8.4 °C in January and an average maximum temperature of 31.3 °C in July. This region has an average annual precipitation of 32 cm and an average total annual snowfall of 108 cm (40-yr averages; Western Regional Climate Center 2010). In contrast, the Puget Trough area has an average minimum temperature of 2.2 °C in December and an average maximum temperature of 25 °C in August. Average annual precipitation in the Puget Trough is 100 cm and average total annual snowfall is 1 cm (28-yr averages; Western Regional Climate Center 2010). The South Cascades region has an average minimum temperature of -4.9 °C in January and an average maximum temperature of 29.8 °C in August. The average annual precipitation in the South Cascades is 44 cm and the average total annual snowfall is 65.3 cm (105-yr averages; Western Regional Climate Center 2010). Understanding more about western gray squirrels in the upper Methow Valley will aid in the effectiveness of recovery efforts for squirrels living in this unique habitat at their northern-most distribution.

Table 1. Regional differences in climate for western gray squirrel habitats based on weather logging stations.

Region	City	Avg. Minimum Temperature (°C)	Avg. Maximum Temperature (°C)	Avg. Annual Precipitation (cm)	Avg. Total Annual Snowfall (cm)	# of Years Averages Are Based On
North Cascades	Winthrop	-12	30	36	180	104
North Cascades	Methow	-8	31	32	108	40
North Cascades	Stehekin	-5	28	87	314	104
South Cascades	Goldendale	-5	30	44	65	105
Puget Trough	Tacoma	2	25	100	1	28

Study objectives

The primary objective of this study was to determine regions used by western gray squirrels in the northern-most portion of their range to aid in their recovery. The upper Methow Valley has different ecosystem qualities than the other areas where much of the research has been conducted on western gray squirrels. Therefore, increasing the knowledge base of this northern-most extent of the species distribution will provide needed information to help in recovery efforts where western gray squirrels experience a different habitat that lacks oaks and has harsher winters. We focused our efforts on the upper Methow Valley to cover a larger area and add to previously gathered western gray squirrel distribution sampling data from Okanogan County from 2006-2009 by the Washington Department of Fish and Wildlife (Figure 2). Survey areas were chosen within habitats dominated by ponderosa pine habitats.

Education and outreach are essential goals of the western gray squirrel project. Beginning in 2010 PBI has sponsored workshops and media events to share information with the public. Community outreach to engage volunteers, landowners, and the public was also a large component of this western gray squirrel project. Our study is unique in two ways. We concentrated our survey efforts in the northern part of the Methow Valley where information is least available and we utilized volunteers to set up and conduct the study. The use of volunteers allowed more locations to be monitored over a larger area than would have been possible without volunteer participation. The northern part of the Methow Valley was chosen because it has not yet received systematic squirrel surveys despite having high quality ponderosa pine habitat. We conducted a hair-sampling tube distribution survey to determine western gray squirrel occurrence, in addition to recording nest and sighting information. Because the western gray squirrel is vulnerable to habitat loss and low genetic diversity, a better understanding of areas where they occur is needed to help managers protect critical habitats.

In addition, we engaged in a related comparison trial of different sampling tube diameters and lengths. This study was begun after discovering damage to some sampling tubes caused by squirrels nibbling the tubes. The purpose of this study was to determine the most efficient tube design for collecting hair samples. In this study we also used a motion triggered remote video cameras at sample tube test locations to observe squirrel behavior as they interacted with the various types of comparison hair tubes. The resulting videos also became useful as a tool for education and outreach for this project.

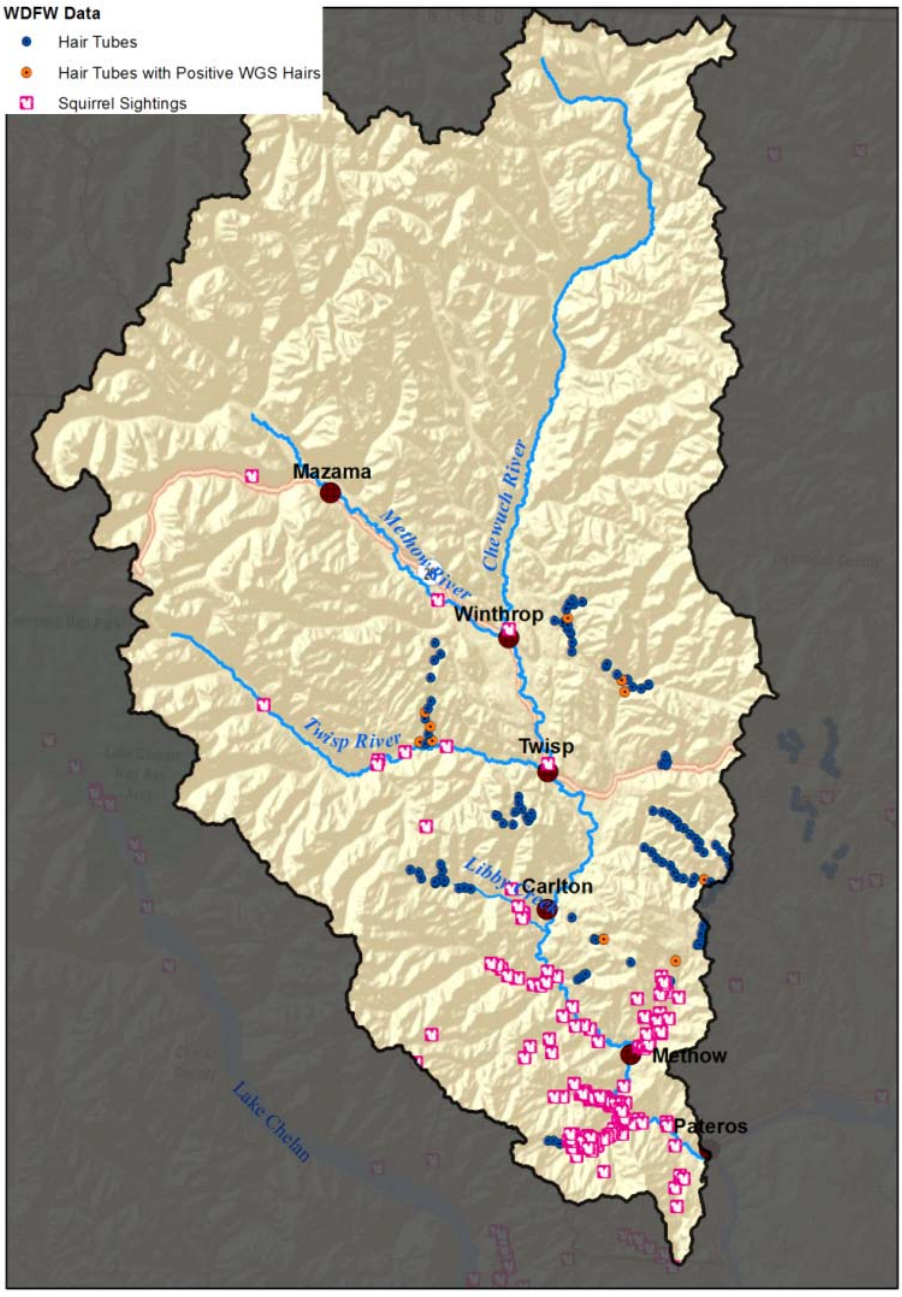


Figure 2. Western gray squirrel hair-sampling tube distribution survey from 2006-2009 by the Washington Department of Fish and Wildlife (WDFW) and historical sightings in Okanogan County.

METHODS

Community education on western gray squirrels

Pacific Biodiversity Institute (PBI) provided several education and outreach opportunities for Methow Valley community members where the public could learn more about western gray squirrel identification, status, threats, and conservation needs. Attendants were provided with identification guides and background information (Figures 3, 4). Community education was conducted through: i) newspaper articles seeking volunteers and any western gray squirrel sighting information, ii) involving volunteers and private landowners in conducting the western gray squirrel distribution surveys, and iii) a public talk open to community members interested in learning more about western gray squirrels and specifics of our project. We were interested in informing landowners about stewardship of the squirrels throughout the valley, since the increased knowledge may lead to greater interest in managing the landscape for western gray squirrels. Additionally, we encouraged community members to report western gray squirrel sightings and locations, especially if they were hit on the road.

Methow Valley Squirrel Types

Tree squirrels

Red squirrel

Western gray squirrel

Ground squirrels

Yellow-pine chipmunk

Townsend's chipmunk

Yellow-bellied marmot

Hoary marmot

Columbian ground squirrel

Cascade Golden-mantled ground squirrel

Flying squirrel

Northern flying squirrel

Figure 3. Squirrels and squirrel-like rodents of the Methow Valley.

		
• Head and body = 9-12 inches • Tail = 10-12 inches • Large, gray body, bushy tail, white belly with solid border • Tends to be quiet	• Head and body = 6-8 inches • Tail = 4-6 inches • Small, rust-red to grayish-red body and tail, white or grayish white belly • Noisy, aggressive and territorial	• Head and body = 9-12 inches • Tail = 7-9 inches • Body has rufous color on face, back and tail, ears are shorter, tails are narrower • frequently seen in urban areas

Figure 4. General differences between western gray squirrels (left), red squirrels (middle) and eastern gray squirrels (right).

Utilizing volunteers to monitor western gray squirrels in the upper Methow Valley

PBI sought volunteers to assist with western gray squirrel surveys in the Methow Watershed during the field season (March-October). Local volunteers, including some landowners with western gray squirrel habitat on their property, were involved in conducting distribution and nest count surveys.

Hair-sampling tubes for distribution surveys

Hair-sampling tubes were used to study the distribution of western gray squirrels between March and October. This methodology has been previously used in western gray squirrel studies to determine presence at specific locations (Fimbel & Freed 2008; Vander Haegen & Orth 2009). This is a low cost, noninvasive sampling technique, which allows for more sites to be monitored compared to other sampling techniques such as trapping. If a hair-sampling tube is positive for western gray squirrels, we can conclude that a western gray squirrel was in the area, but we cannot determine whether this region is part of the squirrel's home range territory or if it was a dispersing individual. Similarly, hair-sampling tubes do not allow us to quantify squirrels in an area or determine western gray squirrel densities. Additionally, if hair is not collected in a hair-sampling tube, we cannot conclude that there are no squirrels in the area; the squirrel may not have found the hair-sampling tube and entered it.

Sampling tubes were constructed with the aid of volunteers (Figure 5). The hair-sampling tube is a 7.6cm diameter, 45.7cm long pipe of black ABS within which we glued (important to use nontoxic) one English walnut in the center of the tube to the inner wall. The walnut is glued to the "bottom" of the tube (side to be placed on the ground).

Sanding edges and drilling holes

Adding walnut, hardware, & sticky tape

Finished hair-tube

Hair-tube deployed

Figure 5. Construction of sampling tubes by volunteers in 2010.

Alternative tube designs were tested during the 2011 season (Appendix B). On the opposite inner wall of the tube (top), approximately 3.8cm from the ends, flat aluminum bars (5.8 x 2.5cm) were secured into place with nuts and bolts. The metal bars were covered with a double-sided sticky tape (3M Double-Sided Foam Tape, 0.2 cm thick & 2.5cm wide). The walnut lures the squirrel into the tube and as it walks through, the squirrel will leave back and/or tail hair on the sticky tape. Each tube had a unique number associated with it to help keep track of individual tubes, which are recorded on each photopoint with number cards. Each location was given a unique identifying code. Each location could have different tubes at different times, since tubes were switched out during the sampling season.

Hair-sampling tubes were placed at the base of a tree and the tree was flagged to aid in relocating it. Surveyors double-checked that the hair-sampling tube was placed flat with the sticky tape on top, walnut on bottom, and that both open ends of the tube were not obscured (Figure 6). Since the squirrel must enter the tube to reach the inner walnut and leave a hair sample, surveyors prevented the hair-sampling tube from moving by securing it with natural materials such as rocks and wood. One loose bait walnut was placed outside the tube by both openings (two walnuts total) to get the squirrel acclimatized to walnuts and to aid in luring the squirrel into the tube to get the third walnut. GPS locations were recorded for mapping and to help find the tube during revisits. Volunteers recorded the hair-sampling tube GPS location and site information, including drainage, dominant overstory, and dominant understory. Volunteers were advised in deciding where to place the hair-sampling tubes.

Previous studies in the lower Methow Valley had concluded that large diameter ponderosa pines, interconnected canopy, and an open understory were favored by western gray squirrels (Gregory 2010). Therefore, volunteers were directed to place hair-sampling tubes in areas with these preferences in mind. Volunteers were also trained to identify squirrel signs such as cut cones, cone scales, and dig holes to aid in finding potentially favorable squirrel habitats to place hair-sampling tubes. However, criteria were not strict since all preference criteria were difficult to meet, it can be difficult to tell the difference between red squirrel and western gray squirrel signs in the area, and we were not sure whether known habitat and behavioral preferences based on research conducted in the lower Methow Valley would be the same for squirrels in the upper Methow study area.

Hair-sampling tubes were placed on both public and private lands. Hair sampling tubes were only placed on private land after written permission was granted. Hair-sampling tubes were placed at least 200 m apart and checked every three to four weeks to determine whether hair was collected on the sticky tape. Data collected during hair-sampling tube checks include: date deployed, date checked, observers, tube status, whether hair was collected, tube action, and notes. Additional data collected included whether the hair-sampling tube looked disturbed (e.g., rolled) and whether walnuts were missing or present (Appendix A). We replaced bait walnuts if they were missing. If hair was detected, the hair-sampling tube was removed and a replacement hair-sampling tube was put in the exact same place to replace it. Additionally, during each check, the stickiness of the sticky tape was checked and if it feels less adhesive, the tape was replaced by attaching another tape layer to the metal bar (up to three layers).

Figure 6. Diagram of deploying hair-sampling tubes by western gray squirrel distribution study volunteers.

The hair collected was visually analyzed to determine what animal it was from. The tape was removed from the aluminum bars and examined under a dissecting microscope at 30x magnification. Hair color patterns and hair size were used to categorize the hair into the

following categories: western gray squirrel, red squirrel, yellow-pine chipmunk, or unknown. We compared our hair sample collected from the tubes with back, tail, and belly/chin hair collected from road-kill specimens. Hair samples were categorized by two people to reduce observer bias. We documented tube number, date, and location for each hair sample collected. Throughout the field season, GIS maps were updated with hair-sampling tube locations with and without western gray squirrel hair. Data forms were entered into a Microsoft Access Database. Sampling location coordinates recorded in the database were compared with those of GPS waypoints in order to ensure the data was correctly located.

Western gray squirrel sightings

In addition to utilizing hair-sampling tubes to determine western gray squirrel distributions in the upper Methow Valley, volunteers were asked to record any visual sightings of western gray squirrels (Appendices B & C). If a positively identified western gray squirrel was sighted, location notes were recorded along with whether it was an adult male, adult female, subadult, unknown, or young of year, time of detection, and behavior (i.e., nest building, perched on tree, perched in nest, perched on ground, perched on rock or stump, copulating, vocalizing, foraging, aggressive, defensive, courtship, excavating, playing, feeding, running on ground, and/or climbing in tree). All sightings were also entered onto Washington Department of Fish and Wildlife, Wildlife Observation Forms to be added to the WDFW Heritage database.

Western gray squirrel nest surveys

Nest detection indicates that an area was occupied by western gray squirrels. In 2010 we used the Black Canyon study area in the lower Methow Valley, where nests are known from radio-telemetry data (Gregory 2005), to test our methodology and nest identification skill. During our nest surveys, we systematically searched for western gray squirrel nests to gain information about areas that western gray squirrels occupy. Nest searches were conducted in areas where confirmed western gray squirrels have been sighted or positive western gray squirrel hair was collected in hair-sampling tubes this field season.

The procedure for conducting detailed nest surveys is as follows. First, we created a map of the target location with the best potential habitats clearly identified. We determined an approximate layout of nest search survey transects. Nest searchers stood 20-30 m apart (marked by paces) in a line, abreast, and in view of one another. Each person used a two-way radio for communication between observers. Nest searchers on either end of the search transect took a starting GPS reading. Nest searchers walked along a transect or contour of a steep slope using a compass bearing. Nest searchers walked for approximately five minutes while looking for nests and stopped for a more detailed search with binoculars (looking around 360 degrees) for one minute systematically, or a detailed search was coordinated via walkie-talkies when potential nest trees or complicated canopy was encountered. During this detailed search, nest searchers also realigned themselves. One person in the middle of the search line announced on the walkie-talkies when one minute of detailed searching had ended and the walking search continued. When a nest was located, all nest searchers marked their location (visually or with temporary flagging) and gathered to collect nest data and fill out vegetation sampling forms describing forest structure and habitat condition of the area. Nest searchers returned to their previous locations to resume the nest survey. Survey results are recorded on a form. Once a nest was found, the GPS locations were recorded.

Beginning in 2011, nest surveys were only conducted in areas where squirrels were located with sampling tubes during the field season. These surveys were less intensive and involved observers walking around the area where squirrel activity was observed while scanning the tree canopies

for nests. One nest survey was conducted by tracking squirrels in fresh snow during late winter to locate the nest.

COMMUNITY EDUCATIONAL ACTIVITIES AND VOLUNTEER INVOLVEMENT

2010 community education activities

We had a community field day on March 20, 2010 for training in western gray squirrel identification, survey methods, ecology, and conservation measures. The field day was attended by several dozen volunteers and members of the public.

Articles about the project were printed in the Wenatchee World newspaper and Methow Valley News. On October 5, 2010, we presented an hour and a half PowerPoint presentation in the Methow Conservancy First Tuesday Lecture Series at the Twisp Grange. This Methow Conservancy lecture series invites speakers to discuss nature-related topics of interest to local community members. For the talk, we partnered with Katy Stuart, a University of Washington graduate student working on western gray squirrels in the Squaw Creek watershed (lower Methow Valley) and Stehekin (adjacent to Lake Chelan in the lower Methow Valley).

There were approximately 50 people in attendance; we presented information on squirrels, adaptations, their ecological diversity, and specifically about the North Cascades western gray squirrels and their unique habitats found in the region.

Stuart presented her research and preliminary findings, while PBI presented their project scope and findings. Hands-on examples of western gray squirrel sampling equipment (radio collars, traps, and hair-sampling tubes) were on display, along with a WDFW western gray squirrel study skin, and hair samples of different small mammals for comparisons to the species of interest.

2011 community education activities

To provide information about western gray squirrels, Pacific Biodiversity Institute continually updated its website with a western gray squirrel project page (www.pacificbio.org/initiatives/wgs/gray_squirrel_background.html), volunteer advertisement (www.pacificbio.org/helpout/volunteer-western-gray-squirrel.html), and page for volunteers to access data sheets and sampling guides (www.pacificbio.org/initiatives/wgs/wgs-volunteer-page.html). These web pages link to videos we made showing western gray squirrel behavior.

Workshop activities were described on our website at http://www.pacificbio.org/initiatives/wgs/wgs-workshop-2011-june04.html. A gallery of notable photographs from the 2011 field season was documented in a photo gallery at http://www.pacificbio.org/initiatives/wgs/year-in-photos/index.htm.

Volunteers and the public attended an end of year get-together at the Pacific Biodiversity Institute on Thursday, December 1, to celebrate the 2011 western gray squirrel research season.

2012 community education activities

In spring of 2012, PBI's western gray squirrel study was the subject of a story in the Methow Valley News. This article also notified the public of upcoming field workshops.

2010 volunteer activities

On March 5, 2010, volunteers helped build 200 non-invasive hair-sampling tubes to collect hair that can be used to identify the species (Figure 4). Fourteen volunteers participated in a second workshop on May 5, 2011 to learn about gray squirrels and to reconstruct the hair-sampling tubes.

At the workshops, volunteers were trained how to recognize the difference between the more rare western gray squirrel and the common red squirrel (Figure 4), determine good habitat for the species, deploy and check non-invasive hair-sampling tubes, and help conservation of the North Cascade western gray squirrel population. Additionally, volunteers were trained to recognize the type of preferred habitat and visually identify western gray squirrel nests and signs (e.g., feeding, hoarding). In 2010 we used the lower Methow Valley Black Canyon study area as a control site, where ongoing studies have been conducted by WDFW and research studies were conducted by University of Washington graduate student Sarah Gregory in 2005, to test methodologies and nest identification skills. Once the volunteers had placed their first set of hair-sampling tubes, a PBI intern/volunteer went out to the tube locations to address any concerns community volunteers might have had and also suggested better and/or other locations to place hair-sampling tubes. The PBI intern/volunteer also regularly updated community volunteers on project progress and provided further assistance in the field when necessary.

During 2010, volunteers put in 1782 hours of time. A volunteer appreciation evening was held on November 4, 2010 at the Pacific Biodiversity Institute office to show appreciation to all volunteers involved in the western gray squirrel distribution study and to discuss their experiences working on the project.

2011 volunteer activities

In 2011, volunteer activities began at the Pacific Biodiversity Institute office on June 4. Workshop activities were similar to those of the 2010 workshop. The workshop included an introduction to the project, followed by a sampling tube reconditioning session, and then in the afternoon, a visit to a known squirrel activity center.

In 2011, fourteen volunteers put in a total of 1993 hours. On December 1, about 15 volunteers and members of the public attended an end of year get-together at the Pacific Biodiversity Institute to celebrate the 2011 western gray squirrel research season, to watch entertaining videos about western gray squirrels and to receive achievement awards.

2012 volunteer activities

We held a western gray squirrel field workshop on July 14 for interested public attendants and citizen science volunteers. This workshop emphasized the need to study gray squirrels in the context of ponderosa pine forests of the Methow Valley.

On November 29, we recognized the contributions of citizen science volunteers at an awards gathering at the Twisp Pub.

RESULTS

2010 Hair-sampling tube distribution results

In 2010, volunteers placed hair-sampling tubes in a total of 176 locations in the upper Methow Valley (Figure 7). Of the 176 locations, hair-sampling tubes from 17 locations collected western gray squirrel hair (Figure 8). Some of the hair-sampling tubes that were positive for western gray squirrel hair were concentrated in the same region, resulting in eight regions occupied by western gray squirrels. After comparing our distribution data with previously gathered data by Washington Department of Fish and Wildlife staff, we found that our study produced five new areas that previously were not known to have western gray squirrels (Figure 9).

Some locations collected hair on more than one occasion. We collected a total of 134 hair samples from tubes, 17 of which were western gray squirrel hair. 61 samples were identified as "unknown" since they were not comparable to our reference hair samples. Fifty five samples were identified as red squirrel, and 11 were identified as yellow-pine chipmunk. There appears to be no obvious patterns between western gray squirrel locations and red squirrel and/or yellow-pine chipmunk locations.

Six volunteers had both live and road-kill western gray squirrel sightings. One volunteer had three separate observations in the Benson Creek region. During his first sighting, the western gray squirrel was chased by a red squirrel down a ponderosa pine tree. A western gray squirrel was seen climbing a ponderosa pine and investigating a manmade structure previously used as a nest by a red squirrel. The third sighting involved two western gray squirrels running together. Also in the Benson Creek watershed, another volunteer regularly saw a western gray squirrel frequently visit his bird feeders. In the Libby Creek watershed, a volunteer saw a western gray squirrel climb down a ponderosa pine and eventually run down a hill. Within the Little Bridge Creek region, a volunteer observed a western gray squirrel foraging and running on the ground. Two separate sightings were made, also in the Little Bridge Creek region. A western gray squirrel was also seen by a volunteer running across a Highway153 near the town of Methow. During the span of this year's study, there were also four road-kill western gray squirrels brought in to our office and locations were recorded.

In 2010, nest surveys were completed in two separate areas. First, we conducted a nest survey in the Chewuch River drainage, where we had many hair-sampling tubes that had collected western gray squirrel hair. Within the nest search area, we found one nest that looked like it was not actively used based on the nest having gaps between structural branches and it lacked newer green or red pine needles and instead had black decomposed needles. Our second nest survey was conducted in the Benson Creek watershed where hair-sampling tubes had collected western gray squirrel hair and squirrels were observed on three separate occasions. During this nest search we did not find any nests.

2011 Hair-sampling tube distribution results

In 2011, we recorded 629 observations at 101 hair tube sample locations (Figure 7 and 9). There were also 17 sites where multiple tube designs were placed to study squirrel behavior.

There were five population centers in the seventeen sample locations containing western gray squirrel hairs Two of these locations were new sightings, located more than 500 meters from a previously known site.

In addition there were 55 samples recorded as red squirrel hairs, 11 samples recorded as yellow-pine chipmunk hairs, and 80 samples recorded as unknown species' hairs. The results of the 2011 surveys are displayed in Figure 10, along with the combined results from 2010 and 2012.

2012 Hair-sampling tube distribution results

In 2012, volunteers observed western gray squirrel hairs in 10 sites out of 186 sample locations (Figures 7 and 10). Four of these sites were new. The other six sites were located in a cluster where gray squirrels had been discovered earlier.

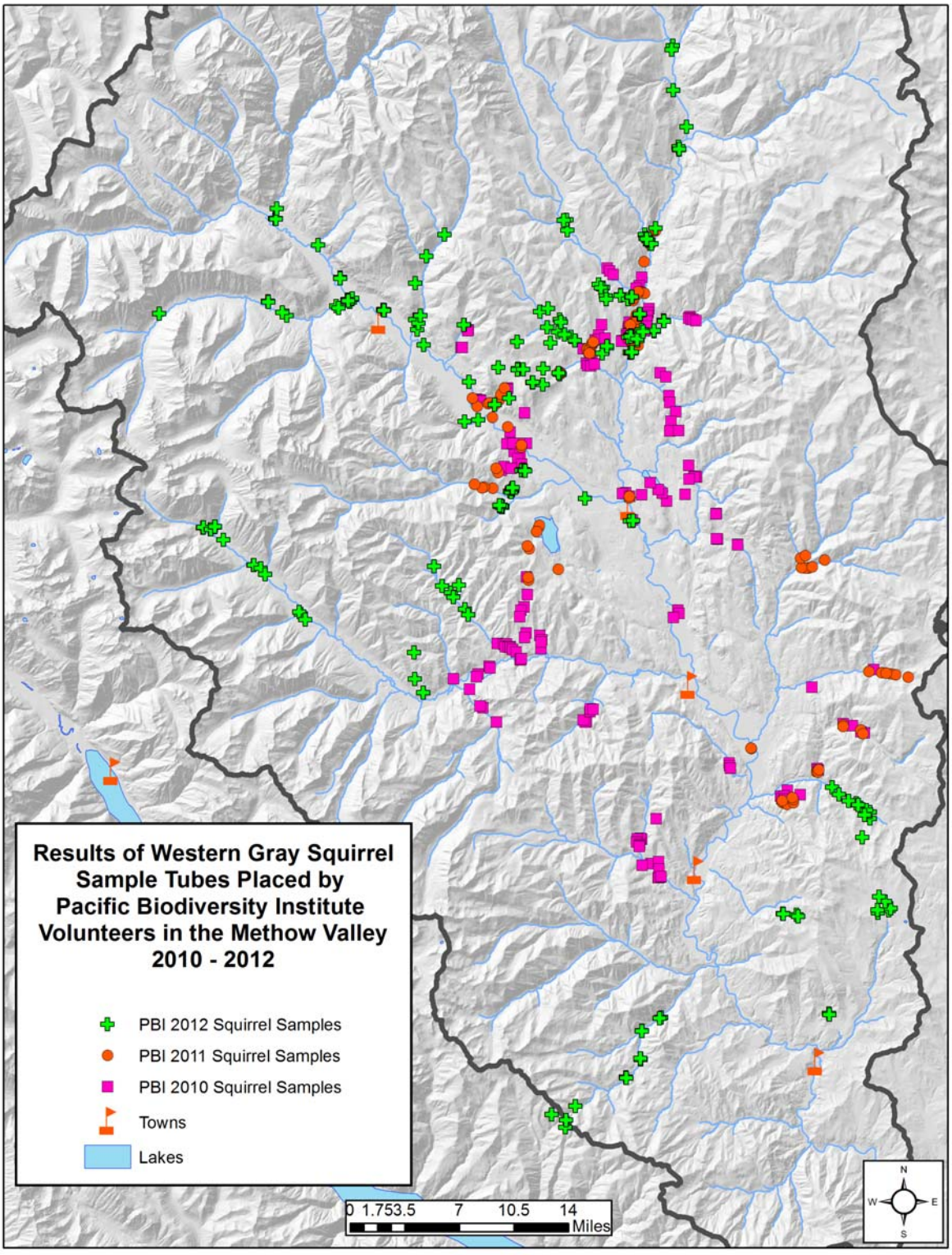


Figure 7. Pacific Biodiversity Institute volunteer hair-sampling tube locations placed from 2010 to 2012.

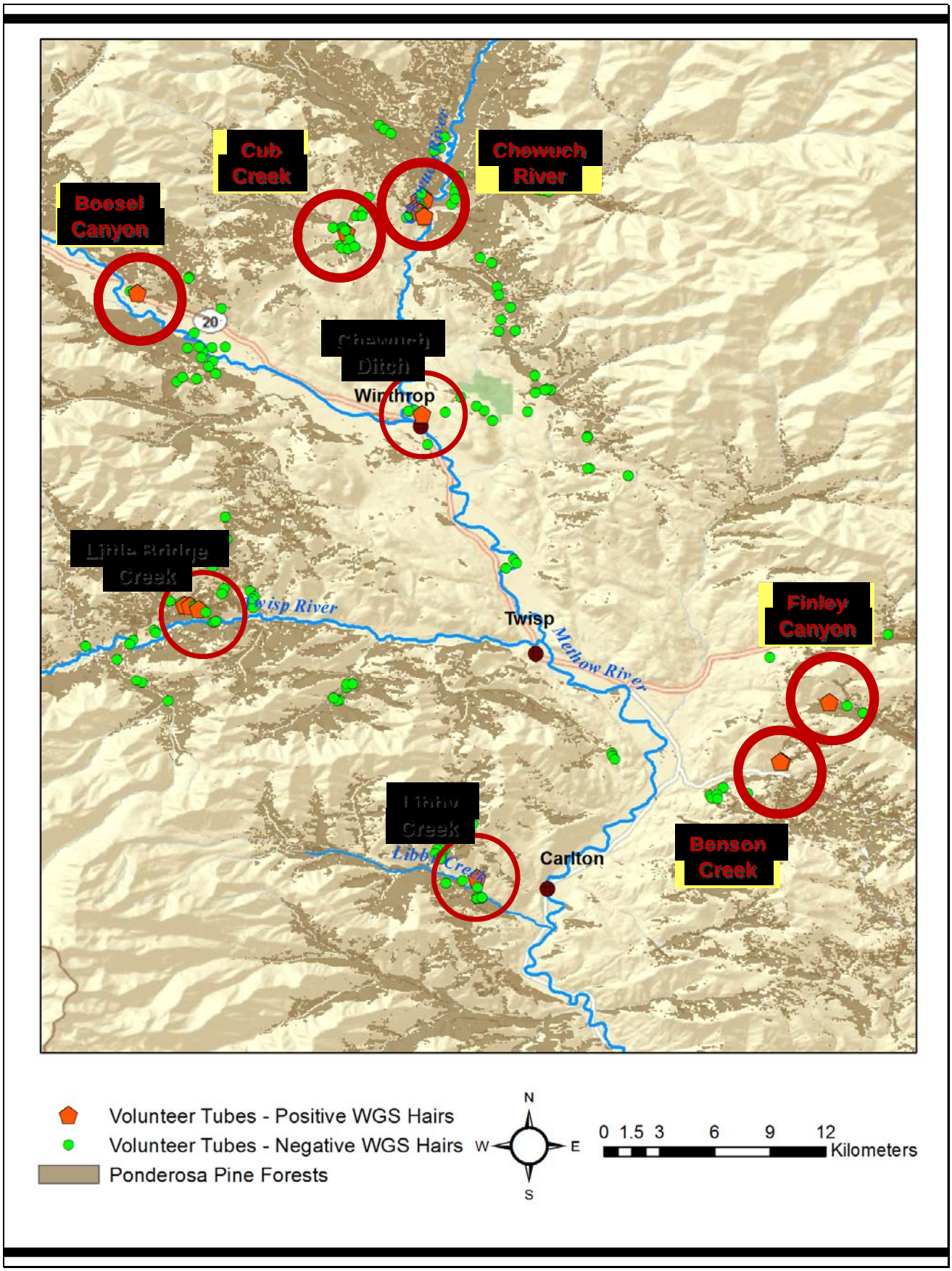


Figure 8. Pacific Biodiversity Institute volunteer hair-sampling tube locations from 2010 showing five new gray squirrel locations (thicker red circles) not previously known to have western gray squirrels (WGS).

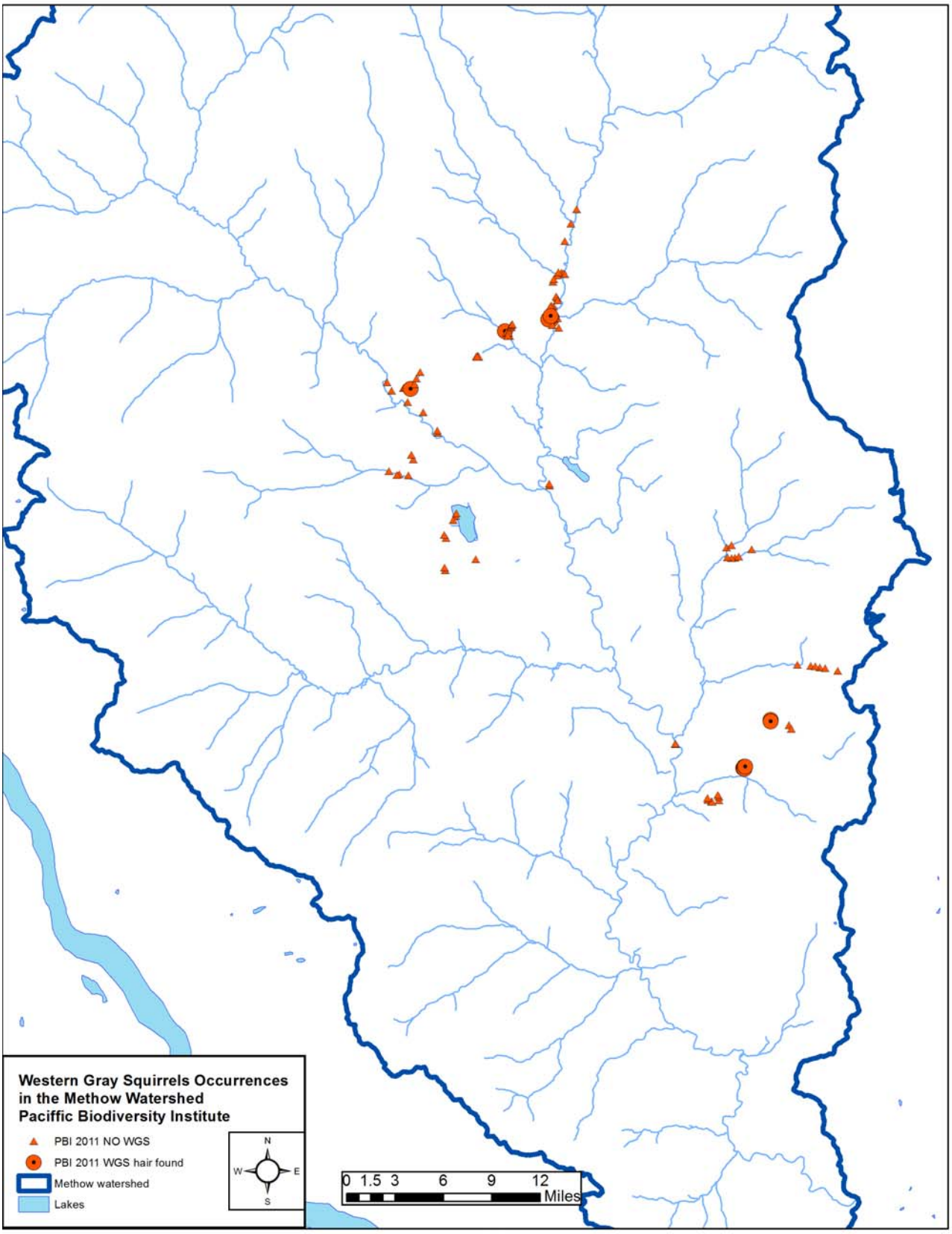


Figure 9. Western gray squirrel sampling tube results from 2011.

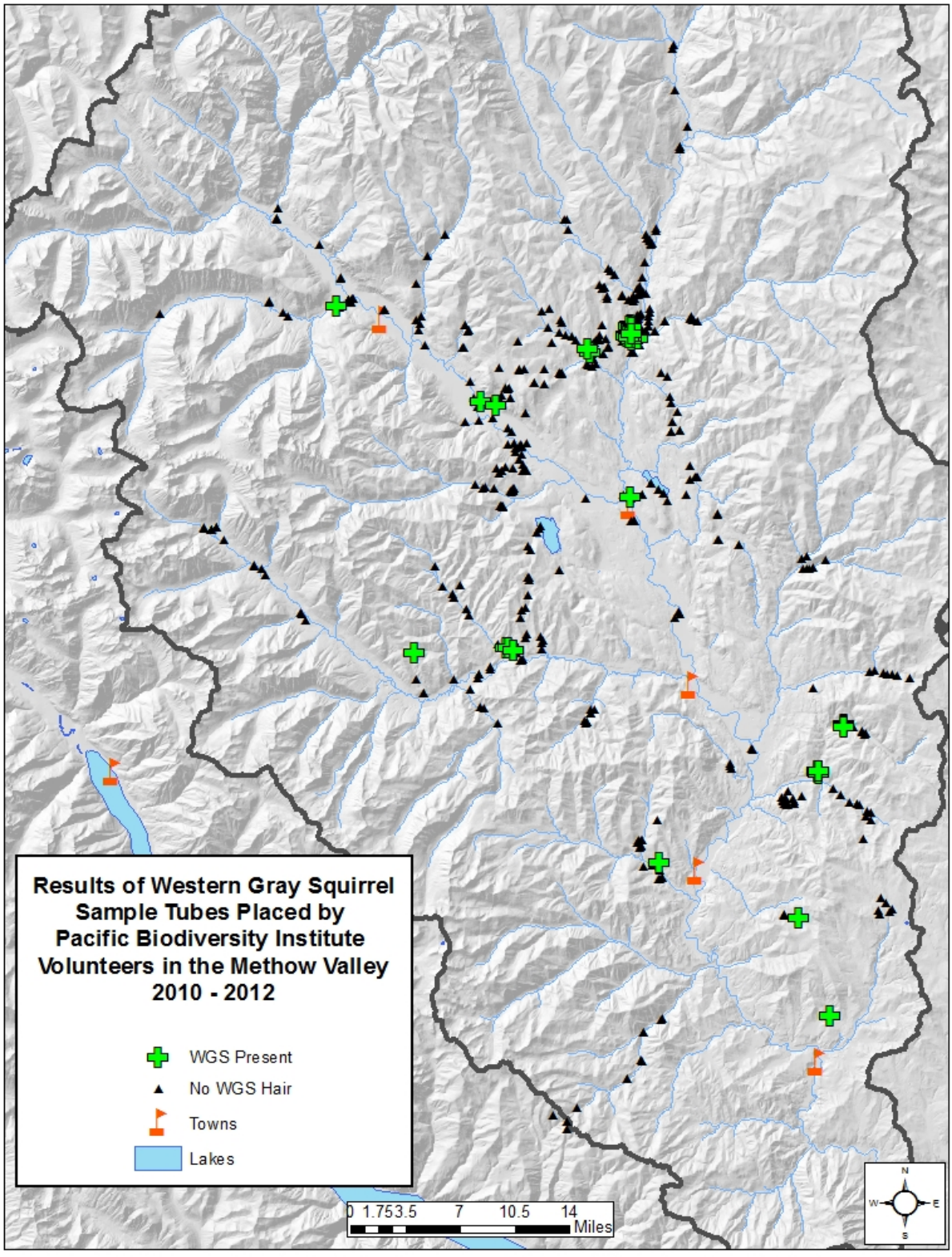


Figure 10. Pacific Biodiversity Institute volunteer hair-sampling tube locations showing sites where western gray squirrel (WGS) hair was collected for all years, 2010-2012.

DISCUSSION

Volunteer efforts

In 2010, we identified five new areas in the upper Methow watershed where western gray squirrels were previously not documented. Our findings expand the knowledge base for the northern range of known western gray squirrel distribution in the North Cascades. Volunteers were effective in deploying and checking hair-sampling tubes for western gray squirrel hair throughout the field season. They were confidently able to choose locations to place tubes in potential western gray squirrel habitats. Hair-sampling tubes baited with walnuts were effective in luring squirrels through the tubes, however we do not know to what extent they used the tubes based on their encounters. One tube placed by bird feeders on a volunteer's property allowed for visual observation of a western gray squirrel encountering the hair-sampling tube and immediately picking up one of the walnuts outside of the tube and running away with it. This activity was documented in photographs. A majority of the tubes did not collect western gray squirrel hair. While hair tubes are not used to determine density estimates, based on the numbers of tubes with western gray squirrel hair, the species does not appear to be in high densities in the upper Methow Valley. Additionally, throughout the field season (March-October), there were few reported western gray squirrel sightings, and even fewer nests found throughout the study area.

Hair-sampling tube techniques

Some interpretations cannot be made based on our hair-sampling tube distribution survey techniques. For example, since hair-sampling tubes were checked every three to four weeks, we were unable to differentiate whether multiple squirrels entered the tube, or only one. Similarly, we were unable to determine whether hair-sampling tubes in the same region that collected western gray squirrel hair were visited by the same individual or different squirrels. However, collected hair indicates that a squirrel was in the area, but we cannot conclude that this is part of their home range or whether they were dispersing through the area. In order to learn more about western gray squirrel home ranges in the upper Methow Valley, radio-telemetry data would be more effective. However, if a hair-sampling tube collects repeated samples of western gray squirrel hair over a several month period, this would provide evidence that the hair-sampling tube location may be part of an individual's home range that is used for a longer term. In contrast, if a hair-sampling tube only collects western gray squirrel hair once, but is never revisited over a long time period, we predict that the squirrel was dispersing through the area where the hair-sampling tube was placed. Hair collected for a period of time (e.g., two months) may indicate that the western gray squirrel has a seasonal residency in the area. Also, hair-sampling tubes located in areas that did not collect hair does not mean that squirrels are not present. We can only conclude that either they were not in the area, they were not familiar with the lure and therefore did not leave hair when they encountered a hair-sampling tube, or they did not encounter the tube even when in the area.

Western gray squirrel nest surveys

Based on our experience with western gray squirrel nest searches, we found that in the upper Methow Valley, walking nest searches may not be the most efficient method for finding nests. The upper Methow Valley appears to have a lower density of squirrels than other areas where similar walking nest searches have been conducted (Hamer et al. 2005). The ponderosa pines, Douglas fir trees, as well as abundant mistletoe growths all provide excellent cover to hide nests and therefore nests are likely to go unobserved by nest searchers. Additionally, the terrain is often steep in many areas of the upper Methow Valley. This slows down the walking pace,

which prevents coverage of large areas searched for potential low densities of well-hidden nests. Other western gray squirrel researchers (pers comm. Katy Stuart, Sarah Gregory) find nests most effectively by using radio-telemetry to follow radio-collared squirrels.

Future work

This study helped identify areas that western gray squirrels occupy in the upper Methow Valley and outreached to private landowners in areas where western gray squirrels were documented. Our findings provide data to local agencies and organizations to help protect western gray squirrels and their habitat during land management activities. We at Pacific Biodiversity Institute can now further our research in these particular areas to better understand how to protect this state-threatened species.

Potential western gray squirrel habitats to be surveyed

Pacific Biodiversity Institute aims to continue the same work to understand their distribution in the Methow Valley since they may occupy currently unknown areas (Figure 11). Additionally, we were limited on the number of hair-sampling tubes available to put in the field and there are areas within the upper Methow Valley that may not have been adequately surveyed. To address this, we have initially identified additional regions for a future hair-sampling tube distribution study by using aerial photography on GIS to identify areas with large ponderosa pines and Douglas fir trees. For example, Beaver Creek and Cub Creek would be good places to sample in future years because it is identified by local biologists and GIS aerial photography as excellent western gray squirrel habitat with large ponderosa pine and Douglas fir trees, and it has not been surveyed using hair sampling techniques.

Improvements in hair-sampling tube and other non-invasive sampling methods

We recommend that future hair-sampling tube sampling efforts consider leaving the tubes in place during the entire field season, regardless of whether positive hair samples are collected. The tubes should be checked every 2-4 weeks and a record of all the positive hair samples should be made. This will allow us to better determine if the squirrel(s) accessing the walnuts in the hair-sampling tube are residents or dispersers.

The use of remote wildlife cameras or video could help determine use patterns in areas where a positive hair sample was collected. A wildlife camera focused on the hair-sampling tube and walnuts could provide documentation of the amount of activity around a hair tube. Likewise, a camera positioned on a squirrel nest could record information about a squirrel's activity and use of a nest, as well as their travel from the ground up or canopy down into the nest. This would require tree climbing expertise.

Assessing habitats that western gray squirrels occupy

Pacific Biodiversity Institute wants to learn more about the habitat that western gray squirrels utilize. In areas where western gray squirrel hair was collected in hair-sampling tubes, sightings occurred, or nests were found, we initiated detailed habitat field surveys to accurately describe tree density and size, and plant community composition. Eventually, we will compare our findings among regions in the upper Methow Valley and between regions previously surveyed in the lower Methow Valley, the South Cascades, and Puget Trough to determine whether there are regional specific habitat preferences. Using GIS, we created habitat polygons around areas where western gray squirrels were present that appear to have similar forest structure (i.e., relatively uniform habitat conditions) based on aerial photographs. We also created polygons around habitats with relatively uniform conditions immediately adjacent to the polygon with

dissimilar habitat conditions containing the positive western gray squirrel hair-sampling tube or nest. These surrounding habitat types might also be utilized by western gray squirrels. Within each polygon, we created a fixed grid in GIS which identified equidistantly spaced sampling points. The GPS coordinates for these sampling points were recorded and we centered our detailed habitat surveys at each of these sampling points. At each sampling point, we used a basal area factor of 20 to sample trees and snags and recorded the tree species, height, and diameter at breast height for each tree within the variable radius plot. We also recorded the number of trees in smaller size categories (0-1, 1-3, 3-5 inch diameter trunks) and decay classes of dead trees within an 8.5 m radius plot. Additionally, we assessed the habitat plant associations for each polygon by walking through the polygon and characterizing the dominant trees, shrubs, and herb species and noting an estimated forest canopy cover to one of six Daubenmire cover classes. The percent cover classes of each in addition to percent cover classes of nonorganic habitat such as gravel. The polygon was also characterized by land-use impacts such as grazing and erosion. The labor-intensive methodology of these habitat surveys only allowed time for assessing five polygons in the Benson Creek watershed where there were frequent western gray squirrel sightings and two nests (Figure 12). One polygon was also characterized in the Chewuch River watershed. Future work includes surveying additional polygons in the Chewuch River watershed and other areas where western gray squirrels were determined to occur.

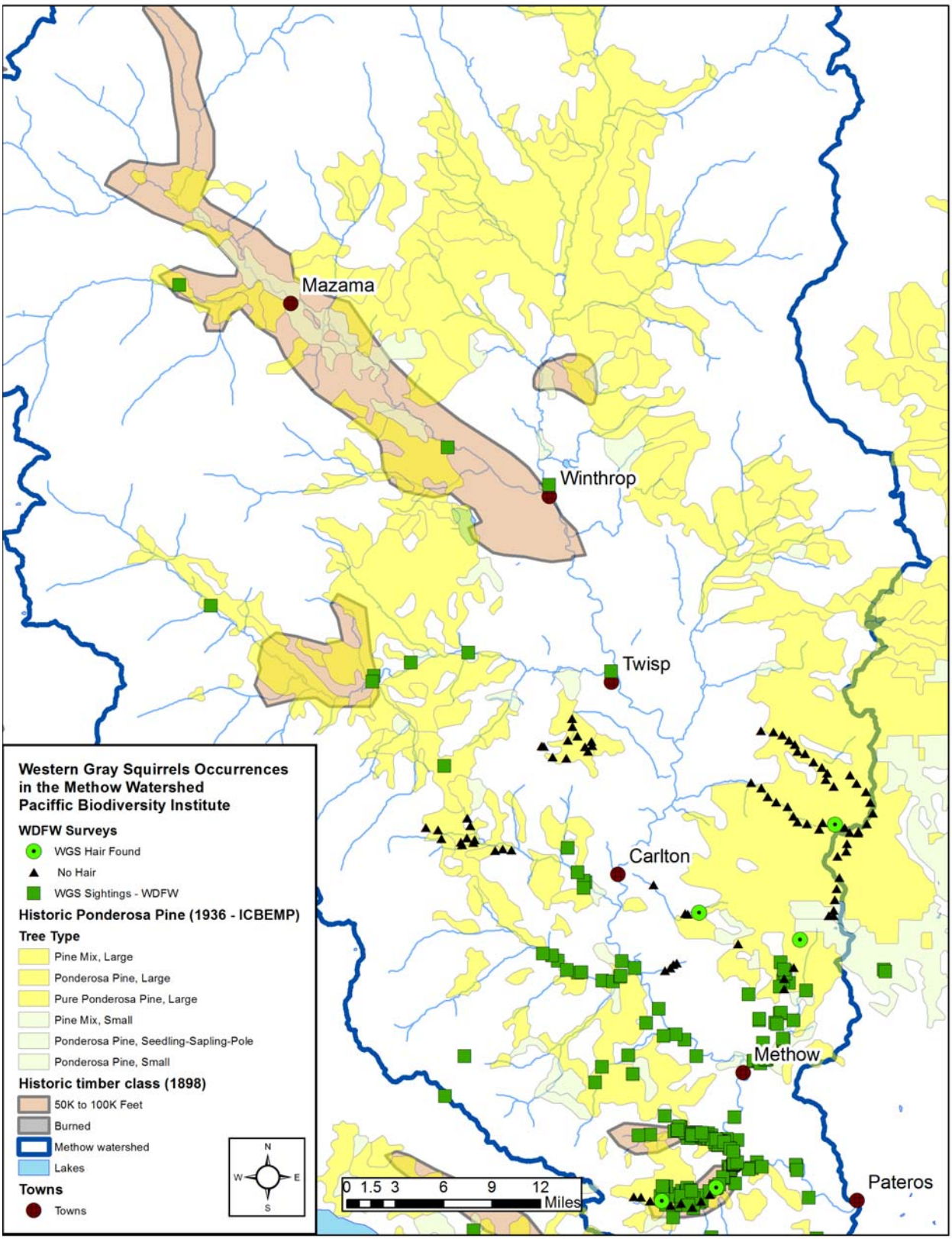


Figure 11. Study Area for western gray squirrel hair-sampling tube distribution survey overlaid on 1898 and 1936 maps of large timber and ponderosa pine habitats. Historical sightings and results of hair tube surveys conducted by WDFW are also shown. The 1898 map is from

Gorman. 1936 map is from the Interior Columbia Basin Ecosystem Management Project (Bureau of Land Management and Forest Service).

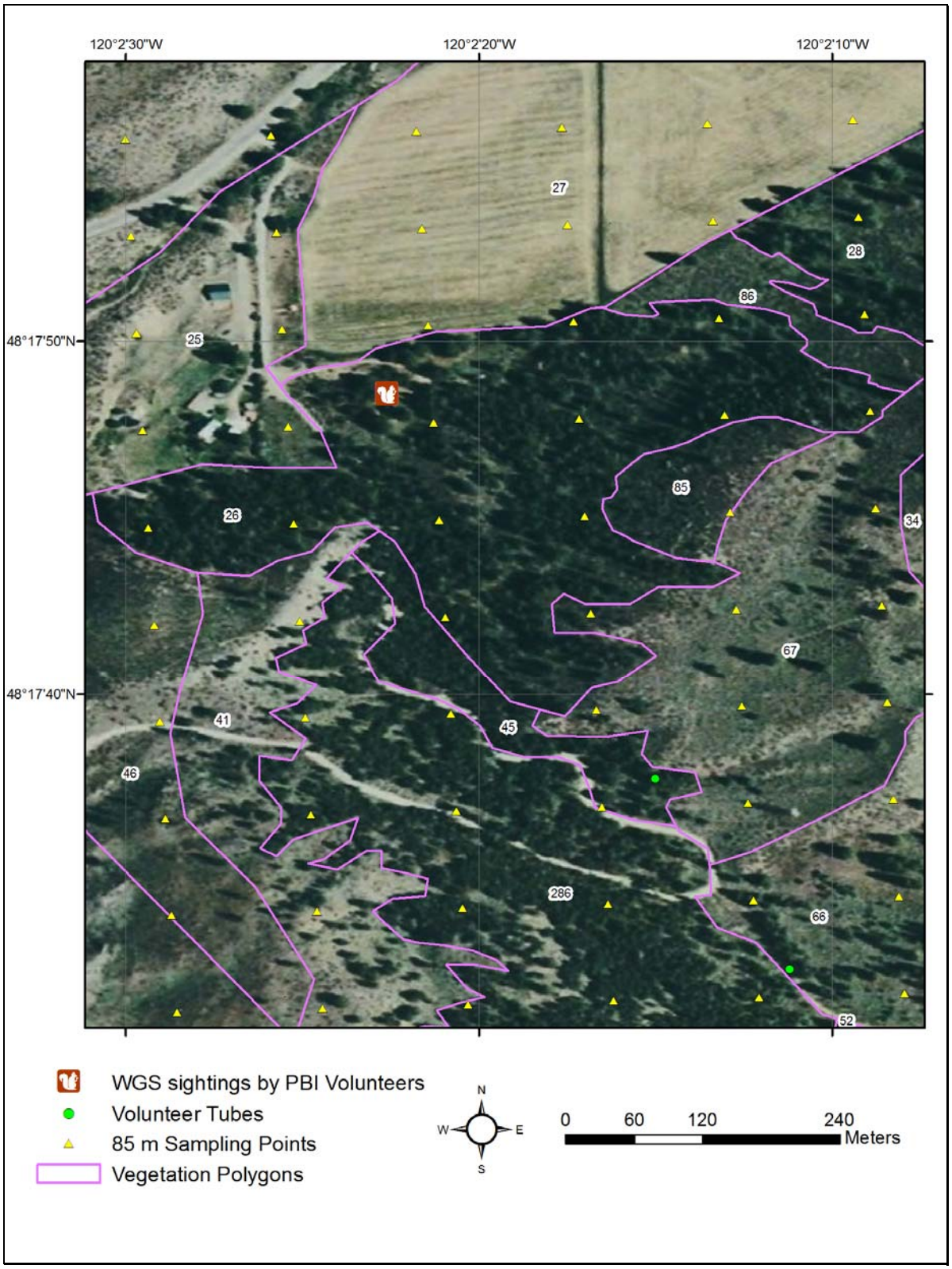


Figure 12. Vegetation polygons (purple outline) and sampling points (yellow triangles) for detailed habitat field surveys in the Benson Creek watershed.

Connectivity between areas occupied by western gray squirrels

Our findings of where western gray squirrels are distributed in the upper Methow Valley have generated questions of corridor connectivity between occupied areas, dispersal between these locations. Future work may concentrate on existing connectivity as corridors for western gray squirrels in the Methow Valley. These connections are vital to recovery efforts which aim to help maintain healthy populations of western gray squirrels since young squirrels disperse when they are weaned from their mother, males travel substantial distances to find females that are in estrous one day out of the year, and squirrels travel to find food resources (Linders & Stinson 2007). Corridors between individual gray squirrel home ranges and between source population centers are vital to increase genetic variability within a breeding population since low genetic diversity is a threat to western gray squirrels in Washington State (Linders & Stinson 2007). There may be potential movement corridors on larger (Figure 13) and smaller scales (Figure 14) between regions we have identified as occupied by western gray squirrels. Future studies can help determine whether individuals move along river riparian zones, or stay within ponderosa pine and/or Douglas fir forests. An effort could be made to determine large landscape connections, such as whether and how western gray squirrels disperse between major watersheds (e.g., between Lake Chelan/Stehekin and the Methow Valley, or between Okanogan Valley and the Methow Valley) (Figure 15). An example of dispersal was observed on June 17, 2000, when a western gray squirrel was observed at high elevations in open, whitebark pine forests along the Chelan-Sawtooth Crest (Morrison 2000, personal communication and WDFW Heritage sighting database).

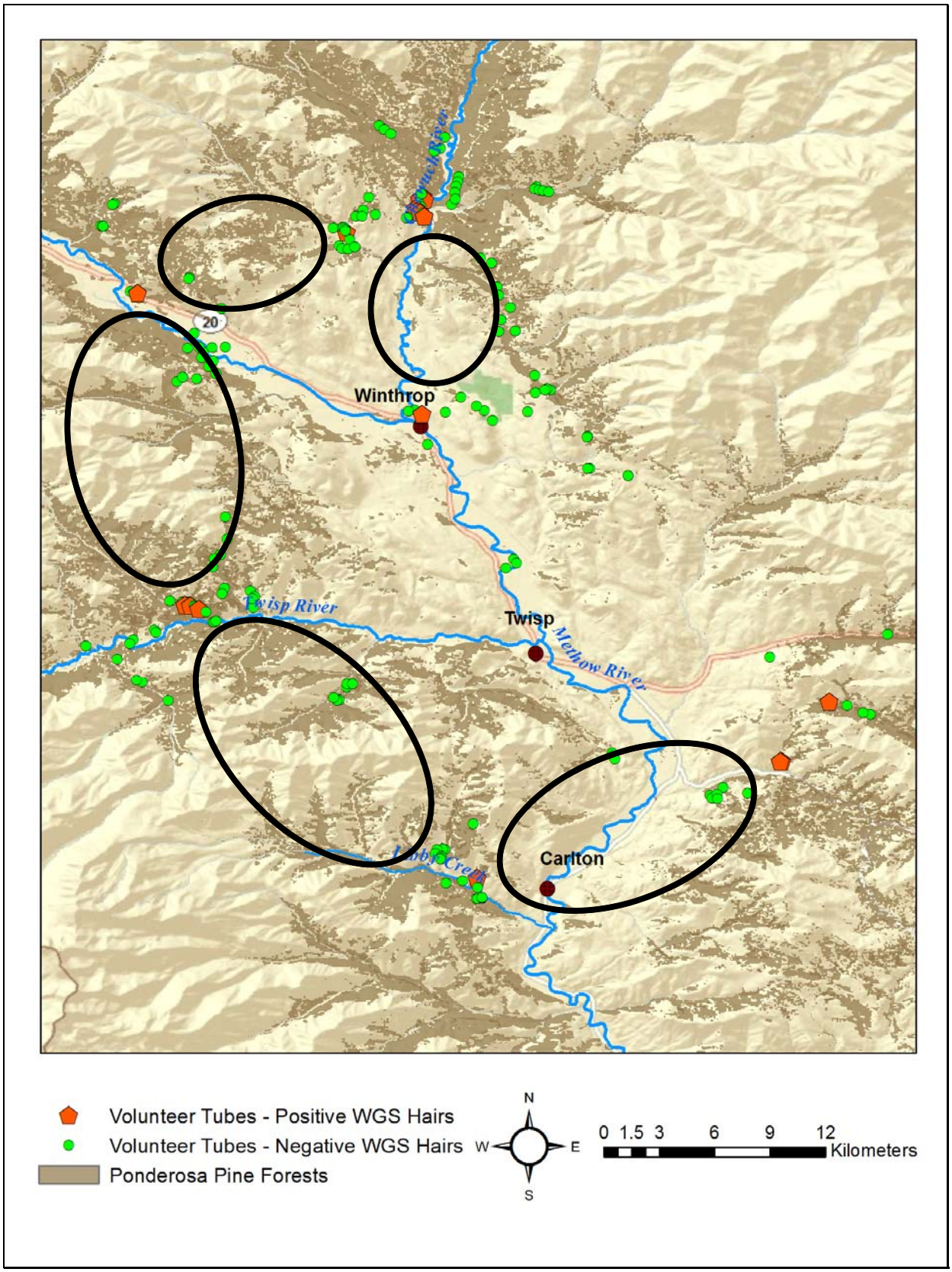


Figure 13. Potential corridors of connectivity (black ovals) between known western gray squirrel locations in the upper Methow Valley.

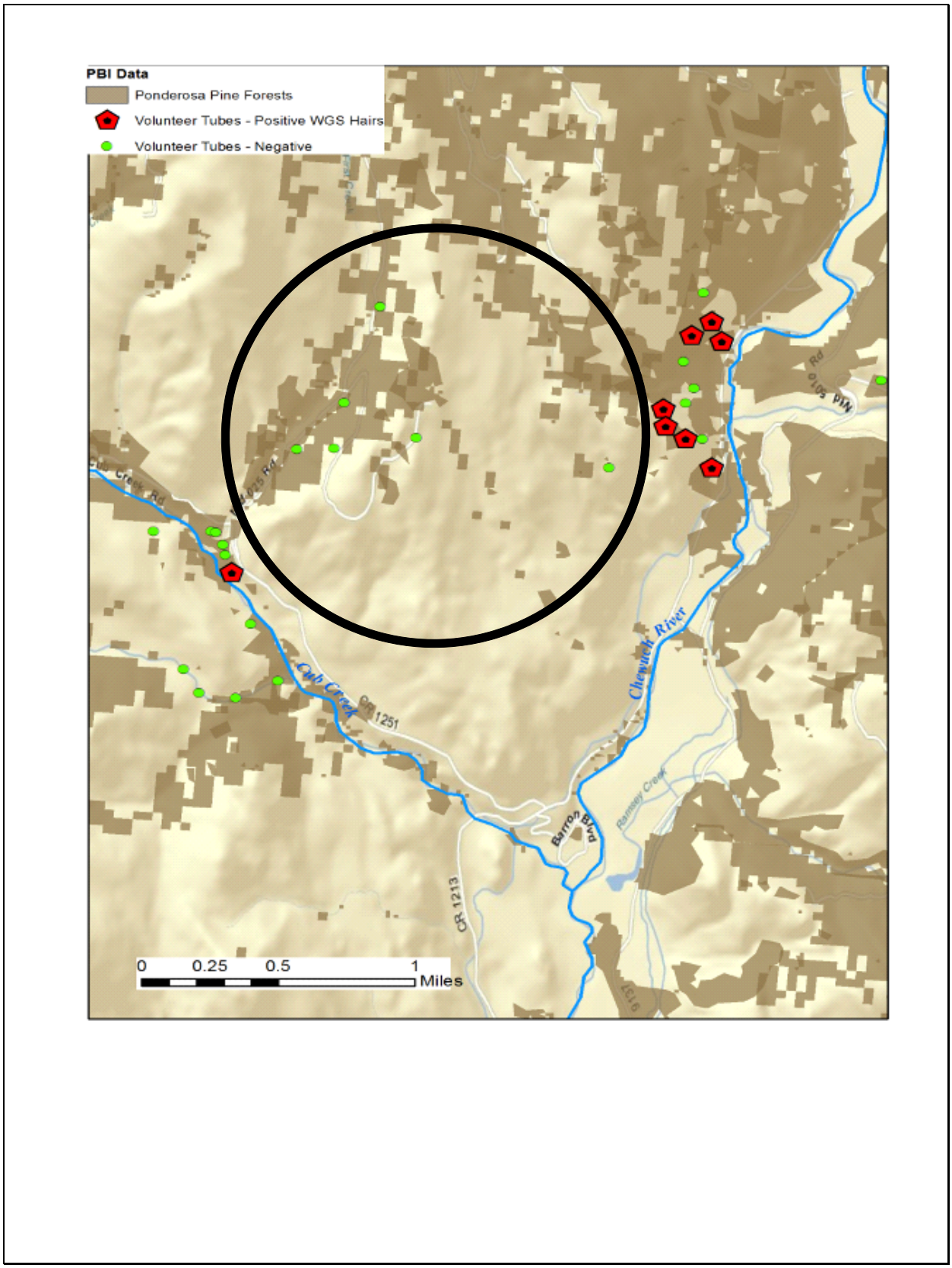


Figure 14. Potential corridor of connectivity (black circle) between western gray squirrel locations in the Chewuch River watershed and the Cub Creek watershed.

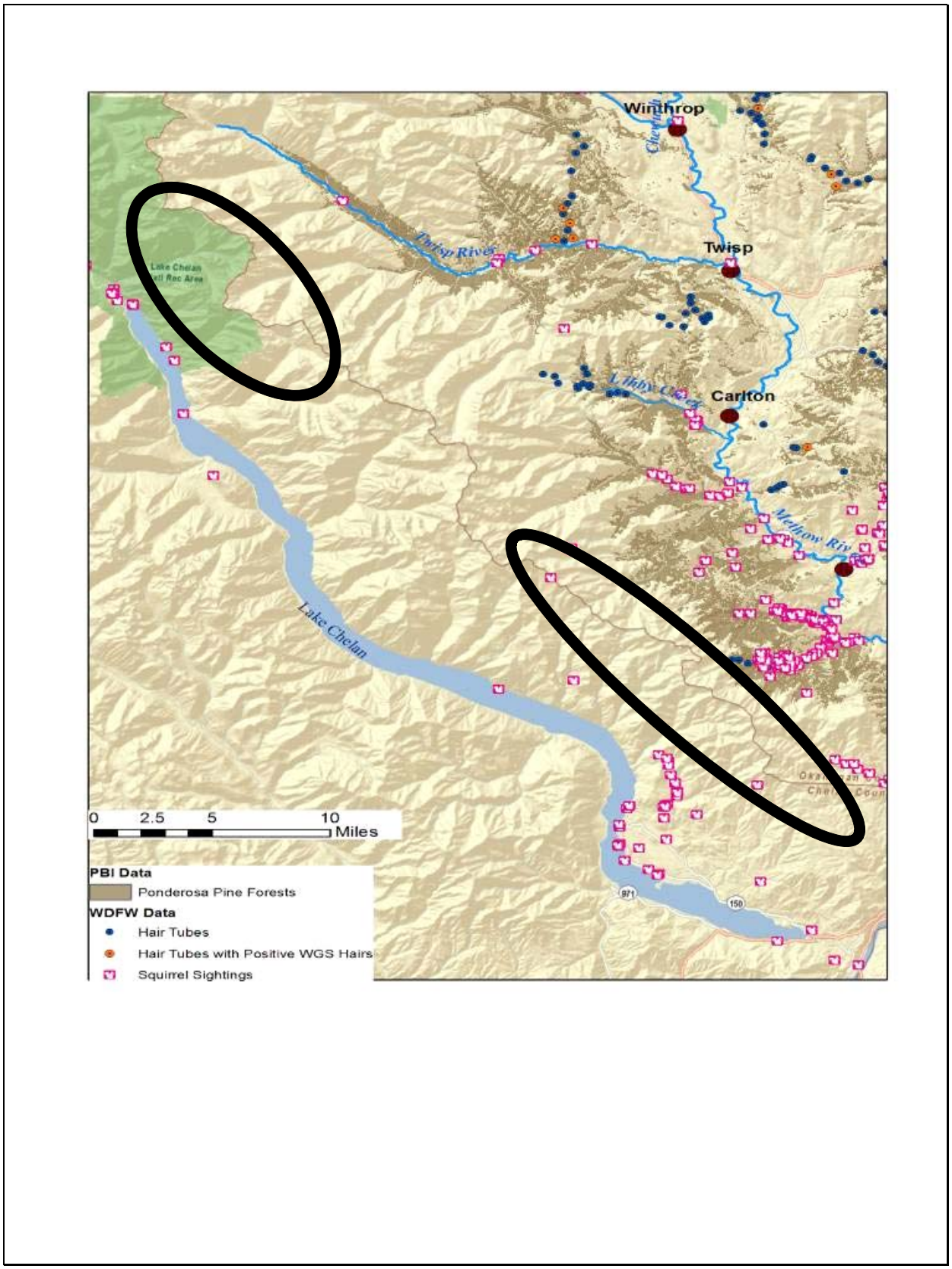


Figure 15. Potential corridors of connectivity (black ovals) between western gray squirrel locations near Lake Chelan/Stehekin region and the Methow Valley.

Reducing road-killed western gray squirrels

We are interested in reducing the number of road-killed western gray squirrels in the Methow Valley. Volunteers were urged to record any road-kill western gray squirrel sightings on car trips. Recording road-kill locations and sighting date may help determine seasonal use of more established routes used by western gray squirrels. One possibility for reducing road-kill deaths is to identify areas where road-kill accidents are at a higher density and erect warning signs urging motorists to slow down since this is a road crossing area for the state threatened western gray squirrels. Common road crossing areas for western gray squirrels may put them at a high mortality risk and hinder recovery efforts.

Western gray squirrel conservation implications

Our study has helped identify five new western gray squirrel areas, which has expanded the knowledge base for the upper Methow Valley, a northern part of their distribution range. Landowners and managers may make informed management practice decisions knowing they have western gray squirrels in the vicinity. Our study provided important information for agencies, private landowners, and local working groups for ongoing management activities such as timber harvest, prescribed burning, and livestock grazing that could potentially affect western gray squirrels and their habitats. Our findings of western gray squirrel distributions will also help guide conservation prioritization of western gray squirrel habitats by local conservation agencies in Okanogan County. Additionally, our community education component has allowed locals to be aware of their "backyard biodiversity". During our community education, we suggested potential ways to enhance western gray squirrel habitat. Suggested enhancements include promoting the growth of large trees which squirrels use for feeding and nesting, maintaining tree canopy connection so squirrels can travel between trees, and avoiding livestock overgrazing which leads to erosion and habitat degradation of squirrel foraging areas.

LITERATURE CITED

Asserson, W.C. III. 1974. Western gray squirrel studies in Kern County, California. Administrative Report No. 74-1. California Department of Fish and Game, Sacramento, CA. 32 pp.

Bailey, V. 1936. The mammals and life zones of Oregon. North American Fauna 55:1-416.

Bartels, P. 1995. Western gray squirrel survey inOkanogan and Chelan counties, Washington. Unpublished report. Washington Department of Fish & Wildlife, Olympia, WA. 4 pp. + appendices.

Bartels, P. 2000. Western gray squirrel survey in Okanogan and Chelan Counties, Washington. Unpublished report. Washington Department of Fish and Wildlife, Olympia, WA. 4 pp. + appendices.

Bryant, H.C. 1921. Tree squirrels infested with scabies. California Fish and Game 7:128.

Byrne, S. 1979. The distribution and ecology of the non-native tree squirrels *Sciurus carolinensis* and *Sciurus niger* in northern California. Ph.D. Dissertation. University of California, Berkeley, CA. 190 pp.

Carraway, L.N. and B.J. Verts. 1994. Sciurus griseus. Mammalian Species No. 474:1-7.

Cornish, T.E., M.J. Linders, S.E. Little, and W.M. Vander Haegen. 2001. Notoedric mange in western gray squirrels from Washington. Journal of Wildlife Diseases 37:630-633.

Crase, F.T. 1973. New size records for the western gray squirrel. The Murrelet 54:20-21.

Cross, S.P. 1969. Behavioral aspects of western gray squirrel ecology. Ph.D. dissert., University of Arizona, Tucson, 168 pp.

Dalquest, W.W. 1948. Mammals of Washington. University of Kansas, Museum of Natural History. Volume 2. Lawrence, KA. 444 pp.

Fimbel, C., and S. Freed. 2008. Monitoring western gray squirrels for landscape management in western Washington. Northwest Science 82:299-308.

Gregory, S.C. 2005. Seasonal movements and nest site selection of the western gray squirrel (Sciurus griseus) in the Methow River watershed. M.S. thesis. University of Washington, Seattle. 92 pp.

Gregory, S.C., W.M. Vander Haegen, W.Y. Chang, and S.D. West. 2010. Nest site selection by western gray squirrels at their northern range terminus. Journal of Wildlife Management 74:18-25.

Grinnel, J., and T.I. Storer. 1924. Animal life in the Yosemite: an account of the mammals, birds, reptiles, and amphibians in a cross-section of the Sierra Nevada. University of California Press, Berkeley, 752 pp.

Gurnell, J., Lurz, P.P.W. & Pepper, H. (2001) Practical techniques for surveying and monitoring squirrels. Forestry Commission Practice Note 11. Forestry Commission, Edinburgh. 12 pp.

Hall, E.R. 1981. The mammals of North America. Second ed. John Wiley & Sons, New York, 1:1-600+90.

Hamer, T., N. Denis, and J. Harmon. 2005. Distribution and habitat characteristics of western gray squirrel nest sites in the Stehekin River Valley, North Cascades National Park. Report prepared for North Cascades National Park, Sedro-Woolley, Washington. 44 pp.

Ingles, L.G. 1947. Ecology and life history of the California gray squirrel. California Fish and Game, 33:139-158.

Ingles, L.G. 1965. Mammals of the Pacific states. Stanford University Press, Stanford, CA. 506 pp.

Kertis, J. 1986. Vegetation dynamics and disturbance history of Oak Patch Preserve, Mason County, Washington. Unpublished report. Washington Department of Natural Resources, Olympia, WA.

Linders, M.J., and D.W. Stinson. 2007. Washington State Recovery Plan for the Western Gray Squirrel. Washington Department of Fish and Wildlife, Olympia. 128 + viii pp.

Linders, M.J, S.D. West, and W.M. Vander Haegen. 2004. Seasonal variability in the use of space by western gray squirrels in southcentral Washington. Journal of Mammalogy 85:511-516.

Maser, C., B.R. Mate, J.F. Franklin, and C.T. Dyrness. 1981. Natural history of Oregon coast mammals. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, General Technical Report. PNW-133. Corvallis, OR. 496 pp.

Merriam, C.H. 1930. A nest of the California gray squirrel (Sciurus griseus). Journal of Mammalogy 11:494.

Noss, R.F., E.T. La Roe III, and J.M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. U.S. Dept. of the Interior, national Biological Service, Washington, D.C. 58 pp.

Rodrick, E.A. 1986. survey of historic habitats of the western gray squirrel (Sciurus griseus) in the southern Puget Trough and Klickitat County, Washington. M.S. Thesis. University of Washington, Seattle, WA. 41 pp.

Ryan, L.A. and A.B. Carey. 1995. Biology and management of the western gray squirrel and Oregon white oak woodlands: with emphasis on the Puget Trough. General Technical Report, PNW-GTR-348. U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon. 36 pp.

Shannon, B.J. 1922. Gray squirrel disease spreading. California Fish and Game 8:52.

Smallwood, P.D., W. Terzaghi, A. McEuen, J.E. Carlson, E. Ribbens, T. Contreras, and M.A. Steele. 2003. Searching for effects of tree squirrel caching behaviour on the distribution of oak seedlings (abstract). 3rd International Colloquium on the Ecology of Tree Squirrels. Ford Castle, Northumberland. May 2003.

Stienecker, W.E. and B.M. Browning. 1970. Food habits of the western gray squirrel. California Department of Fish and Game Bulletin 56:36-48.

Vander Haegen, W. M., S. C. Gregory, and M. J. Linders. 2007. Implementation Plan for Augmentation of the Western Gray Squirrel Population, Fort Lewis, Washington. Washington Department of Fish and Wildlife, Olympia. 34pp.

Vander Haegen, W. M. and G. R. Orth. 2009. Western gray squirrel ecology and augmentation of the population in the South Puget Trough. Progress report. Washington Department of Fish and Wildlife, Olympia. 14pp.

Vander Haegen, W. M., G. R. Orth and L. M. Aker. 2005. Ecology of the western gray squirrel in south-central Washington. Progress report. Washington Department of Fish and Wildlife, Olympia. 41pp.

Vander Haegen, M., S. Van Leuven, and D. Anderson. 2004. Surveys for western gray squirrel nests on sites harvested under approved forest practice guidelines: analysis of nest use and operator compliance. Wildlife Research Report. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Verts, B.J. and L.N. Carraway. 1998. Land Mammals of Oregon. University of California Press, Berkeley, CA. 668 pp.

Warheit, K.I. 2003. Western gray squirrel population genetics: expanded analysis, March 28, 2003. Unpublished report. Washington Department of Fish and Wildlife, Olympia, WA. 17 pp.

Weaver, H. 1961. Ecological changes in the pine forests of Cedar Valley in southern Washington. Ecology 42:416-420.

Western Regional Climate Center. 2010. Goldendale, Washington (453222) period of record monthly climate summary. ,http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa3222.. Accessed 18 Nov 2010.

Western Regional Climate Center. 2010. Methow 2 S, Washington(455326) period of record monthly climate summary. ,http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa5326.. Accessed 18 Nov 2010.

Western Regional Climate Center. 2010. Stehekin 3 NW, Washington (458059) period of record monthly climate summary. ,http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa8059.. Accessed 30 Nov 2010.

Western Regional Climate Center. 2010. Tacoma 1, Washington (458278) period of record monthly climate summary. ,http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa8278.. Accessed 18 Nov 2010.

Western Regional Climate Center. 2010. Winthrop 1 WSW, Washington (455326) period of record monthly climate summary. ,http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa9376. Accessed 18 Nov 2010.

Weston, S.E. 2005. The distribution of the western gray squirrel (*Sciurus griseus*) and the introduced eastern fox squirrel (*S. niger*) and eastern gray squirrel (*S. carolinensis*) in the north Willamette Valley. M.S. Thesis, Portland State University, Portland, Oregon. 79 pp.

Zielinski, W.J., N.P. Duncan, E.C. Farmer, R.L. Truex, A.P. Clevenger, and R.H. Barrett. 1999. Diet of fishers (*Martes pennanti*) at the southernmost extent of their range. J. Mammalogy 80:961-971.

Appendix A - Western Gray Squirrel Hair-sampling tube Survey Datasheet, (2012 version)

Location ID: _____ Watershed: _____ Tube Number: ___
Observers: _____ Date Deployed (mm/dd/yyyy):_____
GPS Waypoint ID(s) (note if offset): _____ GPS Name: _____
GPS Accuracy: _____ GPS Lat: _____ GPS Long: _____ GPS elev: __
Flagging color & location: _____ Landowner consent obtained? Y N Public
Dominant Overstory: Ponderosa Douglas_Fir Cottonwood Other _____
Dominant Understory: Grass/Forbs Shrubs Bare-Ground Shrub/Young-Conifers Pine Needles
Photo numbers:_____Notes:_____
_____

Date Checked: _____ New Tube No. if changed: _____ **# Walnuts missing**: ___
Tube: Present Rolled Missing **Hair Collected:** Y N **Tube**: Rebaited (same location) Removed
Notes: _____
_____

Date Checked: _____ New Tube No. if changed: _____ **# Walnuts missing**: ___
Tube: Present Rolled Missing **Hair Collected:** Y N **Tube**: Rebaited (same location) Removed
Notes:
_____
_____

Date Checked: _____ New Tube No. if changed: _____ **# Walnuts missing**: ___
Tube: Present Rolled Missing **Hair Collected:** Y N **Tube**: Rebaited (same location) Removed
Notes: _____
_____

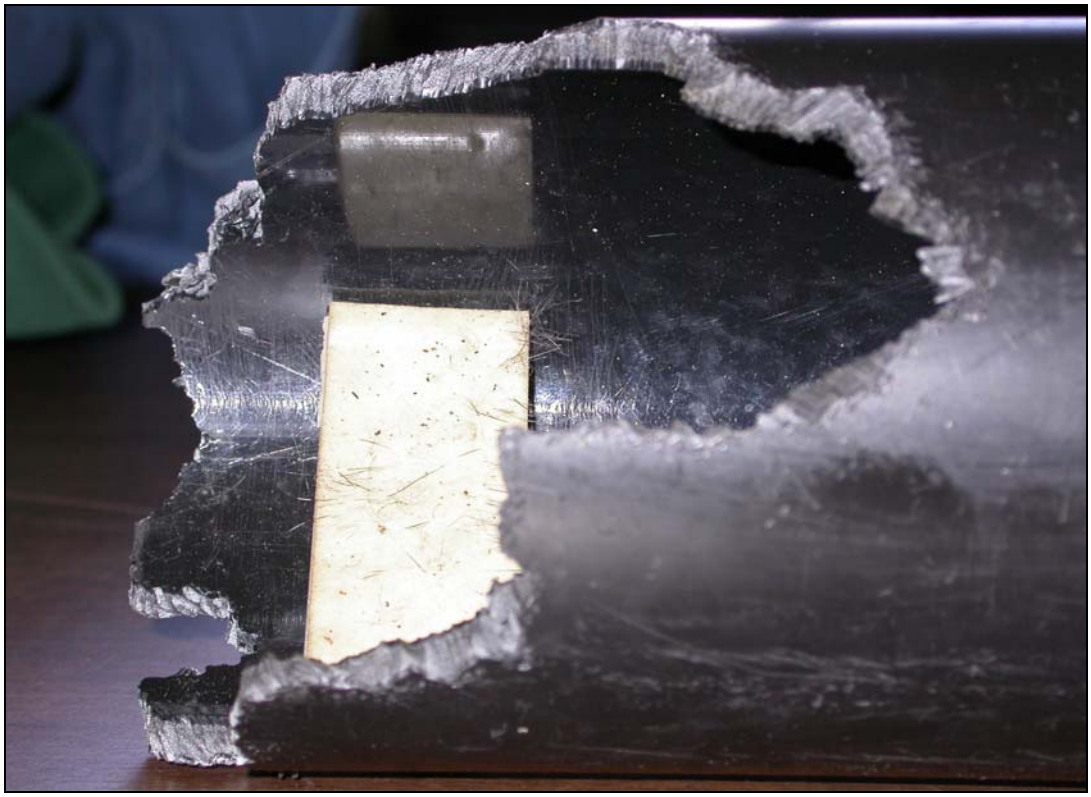
Appendix B - Discussion of Western Gray Squirrel Hair Tube Design

This year, a Pacific Biodiversity Institute volunteer who has western gray squirrels around his house observed a squirrel going for a walnut in a tube and getting stuck in the tube. It eventually got out of the tube, but apparently it required some time and effort. Last year, he photographed a western gray squirrel adjacent to one of the tubes (Figures 1 and 2). From these photos, it is apparent that the squirrel is quite large in comparison to the three-inch diameter tube opening, particularly if you consider the constriction caused by the metal plate and sticky tape.

Figures 1 and 2: Photographs of a western gray squirrel adjacent to hair tube on Olson property.

During Pacific Biodiversity Institute's monitoring of sampling tubes for western gray squirrels, we occasionally find a tube that has been nibbled on the ends or rolled away from where it was set. Last week (2011 July 20) we visited a site on the Chewuch River and found a tube that had approx 4 inches chewed off of one end and 1 inch chewed off the other and had been rolled approx 30 feet (Figure 3 and 4). The angle of the extensive bite marks on the tube ends indicate chewing occurring from outside of the tube and looked to be caused by squirrel teeth. Western gray squirrel hairs were present on the sticky tape on both sides of the tube, but the interior walnut was still glued to the interior of the tube, indicating that the squirrel was probably trying to get the nut but eventually relented.

.



Figures 3 and 4: Photographs of damage to hair tube 314, location LOCH102

.

About 1 inch was chewed off both ends to a nearby tube and the walnut was taken (Figures 5 and 6). Again, the angle of the bite marks to the tube ends indicates the chewing occurred from outside of the tube. Western gray squirrel hair was present on both sticky pads. Both the exterior and interior walnut was removed from the tube. In addition, the tube had been significantly moved from its original position.

A third tube in the vicinity was completely missing. The cause was unknown, except that it was not in an area where people were likely to visit. This last tube was on a steep slope, where it could have rolled, but we did not find it despite an intensive search of a 100-feet radius of the original tube location.

Figures 5 and 6: Photographs of damage to hair tube 281, LOCH 101

Discussion

These various pieces of evidence lead us to wonder if the 3" diameter and 18" long ABS tubes that we are using are too small and/or too long for some of the larger western gray squirrels that are found in this area to successfully reach the interior walnut.

We are concerned that the design of the 3-inch tubes may not be optimal for non-invasive sampling of western gray squirrels that sometimes are larger than the 3-inch opening. While the squirrels probably leave hair stuck to the sticky tape in their effort to get to the interior walnut, they may occasionally get stuck in the tubes. They also seem to have a habit of chewing up a lot of ABS material in their efforts to get to the interior walnut. That could be somewhat harmful to the health of the squirrel as ABS is not known to be an essential nutrient or completely inert.

We are interested in getting more information that might inform us about whether the sampling tube design could be optimized, both for the comfort and safety of the squirrel and for sampling effectiveness. We are interested in knowing what other researchers may know about tube design, materials, diameter and length. We also wonder if the western gray squirrels that we are encountering in the upper Methow Valley might be slightly larger than the squirrels in western Washington, where the hair-sampling technique was first employed. It could be that a slightly large tube diameter might be appropriate here.

To help answer these questions, we are engaged in a small comparison trial of several alternative tube diameters and lengths. We are interested in learning if any others have conducted similar trials.