DISTRIBUTION AND HABITAT CHARACTERISTICS OF WESTERN GRAY SQUIRREL NEST SITES IN THE STEHEKIN RIVER VALLEY, NORTH CASCADES NATIONAL PARK

Sciurus griseus

Submitted to:

Robert C Kuntz II
North Cascades National Park Service Complex
810 State Route 20
Sedro-Woolley, WA
98284-1239

Submitted by:

Thomas Hamer, Nathalie Denis and Jim Harmon
Hamer Environmental L.P.
19997 State Route 9,
Mount Vernon, WA 98274
Phone: (360) 422-6510
e-mail: hamert@aol.com
www.HamerEnvironmental.com

March 2005

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INTRODUCTION

The western gray squirrel (*Sciurus griseus*) belongs to the mammalian order Rodentia, the suborder Sciurognathi, the family Sciuridae, and is the largest native tree squirrel in the Pacific Northwest. *S. griseus* is also the only member of the genus *Scirus* native to Washington. Two other members of the genus have been introduced in Washington: the eastern gray squirrel (*Sciurus carolinensis*) and the fox squirrel (*Sciurus niger*).

Western gray squirrels can be identified by their silver-gray hair, long bushy tail, and large ears without tufts. Body measurements are variable. Adult western gray squirrel weights range from 520 to 942 grams. Total body length (including tail) can range from 50 to 62 cm. The eastern gray squirrel is the only squirrel resembling the western gray squirrel. However, the eastern gray squirrel is slightly smaller, has a shorter tail and a red tinge to its gray coat.

Western gray squirrels are diurnal with peak activity in the morning. Although they forage on the ground, western gray squirrels are mostly arboreal and are rarely found far from trees. Acorns are the primary food source throughout the western gray squirrels range, including Washington populations. Other browse items include pine nuts, Douglas fir seeds, maple seeds, fleshy fruits and masts from shrubs, and hypogeous (underground) fungi (Fed. Reg. 2002 vol. 67).

The historic distribution of the western gray squirrel was widespread throughout Washington, Oregon, California and in western Nevada (Fed. Reg. 2003 vol. 68). In Washington, western gray squirrels probably ranged throughout western Washington and the Cascades. Historically, western gray squirrel distribution in Washington was likely associated with oak communities (Fed. Reg. 2002 vol. 67). Western gray squirrels may have migrated northward into Washington, following the spread of Oregon white oak (*Quercus garryanna*) from the Willamette Valley in Oregon. Indeed, western gray squirrel populations have recently diminished as the distributions of oak woodlands have decreased (Fed. Reg. 2002 vol. 67).

Over time, the distribution in Washington has been reduced to three geographically isolated western gray squirrel populations: the "Puget Trough" population now centered in Thurston and Pierce counties; the "South Cascades" population in Klickitat and Yakima counties; and the "North Cascades" population in Chelan and Okanogan counties (Fed. Reg. 2003 vol. 68). The "North Cascades" population extends beyond the range of Oregon white oak; beyond access to acorns that are thought to be essential to other western gray squirrel populations. This northward range extension may have resulted from the introduction of walnut trees by early settlers (Fed. Reg. 2002 vol. 67). The objective of our study was to document the presence, distribution and general status of western gray squirrels in the Stehekin River Valley, North Cascades National Park Service Complex (NOCA). In addition, we collected baseline information on the understory and overstory plant composition and structure of the forest around nest sites we located.

STUDY AREA

The study area lies east of the Cascade Divide at the head of Lake Chelan, within the "North Cascades" population of western gray squirrels. Lake Chelan is a narrow, 85.3-km long gorge, filled with glacial and mountain runoff. The Stehekin River flows into Lake Chelan, which drains into the Columbia River Basin. The Stehekin River Valley was formed during the last ice age and exhibits the classic U-shape of a glacial trough. At its widest point, the valley floor at the head of Lake Chelan is 1.8 km wide and narrows to 0.6 km near High Bridge, approximately 16 km up river.

The Stehekin Valley bottom is flanked by steep ridges in most areas. Elevations range from 329 m on the valley floor to over 1,340 m on surrounding ridge tops. The wide range of forest types present throughout the Valley represent the transitional zone between forests of the western cascades and eastern cascades. Varying slope and aspect account for the valley's microclimates: dry rock benches of ponderosa pine (*Pinus ponderosa*), lodge pole (*Pinus contorta*) and western white pine (*Pinus monticola*) can lie adjacent to moist drainages where a dense understory is shaded by Douglas fir

(*Pseudotsuga mensezii*), western red cedar (*Thuja plicata*) and big-leaf maple (*Acer Macrophylum*). The common forest type observed on the Stehekin Valley floor was a mix of these species, relative components varying with moisture, but typically consisting of Douglas fir dominated stands with associated ponderosa pine, western red cedar (*Thuja plicata*) and big-leaf maple.

METHODS

Defining the Survey Area

First, the boundaries of potential western gray squirrel habitat in the Stehekin River Valley were defined by National Park Service biologists. The final survey area boundaries delineating this potential habitat ran parallel up the Stehekin Valley, encompassing the valley floor in the lower 25.7 km of the Stehekin Valley and upper Lake Chelan Basin up to an elevation of 700 m (Figure 1). Our objective was to survey

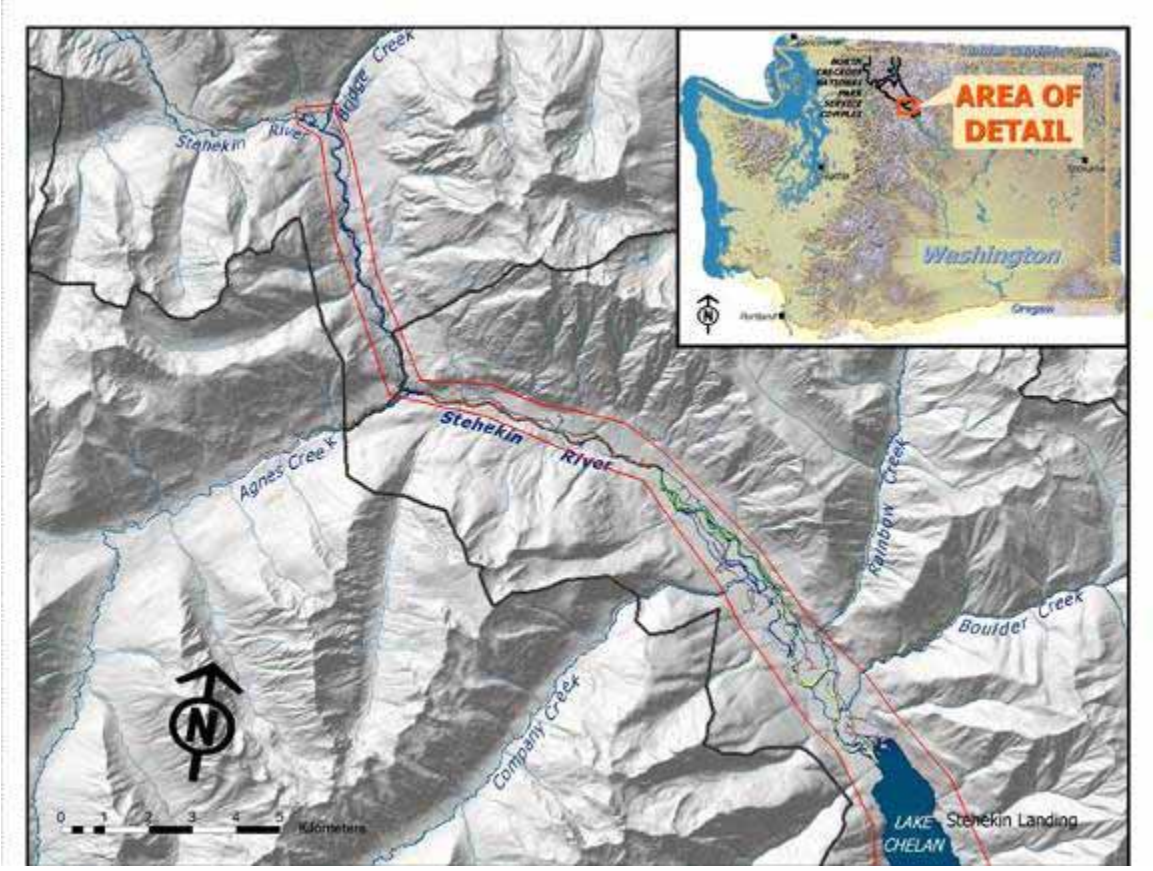


Figure 1. Stehekin Valley Western Gray Squirrel Study area outlined in red.

areas within the Stehekin Valley from near Flick Creek, near the park's southern boundary, to the Stehekin River confluence with Bridge Creek. Second, within the western gray squirrel potential habitat boundaries, smaller areas with a high likelihood of having gray squirrels were identified based on the presence of ponderosa pine forest cover type, historical western gray squirrel sightings and knowledge of current western gray squirrel distribution by National Park Service personnel. Forested stands with a ponderosa pine component were considered to provide better western gray squirrel forage opportunities. Prioritizing areas within the original survey boundary of potential habitat was necessary because the available survey effort was insufficient to cover the entire region that was delineated in step 1.

Western Gray Squirrel Sightings and Hair Snare Traps

As the observer walked survey routes to locate nest sites, any observations of active western gray squirrels were recorded and mapped. Hair snares were also used to corroborate suspected western gray squirrel presence. Baited with walnuts, the hair snares were left near locations of western gray squirrels sightings, nests, or in areas considered optimal habitat. Hair snare traps were constructed of 12-inch lengths of black, four-inch diameter plastic tubes. The traps were baited with whole walnuts, and hair was collected on all-weather carpet tape attached to the roof of the pipe at each end of the tube.

Nests

Walking surveys to locate nest sites and record observations of active squirrels were conducted during daylight hours, except on days with heavy precipitation. Parallel walking transects were spaced 40 to 80 meters apart depending on visibility; a function of stand density and canopy height. Transects were spaced closer together in areas with lower visibility.

Western gray squirrel nest identification can be ambiguous in the field. With varying sizes and stages of nest structural degradation, they may resemble nests of Douglas squirrels (*Tamiasciurus douglasi*) or large birds. In order to maintain objective and

repeatable nest identification, a confidence rating system was developed. Four variables were examined for each potential nest and each variable was noted as present or absent. These variables included whether: 1) nest was clustered with other nests in the area; 2) nest size was ≥ 0.46 m diameter; 3) a mix of nest materials was used and; 4) the nest tree was a ponderosa pine. A present status for each of these variables earned a score of 4, 3, 2 and 1, respectively. Thus, a nest with all four confidence-variables recorded as "present" would sum to a maximum nest confidence rating of 10.

Nests were classified by type: stick nest, cavity nest or summer nest (deciduous leaf nest). Western gray squirrel nests were physically described by two variables: nest condition and nest color. Nest condition described the structural integrity of the nests. All nests were ranked in one of three categories, decreasing in structural integrity (Table 1). A rating of A indicated a fully or partially constructed nest, B indicated a nest that was relatively still intact, while C was used to categorize nests where much of nest material was gone, but material size and composition indicated a western gray squirrel nest.

Table 1. Nest structural integrity categories used for describing western gray squirrel nests found in the Stehekin Valley, North Cascades National Park, 2004.

A	B	C
Fully or partially constructed nest that may contain some green or yellow material.	Nest appears to have lost material and is beginning to fall out of tree.	Much of nest material is gone, but material size and composition indicates western gray squirrel.

The color of western gray squirrel nest material can indicate how recently squirrels have engaged in construction activities at a nest. All nests were ranked as one of three colors; green, red/rust, and brown/black (Table 2). Green colored nest material indicated nest had been added to or built recently while brown/black colors indicated that squirrels had not engaged in construction activities for some time.

Table 2. Nest color ranking system for describing western gray squirrel nests found in the Stehekin Valley, North Cascades National Park, 2004.

Green	Red/ Rusty	Neither
Any amount of green material.	Any amount of red or rust colored material.	All material is brown or black.

We also recorded nest and nest tree heights. We used these data to calculate nest height ratios to determine what portion of the tree crown squirrels typically chose to build their nests. Variables that were gathered to describe the nest tree included: species, dbh, tree-height, relative canopy dominance, and nest-tree position in the stand (see data sheet protocol in Appendix C). Any deformities in the nest-tree were also recorded and we noted whether the deformity was located at the nest location.

Nest Plots

Vegetation data was gathered at each western gray squirrel sighting and each nest site using plots (see example of data sheet in Appendix D). The plot data collected included ground cover, shrub/understory community composition, overstory species composition, and the structure of the forest canopy.

Plot layout consisted of two concentric circles with a radius of 5.6 and 10.6 m; both centered at the western gray squirrel nest or sighting. Understory vegetation and ground cover data were sampled in the 5.6 m radius plot: saplings were defined as trees ranging 5 to <10 cm diameter at breast height (dbh) and ≥ 1 meter in height, and were tallied; coarse woody debris (CWD) was also tallied and categorized in nine classes based on dbh and degree of decadence; percent cover of masting shrubs were recorded by species; percent shrub cover, as well as predominant shrub height, were also recorded. Groundcover was measured by recording percent cover of seedlings, ferns, forbs, grass, moss, rock/bare, litter, and all woody debris (AWD) which combined fine and coarse woody debris in each nest plot (Table 3).

Table 3. Plot sizes and list of variables measured in each plot at western gray squirrel nests, squirrel sightings, and positive hair trap locations in the Stehekin Valley, North Cascades National Park, 2004.

5.6 m radius plot		**10.6 m radius plot**
Understory vegetation	Ground Cover	Overstory vegetation
Saplings, CWD, % of masting shrubs, % shrub cover, shrub height	Seedlings, ferns, forbs, grass, moss, rock, litter, AWD	% Total canopy cover, % coniferous, % deciduous, crown overlap

The 10.6 m radius plot was used to describe the overstory community. Ocular estimates were recorded for total percent canopy cover, percent coniferous canopy cover and percent deciduous canopy cover. Trees ≥ 10 cm dbh were counted with species and dbh recorded, including the nest tree(s). All understory and overstory percent cover data were recorded using a cover class index: 1) 0-1 %, 2) >1-5%, 3) >5-25%, 4) >25-50%, 5) >50 –75%, 6) >75%.

Overstory trees were also evaluated for degree of crown overlap within the plot canopy. Five live overstory trees (≥ 10 cm dbh) were selected by choosing one tree nearest plot center and four trees nearest the quarter points of the plot edge 10.6 meters from plot center. At each of these five trees we tallied the number of overstory trees, live or dead, whose crown was ≤ 1m from the crown of the chosen sample tree.

A Trimble Geo-Explorer 3, hand-held global positioning system (GPS) unit, was used to record all locations of Western gray squirrel activity, nest sites, and hair snares. The location data was then differentially corrected and mapped using Pathfinder Office and Terrain Navigator software.

RESULTS

Survey Effort

The field work was conducted between September 21st and November 17th, 2004 for a total of 38 field days involving approximately 304 hours of survey effort (8 hours/day). In total, five periods of eight consecutive days of constant survey effort in the Stehekin Valley was followed by 5 days off. Surveys started no earlier than 0700 (PST) and sometimes lasted as late as 1800 (PST).

Sightings and Hair Snare Traps

Western gray squirrels were sighted eight times during the survey effort. Squirrels were always solitary and sighting times ranged throughout the daylight hours. Sighting distributions were concentrated centrally within nest concentrations that we identified. However, frequently traveled routes by the field observer, to and from survey sites, may have biased the distribution of sightings. In addition, some frequently traveled routes passed through areas of known western gray squirrel activity.

Twelve hair snare sites were monitored within the survey area. Hair snares were left at sites from 7 to 20 days. Four hair snare traps had western gray squirrel hair present indicating squirrel presence in these areas (Appendix B, Figure 2).

Nests

Twenty eight western gray squirrel nests were found from the mouth of Flick Creek, adjacent to Lake Chelan at the southern boundary of the study area, north to the northern trailhead of the "Rainbow Loop Trail", approximately one kilometer northwest of the Harlequin Bridge. Observer confidence levels averaged 6.2 (range 3-10; 10=highest confidence) indicating that these nests were western gray squirrel nests versus Douglas squirrel (*Tamiasciurus douglasii*) or flying squirrel (*Glaucomys sabrinus*) nests (Table 4).

Table 4. Characteristics of nest trees and nest height ratios (nest height/tree height) for 28 western gray squirrel nests found in the Stehekin Valley, North Cascades National Park, 2004. The higher the ratio, the higher the position of the nest in the tree crown. Nest confidence indicates the relative likelihood that the nest was a western gray squirrel nest (higher score = higher likelihood).

Plot ID	Tree Species[1]	DBH(m)	Tree Height(m)	Nest Height(m)	Nest H/ Tree H Ratio	Nest Confidence
BOCK01	PSME	0.4	24.1	17	70.5	4
BOCK02	PSME	0.85	36.5	17	46.6	7
BOCK04	PSME	0.63	30.8	20	64.9	7
BOCK05	PSME	0.84	38.1	31	81.4	7
BOCK06	PSME	0.46	23.0	19	82.6	4
BOCK07	PSME	1.24	42.3	14	33.1	7
BOCK08	POBA	0.87	31.7	18	56.8	9
BOCK09	PSME	0.58	34.5	28	81.2	7
BOCK10	PSME	0.52	21.5	8	37.2	4
BOCK11	PSME	0.61	27.1	12	44.3	7
BOCK13	PSME	0.39	24.2	16	66.1	7
BOCK14	PIPO	0.68	50.9	14	27.5	3
BOCK15	PSME	0.36	23.2	12	51.7	4
BOCK16	PSME	0.53	30.1	17	56.5	7
BOCK24	PSME	0.47	23.9	22	92.1	3
BOCK25	PIPO	0.73	32.1	17	53.0	8
BOCK26	POBA	0.66	44.4	19	42.8	7
BOCK27	PIPO	0.44	12.0	5	41.7	5
BOCK29	PSME	0.94	38.0	22	57.9	9
BOCK30	PSME	0.66	30.2	25	82.8	7
BOCK31	PIPO	0.49	16.1	15	93.2	8
COMP01	PSME	0.81	35.1	23	65.5	5
LAKE01	PSME	1.00	31.0	18	58.1	3
LAKE02	PSME	0.51	26.0	15	57.7	4
LAKE03	PIPO	0.63	30.1	18	59.8	8
LAKE04	PIPO	0.84	21.4	12	56.1	7
LAKE05	PIPO	0.57	24.4	19	77.9	10
LAKE06	PIPO	0.44	24.6	13	52.8	5
Averages		**0.65**	**29.5**	**17.4**	**60.4**	**6.2**
Max		**1.24**	**50.90**	**31.0**	**93.2**	**10**
Min		**0.36**	**12.00**	**5.00**	**27.50**	**3**
S.D.		**0.2**	**8.5**	**5.5**	**17.4**	**1.2**

[1]PSME=Douglas-fir, POBA=Black Cottonwood, PIPO=Ponderosa pine.

All nests were distributed within a narrow stretch of the valley approximately 11.5 km in length (Appendix B, Figures 2 to 6). All nest sites were low in elevation. Nest site elevations ranged from 329 m at Flick Creek adjacent to Lake Chelan to 500 m on the upper slopes of Flick Creek.

All 28 documented nests were stick nests. A condition rating of A (fully or partially constructed nest) was attributed to 53.6% of the nests, while 28.6% were rated as B (being relatively intact), and 17.9% were rated as C (much of nest material is gone, but material size and composition indicates western gray squirrel nest) (Table 5). While over half the nests qualified for condition ratings of A, 50.0% of nests had no fresh material, receiving a color code of N (neither green nor red/rust). The other 35.7% of nests had rust colored material and 14.3% had green colored material indicating recent construction activity.

Table 5. Color and condition of western gray squirrel nests found in the Stehekin Valley, North Cascades National Park, 2004.

Nests (n=28)						
Color	**Count**	**%**		**Condition**	**Count**	**%**
Green	4	14.3		A	15	53.6
Red	10	35.7		B	8	28.6
Neither	14	50.0		C	5	17.9

Eighteen nests (64.3%) were found in Douglas fir trees. Eight nests (28.6%) were found in ponderosa pine trees while two nests (7.1%) were found in black cottonwood (*Populus balsamifera*) trees. Nests were generally located close to the boles of the nest tree rather than out on a limb. Nests were always arboreal and elevated off the ground. Nest heights ranged from 5 to 31 m with a mean of 17.4 m. The mean nest height/tree height ratio was 60.4% with a maximum of 93.2 % (Table 4). The minimum nest height/tree height ratio was 27.5%. While 25 (89.3%) of the 28 nests had nest height/tree height ratios greater

than 40%, half the nests fell between 41% and 60%, 11 nests were above 60% and six nests had nest height ratios between 81% and 100% (Figure 7).

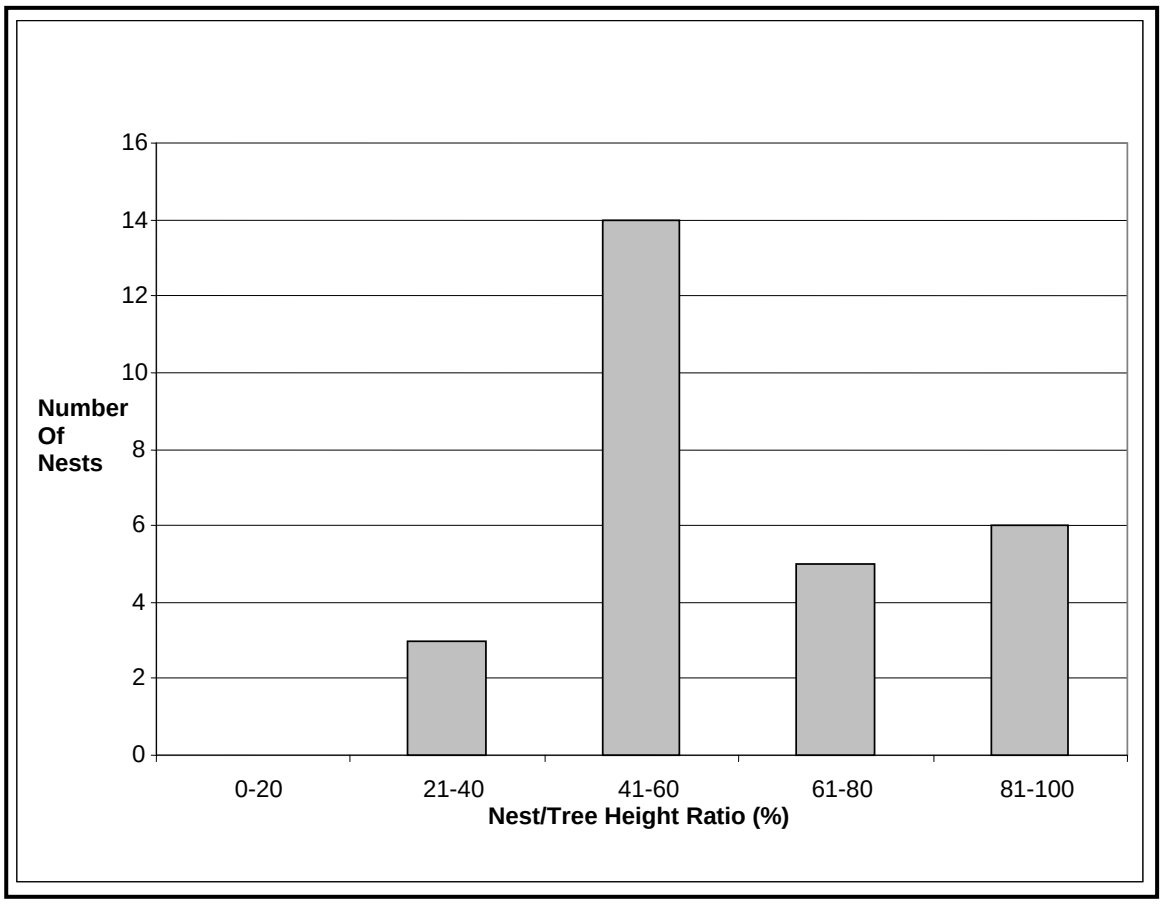


Figure 7. Number of western gray squirrel nests (n=28) in each of 5 categories depicting the ratio of nest height to tree height.

Nest Plots

Overstory Vegetation

Trees ≥ 10cm dbh were tallied in 10.6 m radius plots (area of 353.0 m^2). Plot tallies ranged from 1 to 23 trees with a mean of nine trees per plot (S. D. = 5.3) (Table 6).

Table 6. Tree species, tree stem density and mean, minimum and maximum dbh for each of 28 western gray squirrel nest plots sampled in the Stehekin Valley, North Cascades National Park, 2004.

Plot ID	Tree Species	Tree Stem Count	Mean DBH (m)	DBH Range
BOCK01		**4**	**0.41**	**0.35 - 0.48**
	PSME	4	0.41	
BOCK02		**8**	**0.36**	**0.14 - 0.85**
	PSME	4	0.52	
	ACMA	4	0.2	
	CONU			
BOCK04		**9**	**0.32**	**0.14 - 0.66**
	PSME	3	0.59	
	ACMA	4	0.22	
	CONU	2	0.11	
BOCK05		**9**	**0.48**	**0.11 - 0.84**
	PSME	8	0.53	
	ACMA	1	0.11	
BOCK06		**4**	**0.44**	**0.24 - 0.77**
	PSME	2	0.62	
	ACMA	2	0.26	
BOCK07		**10**	**0.27**	**0.11 - 0.54**
	PSME	5	0.4	
	CONU	5	0.14	
BOCK08		**10**	**0.5**	**0.15 - 0.89**
	PSME	2	0.62	
	ACMA	5	0.28	
	POBA	1	0.87	
	THPL	2	0.73	
BOCK09		**6**	**0.55**	**0.39 - 0.72**
	PSME	6	0.55	
BOCK10		**2**	**0.36**	**0.20 - 0.52**
	PIPO	1	0.2	
	PSME	1	0.52	
BOCK11		**11**	**0.58**	**0.11 - 1.27**
	PSME	1	0.61	
	ACMA	4	0.31	
	ABGR	2	1.24	
	THPL	1	0.92	
	ALRU	3	0.39	
BOCK13		**13**	**0.35**	**0.11 - 1.17**
	PSME	5	0.62	
	ACMA	8	0.17	
BOCK14		**3**	**0.75**	**0.68 - 0.85**
	PIPO	1	0.68	
	PSME	2	0.79	
BOCK15		**11**	**0.35**	**0.13 - 0.76**

	PSME	9	0.38	
	ACMA	1	0.13	
	THPL	1	0.36	
BOCK16		**3**	**0.56**	**0.38 - 0.76**
	PSME	3	0.56	
BOCK24		**13**	**0.52**	**0.30 - 0.84**
	PIPO	5	0.68	
	PSME	8	0.42	
BOCK25		**5**	**0.59**	**0.29 - 1.14**
	PIPO	1	0.73	
	PSME	1	1.14	
	ALRU	3	0.36	
BOCK26		**7**	**0.45**	**0.35 - 0.66**
	POBA	2	0.48	
	ALRU	5	0.44	
BOCK27		**1**	**0.44**	**0.44**
	PIPO	1	**0.44**	
BOCK29		**17**	**0.39**	**0.11 - 0.94**
	PSME	13	0.46	
	ACMA	4	0.14	
BOCK30		**11**	**0.53**	**0.28 - 0.75**
	PSME	9	0.58	
	ACMA	2	0.29	
BOCK31		**7**	**0.27**	**0.15 - 0.49**
	PIPO	3	0.31	
	PSME	3	0.47	
	ACMA	1	0.24	
COMP01		**12**	**0.43**	**0.14 - 0.81**
	PSME	12	0.43	
LAKE01		**4**	**0.55**	**0.12 - 1.00**
	PIPO	1	0.18	
	PSME	3	0.68	
LAKE02		**9**	**0.35**	**0.12 - 0.58**
	PSME	9	0.35	
LAKE03		**23**	**0.24**	**0.11 - 0.72**
	PIPO	4	0.54	
	PSME	19	0.18	
LAKE04		**8**	**0.28**	**0.11 - 0.84**
	PIPO	5	0.29	
	PSME	3	0.27	
LAKE05		**21**	**0.28**	**0.11 - 0.76**
	PIPO	2	0.67	
	PSME	19	0.24	
LAKE06		**8**	**0.35**	**0.21 - 0.47**
	PIPO	4	0.37	
	PSME	4	0.33	
Mean Plot Stem Count		**9**		
STDEV		**5.3**		
Range		**1 – 23**		

[1]PSME=Douglas-fir, POBA=Black Cottonwood, PIPO=Ponderosa pine, ACMA=Big leaf maple, THPL=Western red cedar, ALRU=red alder, CONU=Pacific dogwood.

Douglas fir was present in 93% of the plots, while big leaf maple and ponderosa pine were both present in 39% of nest plots. Within the 28 nest plots, a total of 231 trees were tallied. Of these trees, 64% were Douglas fir, 14.6% were big leaf maple, and 11.3% were ponderosa pine. Almost 90% of all trees tallied in plots included these three species (Table 7). The remaining 10.1% of trees tallied included red alder (*Alnus rubra*) (4.5%), pacific dogwood (*Cornus nuttallii*) (2.8%), western red cedar (1.6%) and black cottonwood (1.2%). The lower Stehekin Valley floor lies within the Douglas fir zone (Franklin and Dyrness 1988) and the plot overstory data represented this with most plots dominated by Douglas fir.

Table 7. Number of dominant trees for each tree species measured in 28 western gray squirrel nest plots sampled in the Stehekin Valley, North Cascades National Park, 2004.

Species[1]	Number	Percent of Total
PSME	158	64.0
PIPO	28	11.3
ACMA	36	14.6
THPL	4	1.6
POBA	3	1.2
ALRU	11	4.5
CONU	7	2.8
Total	**247**	100

[1]PSME=Douglas-fir, POBA=Black Cottonwood, PIPO=Ponderosa pine, ACMA=Big leaf maple, THPL=Western red cedar, ALRU=red alder, CONU=Pacific dogwood.

Almost all nest trees found were dominant or co-dominant members of the canopy community within the vegetation plot. None of the nest trees observed were overtopped (receiving no light from above or on sides and below average canopy height) by surrounding trees. In terms of the position of the nest tree relative to the local stand, nest trees were located largely inside a group of trees and rarely isolated.

Nest plot canopy coverage was broadly uniform among nest sites. Eighty six percent of plots (n=25) had total canopy cover (coniferous and deciduous combined) values between 25 and 75% (Figure 8).

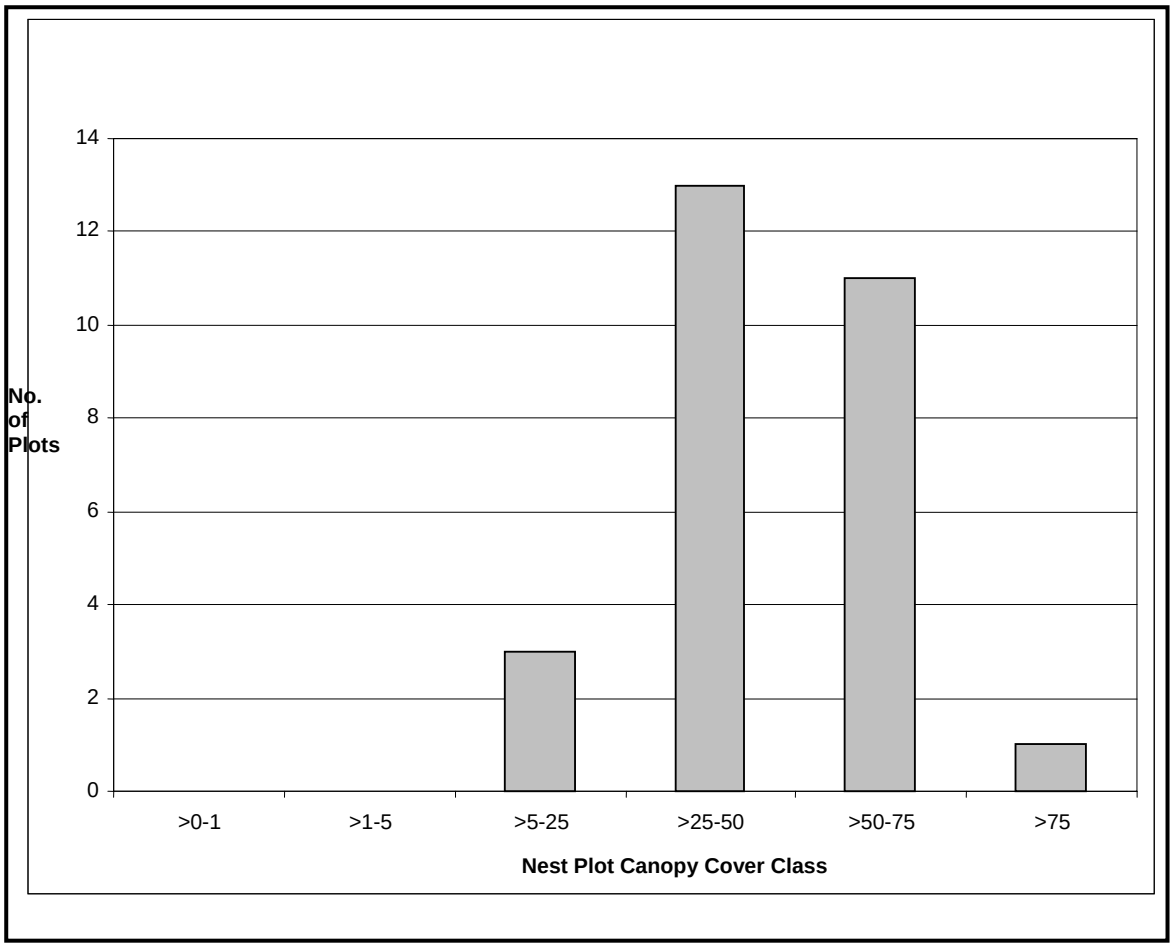


Figure 8. Number of western gray squirrel nest plots (n=28) in each total canopy cover class for deciduous and coniferous trees combined.

Nest plots canopy coverage consisted predominately of conifers with an average conifer canopy cover index of 3.7 (5-25% cover) and an average deciduous canopy cover index of 1.9 (0-1% cover) (Table 8).

Table 8. Canopy cover index for 28 western gray squirrel nest plots sampled in the Stehekin Valley, North Cascades National Park, 2004.

Plot ID	Total Canopy Cover Index[1]	Deciduous Canopy Cover Index[1]	Coniferous Canopy Cover Index[1]
BOCK01	4	3	3
BOCK02	5	3	5
BOCK04	5	3	4
BOCK05	5	3	4
BOCK06	4	2	4
BOCK07	4	3	4
BOCK08	6	4	3
BOCK09	5	2	5
BOCK10	3	0	3
BOCK11	5	3	3
BOCK13	5	3	3
BOCK14	4	4	0
BOCK15	5	2	5
BOCK16	4	0	4
BOCK24	5	1	5
BOCK25	5	3	4
BOCK26	5	4	2
BOCK27	3	0	3
BOCK29	5	4	4
BOCK30	4	2	4
BOCK31	4	2	4
COMP01	4	2	4
LAKE01	4	0	4
LAKE02	4	0	4
LAKE03	4	0	4
LAKE04	3	0	3
LAKE05	4	0	4
LAKE06	4	0	4
Averages	**4.4**	**1.9**	**3.7**
Maximum	**6**	**4**	**5**
Minimum	**3**	**0**	**0**
Median	**4**	**2**	**4**

[1]All overstory percent cover data were recorded using a cover class index: 1) 0-1 %, 2) >1-5%, 3) >5-25%, 4) >25-50%, 5) >50 –75%, 6) >75%.

Distribution of canopy coverage among the nest plots was concentrated between the values of 25 and 50% with 46% (n=13) of the plots falling within this range (Figure 8). Twenty four (85.7%) nest plots had deciduous canopy cover at or below 25% (Figure 9). Nine (32.1%) of those had no deciduous canopy cover at all, and six (21.4%) plots had deciduous canopy cover between 1 and 5%. Deciduous canopy cover exceeded 25% in

only four (14.3%) plots. Conversely, 19 (67.9%) plots had greater than 25% coniferous canopy cover, with 15 (53.6%) of those distributed between 25% and 50% cover. Nine nest plots had coniferous canopy cover at or below 25% with only two (7.2 %) plots below 5%.

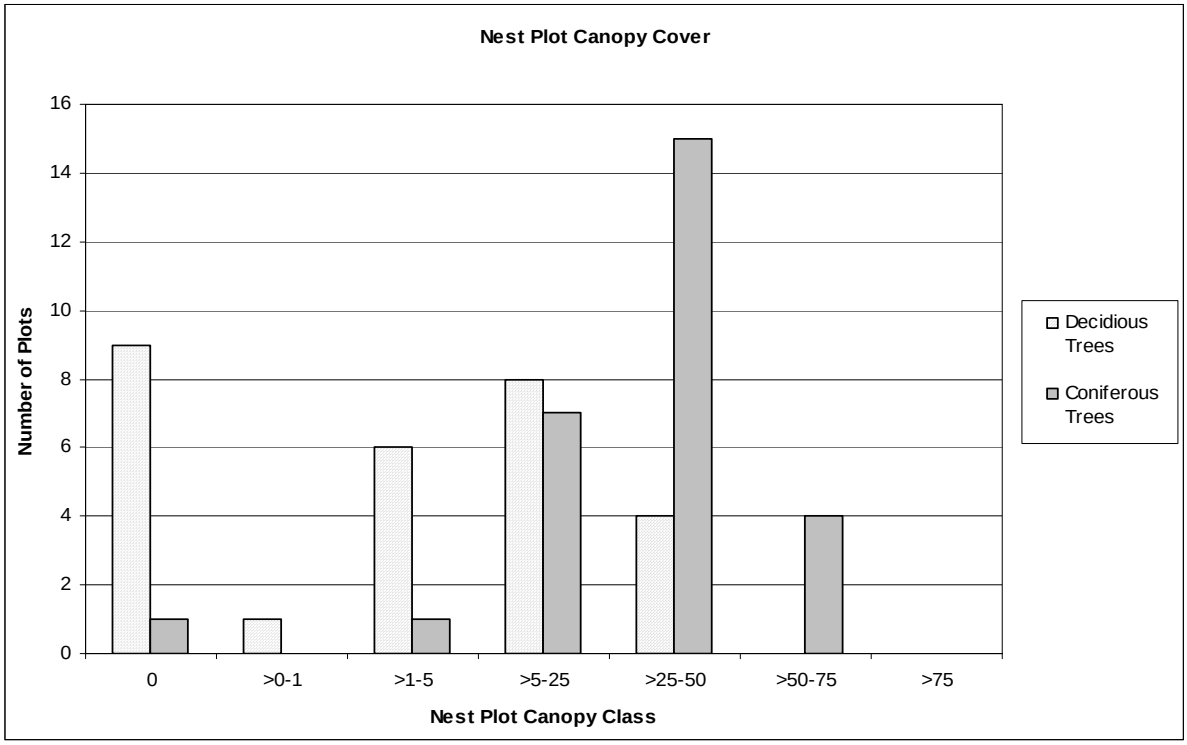


Figure 9. Number of western gray squirrel nest plots (n=28) in each canopy cover class for deciduous and coniferous trees.

Interlocking crown counts compared canopy connectedness among the 28 nest plots. In addition, within each nest plot, canopy connectedness of the nest tree was compared to that of non-nest trees. When combining nest tree and corner trees at each nest plot, the means for interlocking-crown tallies among all nest plots ranged from 1.0 to 6.6 (median of 4.0) with an average of 3.7 (S.D. = 1.3) (Table 9). Separating nest tree interlocking crown tallies from corner tree tallies revealed a slightly higher degree of canopy connectedness at the nest tree compared to other trees at the plot. The mean interlocking crown tally for the 28 nest trees was 4.2 (S.D. = 2.1) while the mean of the 112 non-nest tree tally was 3.4 (S.D. = 2.0).

Table 9. Number of interlocking crowns recorded for 28 western gray squirrel nest plots sampled in the Stehekin Valley, North Cascades National Park, 2004.

Plot ID	Center Tree[1]	Corner Tree Average[1] (n=4)	Plot Average[1]	S.D.
BOCK01	3	3.0	3.0	1.2
BOCK02	7	3.8	4.4	1.5
BOCK04	3	3.0	3.0	1.6
BOCK05	4	2.5	2.8	1.3
BOCK06	1	2.3	2.0	1.9
BOCK07	6	3.3	3.8	2.7
BOCK08	5	3.8	4.0	2.5
BOCK09	4	4.3	4.2	1.5
BOCK10	1	1.0	1.0	0.7
BOCK11	6	3.5	4.0	2.5
BOCK13	3	3.5	3.4	2.6
BOCK15	5	4.0	4.2	1.3
BOCK16	1	3.0	2.6	1.7
BOCK24	7	4.0	4.6	1.5
BOCK25	3	3.5	3.4	1.8
BOCK26	4	4.3	4.2	1.1
BOCK27	0	1.3	1.0	1.2
BOCK29	8	4.3	5.0	2.1
BOCK30	5	4.5	4.6	1.1
BOCK31	5	4.5	4.6	1.5
COMP01	5	4.0	4.2	0.8
LAKE01	1	4.0	3.4	2.1
LAKE02	6	5.5	5.6	1.1
LAKE03	5	4.5	4.6	1.5
LAKE04	4	1.5	2.0	2.0
LAKE05	7	6.5	6.6	2.7
LAKE06	5	2.8	3.2	1.6
Averages	**4.2**	**3.5**	**3.7**	
Max	**8.0**	**6.5**	**6.6**	**2.7**
Min	**0.0**	**1.0**	**1.0**	**0.7**
Median	**5.0**	**3.8**	**4.0**	**1.5**
S.D.	**2.1**	**1.2**	**1.3**	

[1]Number of overstory trees, live or dead, whose crown was ≤ 1m from the crown of the sample tree.

Understory Vegetation

Herbaceous ground cover was typically sparse. Grasses, litter, and all woody debris (AWD) were the most prevalent ground cover types, occurring in 28, 28, and 27 of the plots respectively (Table 10). Percent covers of grasses and litter both ranged from less than 5% to greater than 75%, but AWD cover was more consistent and never exceeded 25% cover.

Table 10. Nest plot ground cover class index[1] values for 28 western gray squirrel plots sampled in the Stehekin Valley, North Cascades National Park, 2004.

Plot ID	Seedlings	Ferns	Forbs	Grass	Moss	Rock/ Bare ground	Litter	AWD	Shrubs	Predom. Shrub Height (m)
BOCK01	1	2	1	1	1	0	3	2	4	1.50
BOCK02	1	1	2	2	1	1	6	3	3	0.50
BOCK04	0	1	1	3	1	1	4	2	2	0.50
BOCK05	2	0	1	2	1	2	4	3	2	0.50
BOCK06	1	0	1	3	1	1	4	3	1	0.50
BOCK07	1	2	1	2	1	2	4	3	1	0.50
BOCK08	1	1	1	1	1	3	3	3	3	0.50
BOCK09	0	0	0	6	1	2	2	2	2	0.00
BOCK10	1	0	1	2	2	3	2	2	3	1.50
BOCK11	1	0	2	2	1	1	3	3	1	0.50
BOCK13	1	0	1	2	1	2	5	2	2	0.50
BOCK14	0	0	1	5	1	0	2	1	0	0.00
BOCK15	0	1	1	1	1	2	3	3	2	0.50
BOCK16	1	1	2	3	1	2	3	3	2	0.75
BOCK24	1	1	1	1	2	1	3	1	2	0.00
BOCK25	1	1	2	1	0	0	3	1	3	0.75
BOCK26	1	1	1	1	0	0	4	2	4	0.75
BOCK27	0	1	1	4	1	3	3	0	0	0.00
BOCK29	0	1	1	1	1	1	4	2	1	0.50
BOCK30	1	0	1	1	1	2	3	2	2	0.50
BOCK31	1	0	0	2	1	1	5	2	0	0.00
COMP01	2	0	1	1	1	2	3	3	3	0.75
LAKE01	0	0	1	4	1	1	2	2	1	4.00
LAKE02	0	0	1	2	1	1	5	3	0	0.00
LAKE03	1	0	1	4	0	0	4	3	1	0.50
LAKE04	0	0	1	2	1	1	5	2	0	0.00
LAKE05	0	0	0	1	1	1	6	3	0	0.00
LAKE06	0	0	0	2	1	1	5	2	0	0.00
Plot Freq.	**17**	**12**	**24**	**28**	**25**	**23**	**28**	**27**	**21**	**N/A**
Average	**0.68**	**0.50**	**1.00**	**2.21**	**0.96**	**1.32**	**3.68**	**2.25**	**1.61**	**0.57**
Max.	2	2	2	6	2	3	6	3	4	4
Min.	0	0	0	1	0	0	2	0	0	0
Median	1	0	1	2	1	1	3.5	2	2	0.5

[1]All understory percent cover data were recorded using a cover class index: 1) 0-1 %, 2) >1-5%, 3) >5-25%, 4) >25-50%, 5) >50 –75%, 6) >75%.

Masting shrubs were differentiated when measuring shrub cover in nest plots. A percent cover was recorded separately for masting shrubs, and for all other shrubs species combined including masting shrubs. Shrub percent cover was generally low. Twenty six nest plots (92.9%) had shrub covers at or less than 25%. Twenty one plots (75.0%) had shrub cover of 5% or less, while 13 plots (46.4%) had 1% or less shrub cover with seven

of these plots having no shrub component in their plant community. Shrub height in plots was low averaging 0.57 m and ranged from 0-4 m (Table 10).

Shrub species considered as masting shrubs included all *Rubus spp.* (raspberries and blackberries, all *Rosa spp.* (roses), *Mahonia aquifolium* (Oregon grape), *Cornus nuttalii* (Pacific dogwood), *Acer circinatum* (vine maple), *Acer macrophylum* (big-leaf maple), *Amelanchier alnifolia* (serviceberry), and *Apocynum androsaemilfolium* (spreading dogbane). Nineteen (67.9%) of the 28 nest plots had masting shrubs present. *Rubus spp.* and Oregon grape were the most common masting shrubs, present in 13 (46.4%) and 10 (35.7%) plots respectively, and Pacific dogwood was present in 6 plots (21.4%). Roses, vine maple, serviceberry and creeping dogbane were present in three plots each. Big-leaf maple was found as an understory mast producer in one plot (Figure 10).

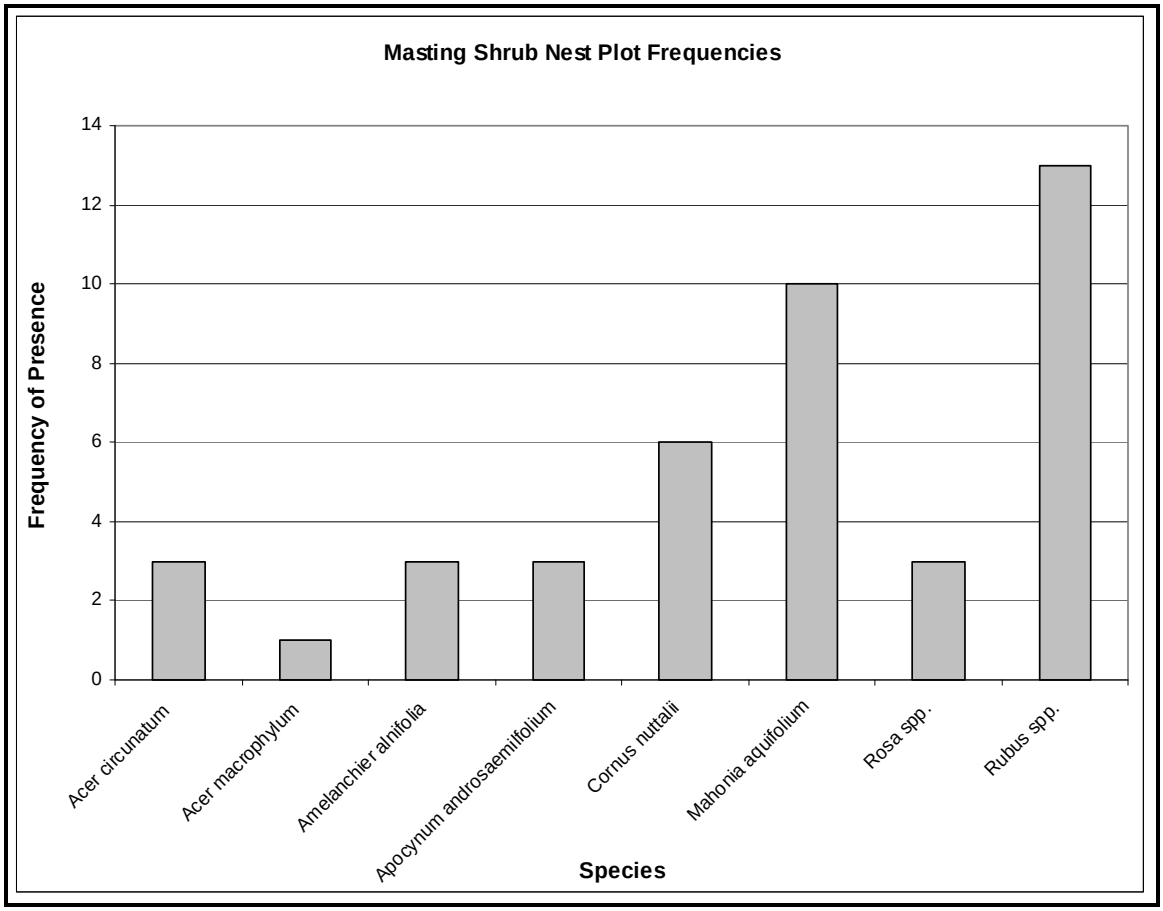


Figure 10. Histogram showing the plot frequency of masting shrub species found at western gray Squirrel nest plots (n=28).

Of the 28 nests documented, 10 nests (35.7%) were found in areas with visible fire sign. The remaining 18 nest sites showed no sign of recent burns (Table 11).

Table 11. Western gray squirrel nest plots where understory burn treatments were applied by the National Park Service.

Plot ID	Fuel Reduction Fire Treatment: Yes/No
BOCK01	Yes
BOCK02	Yes
BOCK04	Yes
BOCK05	Yes
BOCK06	Yes
BOCK07	Yes
BOCK08	No
BOCK09	No
BOCK10	No
BOCK11	No
BOCK13	No
BOCK14	No
BOCK15	Yes
BOCK16	Yes
BOCK24	Yes
BOCK25	No
BOCK26	No
BOCK27	Yes
BOCK29	No
BOCK30	No
BOCK31	No
COMP01	No
LAKE01	No
LAKE02	No
LAKE03	No
LAKE04	No
LAKE05	No
LAKE06	No

DISCUSSION

The western gray squirrel distribution in the Stehekin Valley appears patchy. With the exception of the single nest found up valley from Harlequin Bridge, east of the Valley Road, nests were found in clusters (Appendix B, Figures 2 to 6). Western gray squirrel sightings and nest locations documented during our fall 2004 surveys corresponded

closely to western gray squirrel activity reported by Stehekin residents and NPS personnel. The Lakeshore Trail, the Stehekin Landing and Golden West Visitors' Center, the Stehekin Pastry Shop, Boulder Creek area, the Stehekin School (old and new), the Buckner Orchard and Rainbow Falls are all locations of previously documented western gray squirrel activity as well as locally reported western gray squirrel high-traffic areas. Our western gray squirrel sightings along with observations by local residents also help corroborate that nests we identified as western gray squirrel nests were correctly identified. Our observer confidence levels of nest identification were also generally high, indicating nests were correctly identified as belonging to western gray squirrel (Table 4).

Local reports also indicate that there has been western gray squirrel activity farther up valley than was documented during our surveys. Western gray squirrel sightings have been reported at the Stehekin Valley Ranch (Courtney Family, personal communication, October 2004) and as far up valley as Bridge Creek campground (Scott Ross, personal communication, October 2004). Sightings have also been reported along the Lakeshore Trail, in the area between the Golden West Visitors' Center and our documented nest sites 5 km southeast near Flick Creek (Wendy Ross, personal communication, October 2004). Therefore, additional surveys in the Stehekin Valley in the future would likely extend the known range of this population.

Nest Site Preferences

Western gray squirrels in the Stehekin Valley may be showing preference to nest in trees that provide access to the canopy of the surrounding stand. As an arboreal species, they are known to use the canopy for travel. Interlocking crown tallies for nest trees were higher on average than for plot trees (Table 9). Also, nest trees had a larger mean dbh value than other trees in the plot, were always dominant or co-dominant members of the canopy community and were typically located within a group of trees (Table 6). Selecting dominant large dbh trees within a group of trees may result in selecting trees with larger crowns, which may allow greater access to the surrounding canopy. Dominant nest trees with large stem diameters and large crowns could be accessed from a greater number of adjacent crowns, allowing squirrels to access a number of tree crowns without

descending to the ground. In addition, since trees with larger dbh are also usually taller, choosing large trees to place nests would give animals a choice of placing nest higher off the ground. Western gray squirrels appear to choose to place their nests in the top ½ of the tree crown with many nests located in the top 1/3 of the tree (Figure 7).

Western gray squirrels appear to be selecting conifers as nest trees and selecting to nest in stands dominated by conifers. While 92.9% of nests were found in conifers (Table 4), only 75.3% of all plot trees were conifers (Tables 6 and 7). More specifically, western gray squirrels may prefer ponderosa pine. While 28.6% of the nest trees were in ponderosa pine, only 11.3% of plot trees tallied were ponderosa pine (Tables 4 and 7). Douglas fir represented 64.3% of nest trees and 64.0% of plot trees (Tables 4 and 7). Douglas fir was about six times as likely as ponderosa pine to show up in nest plots but only twice as likely to be a nest tree. This may indicate a western gray squirrel preference for ponderosa pine nest trees in a habitat type offering predominately Douglas fir trees as nest tree choices.

If western gray squirrels are also selecting nest sites based on the presence of understory masting shrubs, it is likely that they may be using *Rubus spp.*, Oregon grape and Pacific dogwood as food sources during summer and fall periods. These masting shrubs were the most common in the nest plots sampled (Figure 10).

No species of oak tree were observed on any of our surveys in the Stehekin Valley. Although most western gray squirrel populations have been associated with Oak forest communities, the Stehekin Valley population of western gray squirrel appears to have adapted to the conifer dominated low elevation mixed Douglas-fir/ponderosa pine/big leaf maple habitat types. These sites typically have low shrub densities and sparse herbaceous ground cover resulting in very open understories (Table 10). The stands are typically park-like, with lower densities of dominant and subdominant trees resulting in low canopy cover (<75%) (Tables 8 and Figure 9). In addition, nest sites were often located near streams indicating riparian areas and water availability may be an important habitat component to these populations. These areas also commonly had an overstory

component of deciduous mast producing trees which could be used as a supplemental food source.

Parts of the Stehekin Valley near residences have been treated with prescribed understory burns in order to reduce fuel loads and decrease chances of high intensity natural burns. Nest sites were clustered in and out of areas that received burn treatments. Although about two thirds of nests were outside burned areas, the burned areas did not seem to deter squirrel activity or inhibit nest building at these sites (Table 11).

More work needs to be conducted in this region to determine the full distribution of this population, population size, population trend and what primary food sources these animals are dependent on. In addition, by sampling habitat at random plots and nest locations through the valley, better information on habitat selection by this unique population could be obtained.

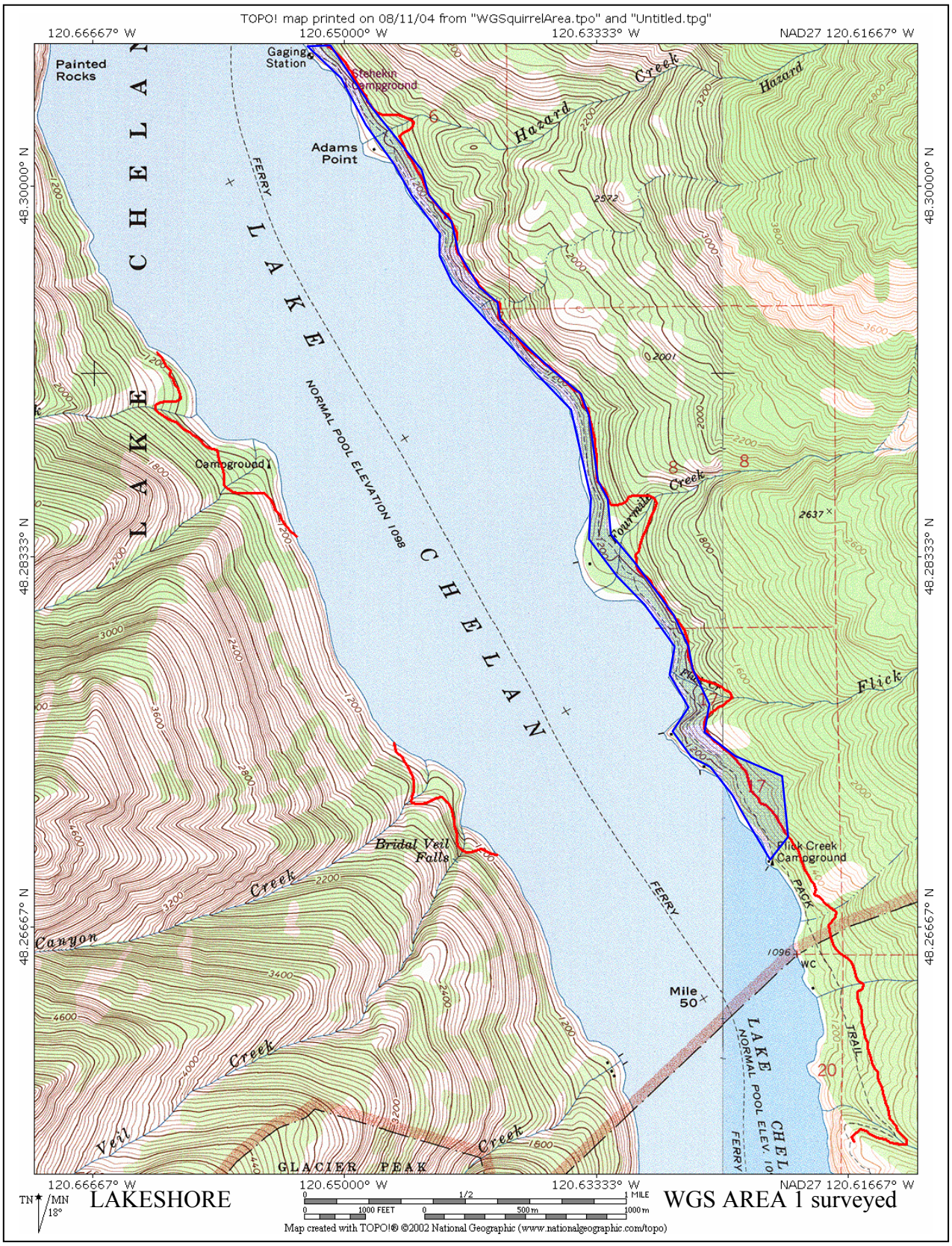
LITERATURE CITED

Department of the Interior, Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; 90-day Finding for a petition To List the Washington Population of the Western Gray Squirrel as Threatened or Endangered. Federal Register, Vol. 67, No. 209. October 29, 2002, pp 65931-65933.

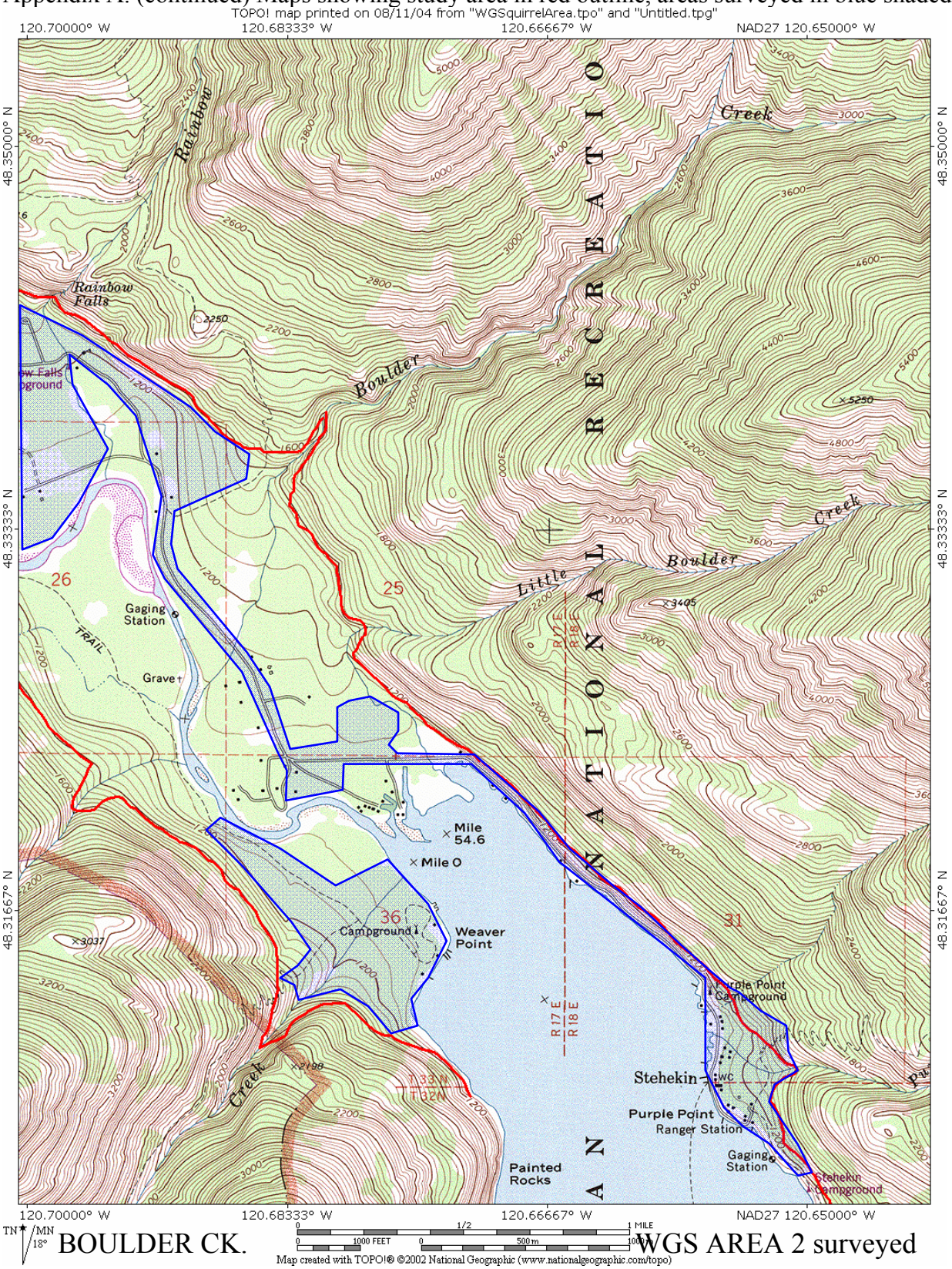
Department of the Interior, Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; Status Review and 12-Month Finding for a petition To List the Washington Population of the Western Gray Squirrel. Federal Register, Vol. 68, No. 111. June 10, 2003, pp 34628-34640.

Franklin, Jerry F. and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Corvallis, OR: Oregon State University Press.

Appendix A. Maps showing study area in red outline, areas surveyed in blue are shaded.

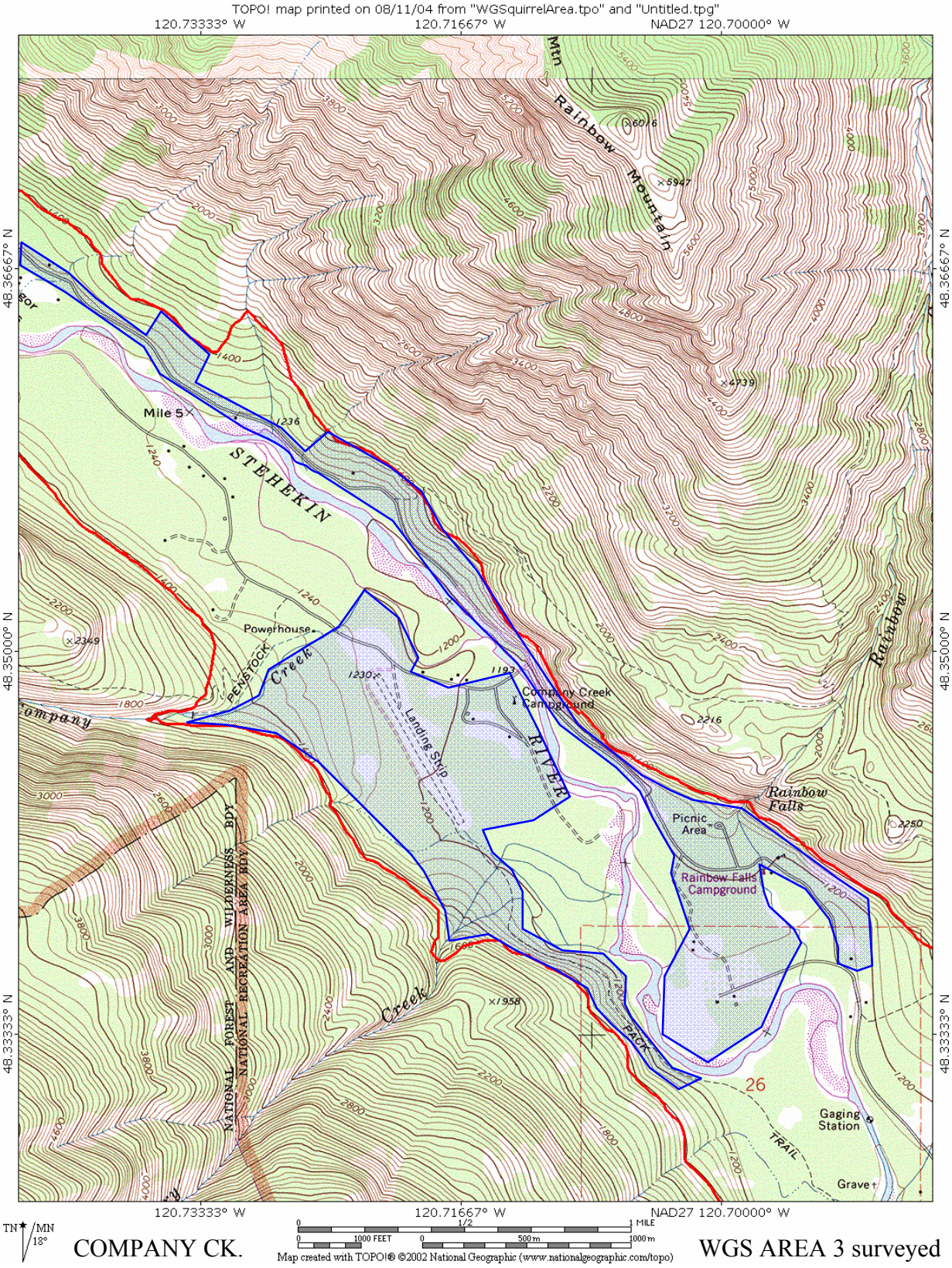


Appendix A. (continued) Maps showing study area in red outline, areas surveyed in blue shaded.



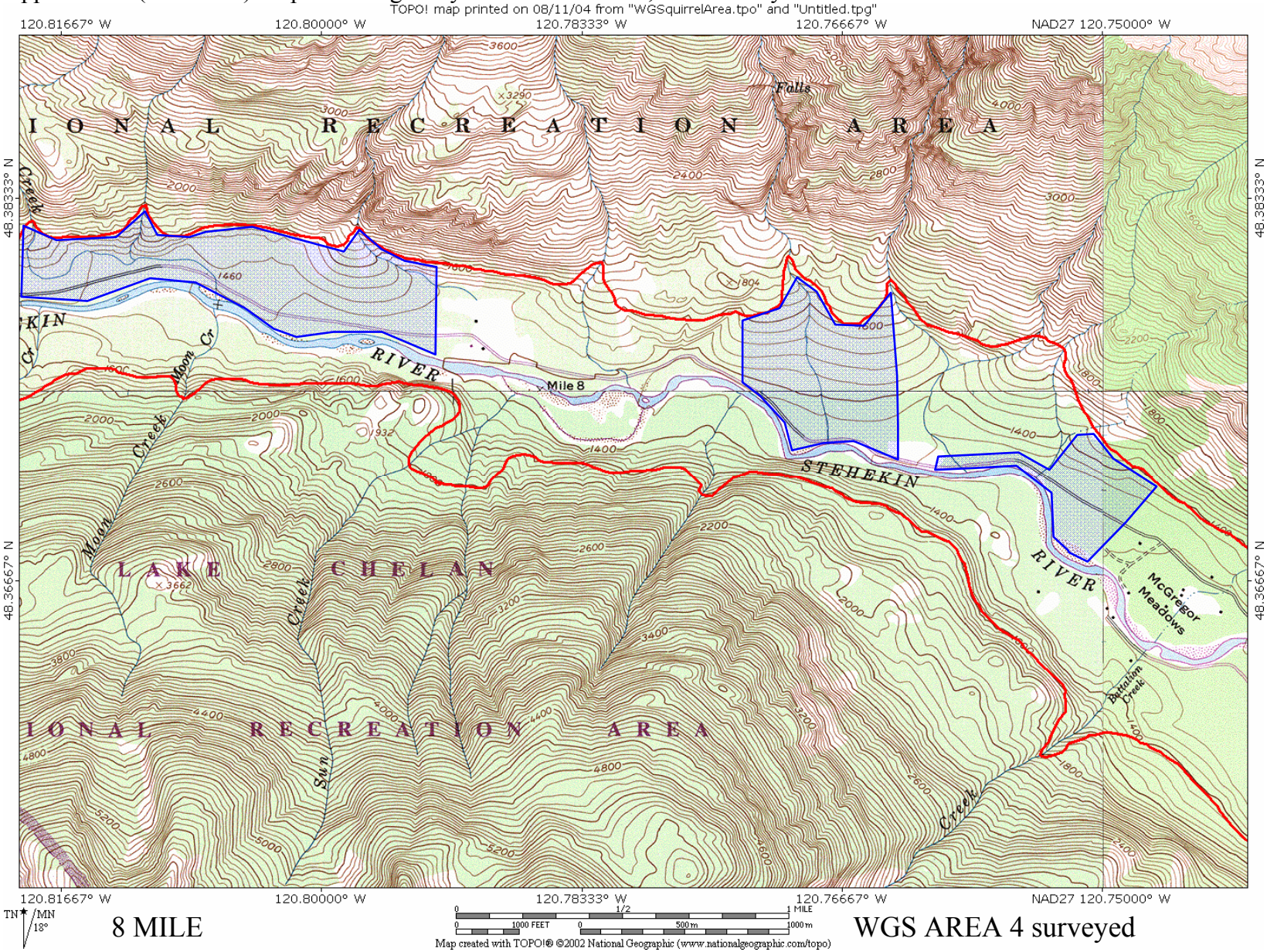
BOULDER CK. WGS AREA 2 surveyed

Appendix A. (continued) Maps showing study area in red outline, areas surveyed in blue shaded.



COMPANY CK. WGS AREA 3 surveyed

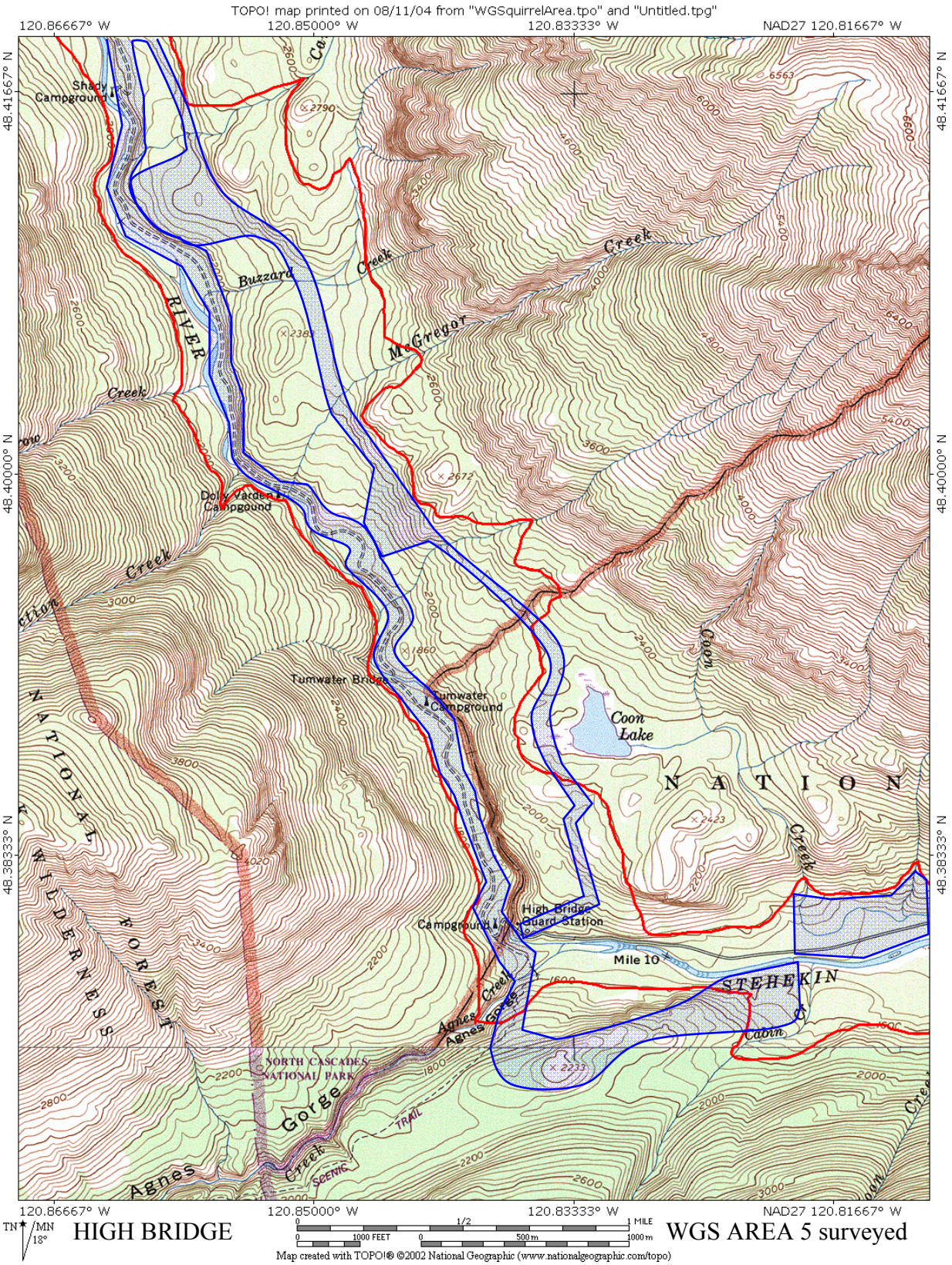
Appendix A. (continued) Maps showing study area in red outline, areas surveyed in blue shaded.



8 MILE

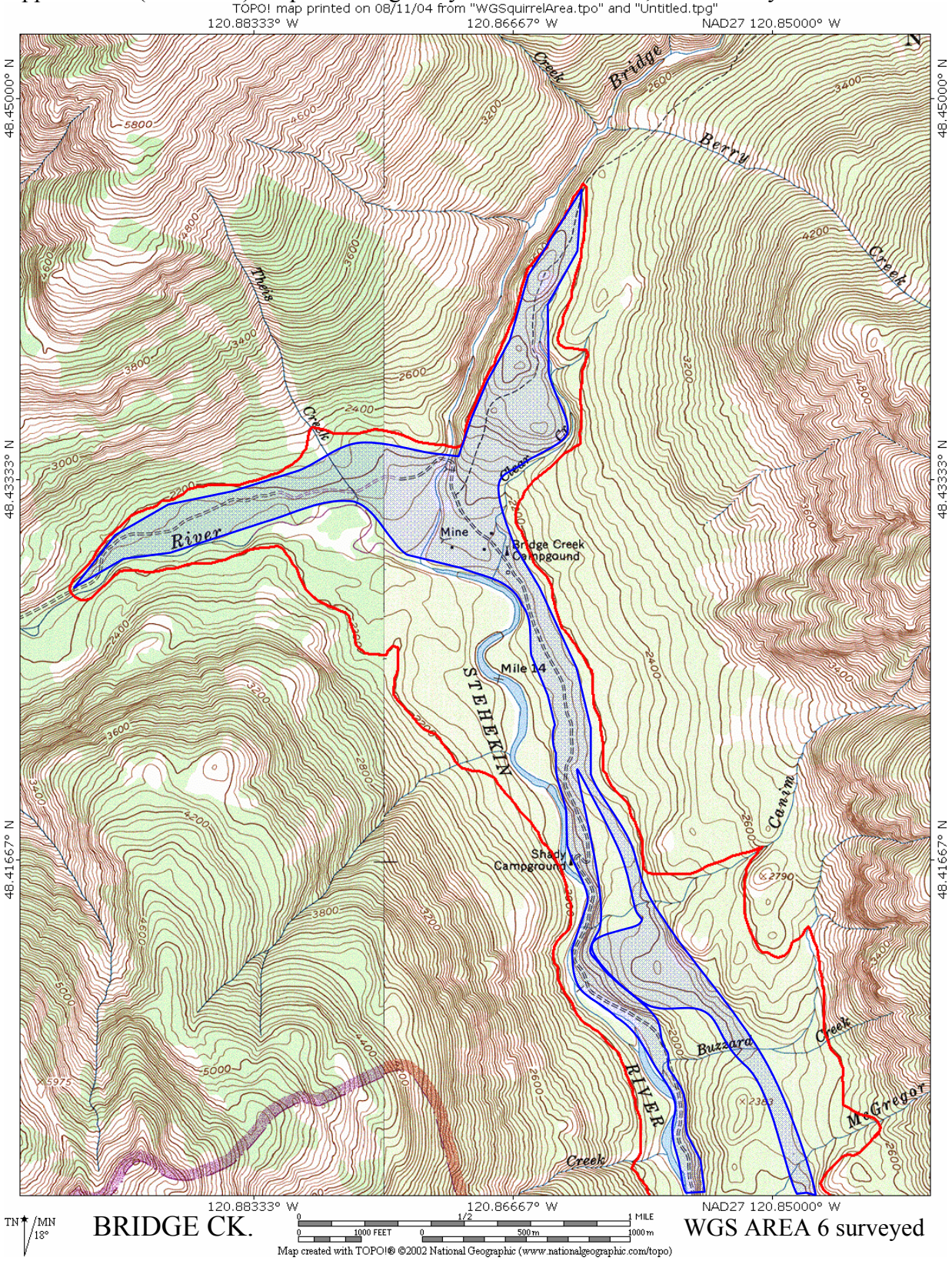
WGS AREA 4 surveyed

Appendix A. (continued) Maps showing study area in red outline, areas surveyed in blue shaded.



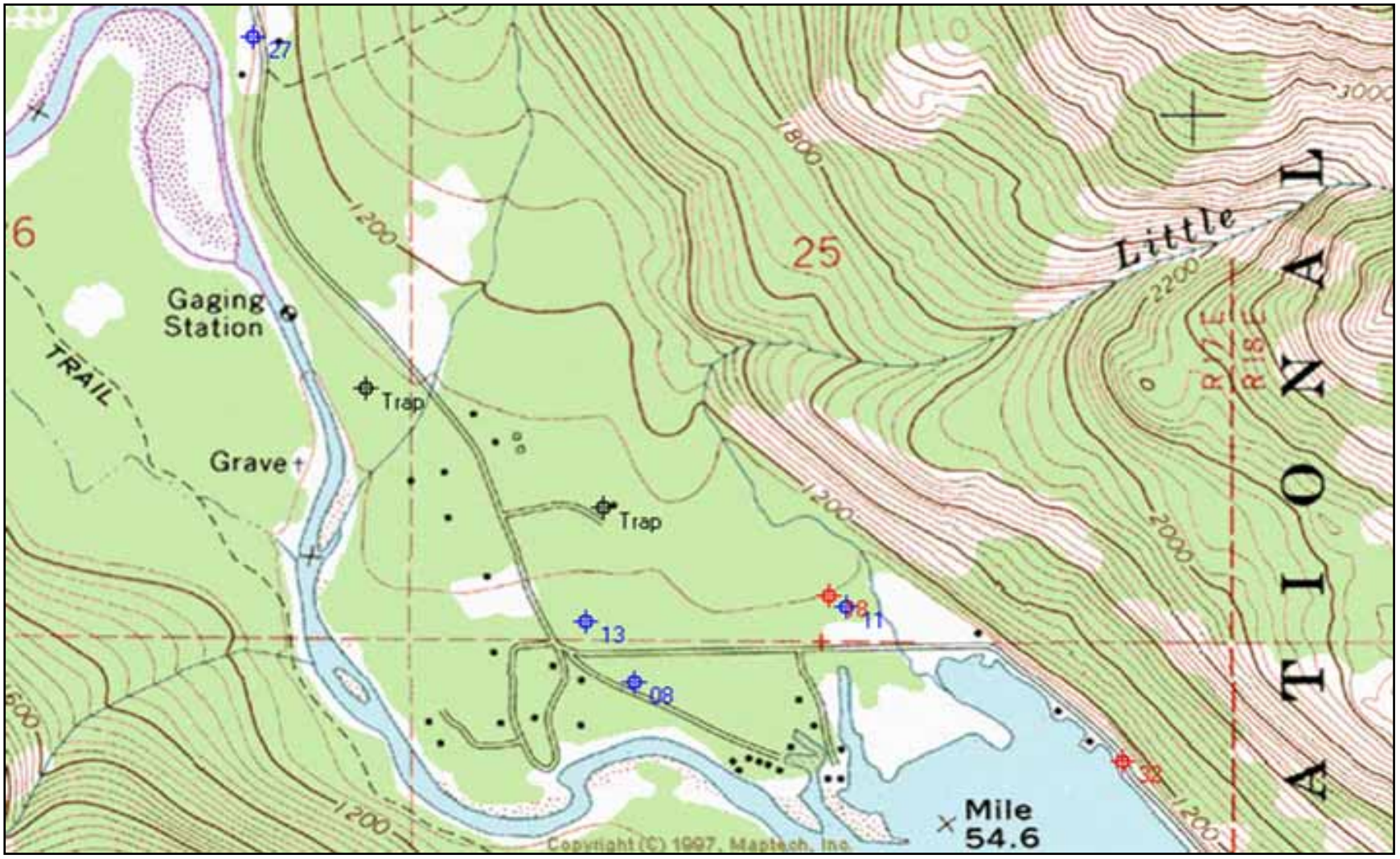
HIGH BRIDGE WGS AREA 5 surveyed

Appendix A. (continued) Maps showing study area in red outline, areas surveyed in blue shaded.

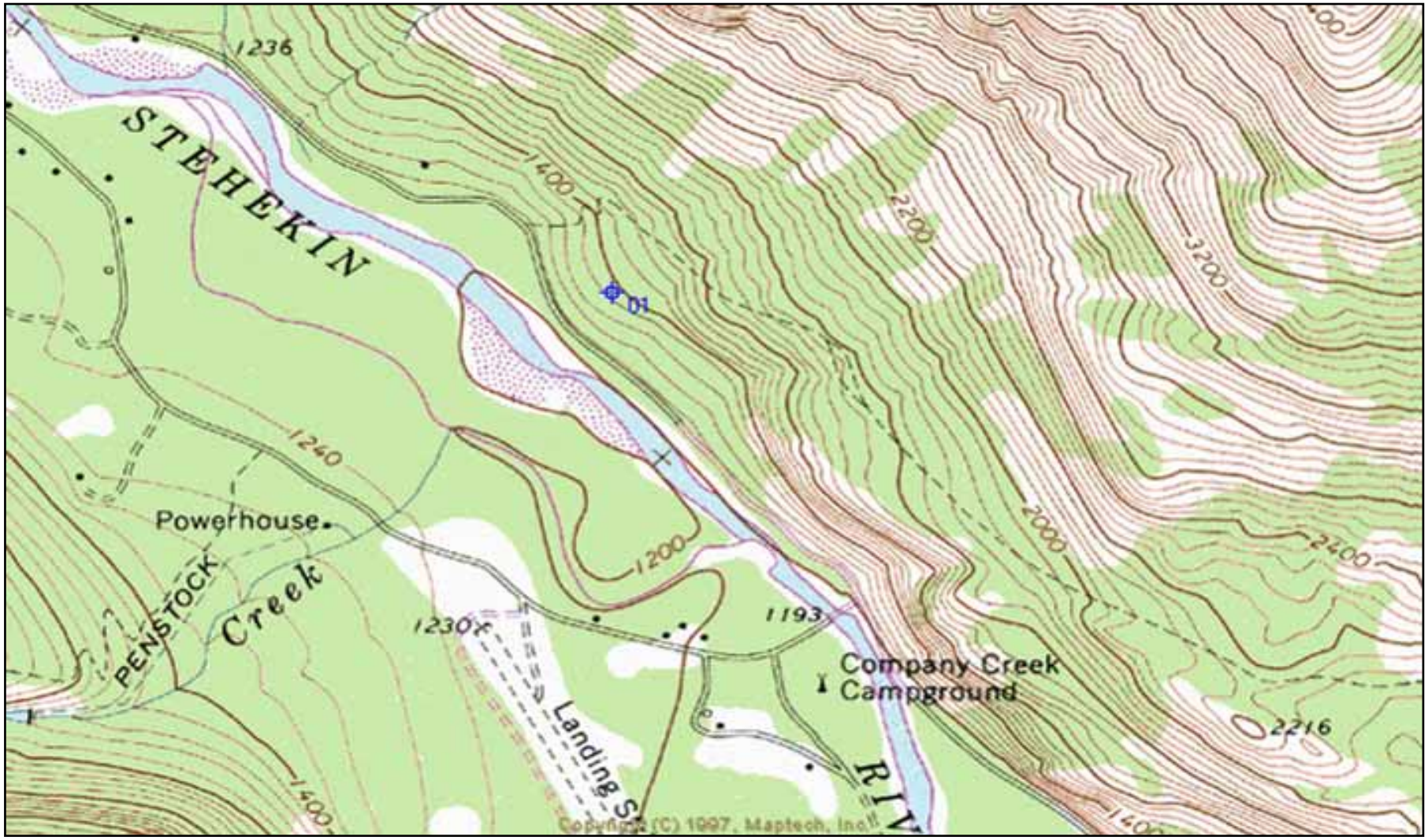


BRIDGE CK. WGS AREA 6 surveyed

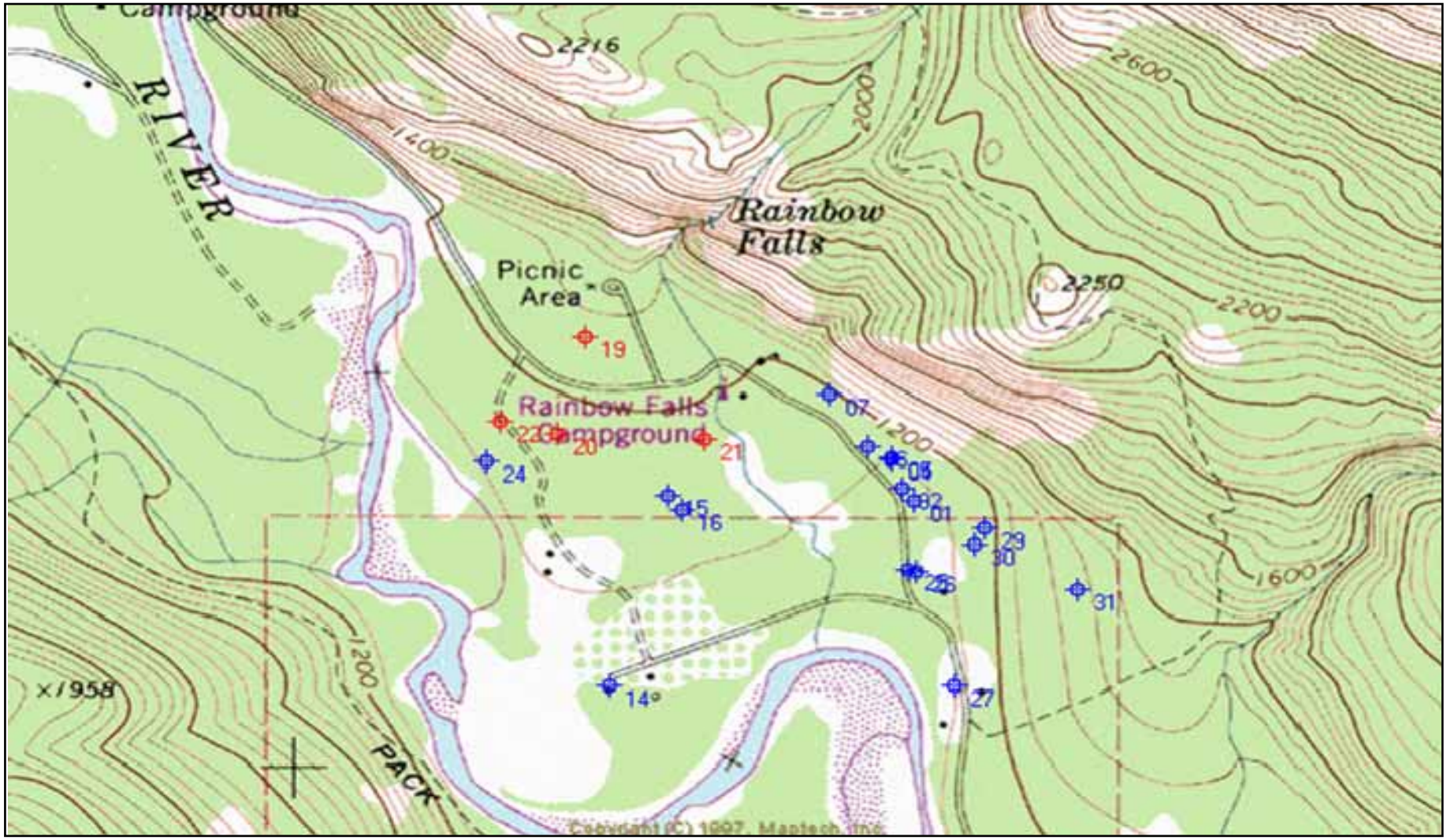
Appendix B, Figure 2. Lake Head western gray squirrel locations. (⊕ Nest sites ⊕ Sightings ⊕ **Hair samples collected**)



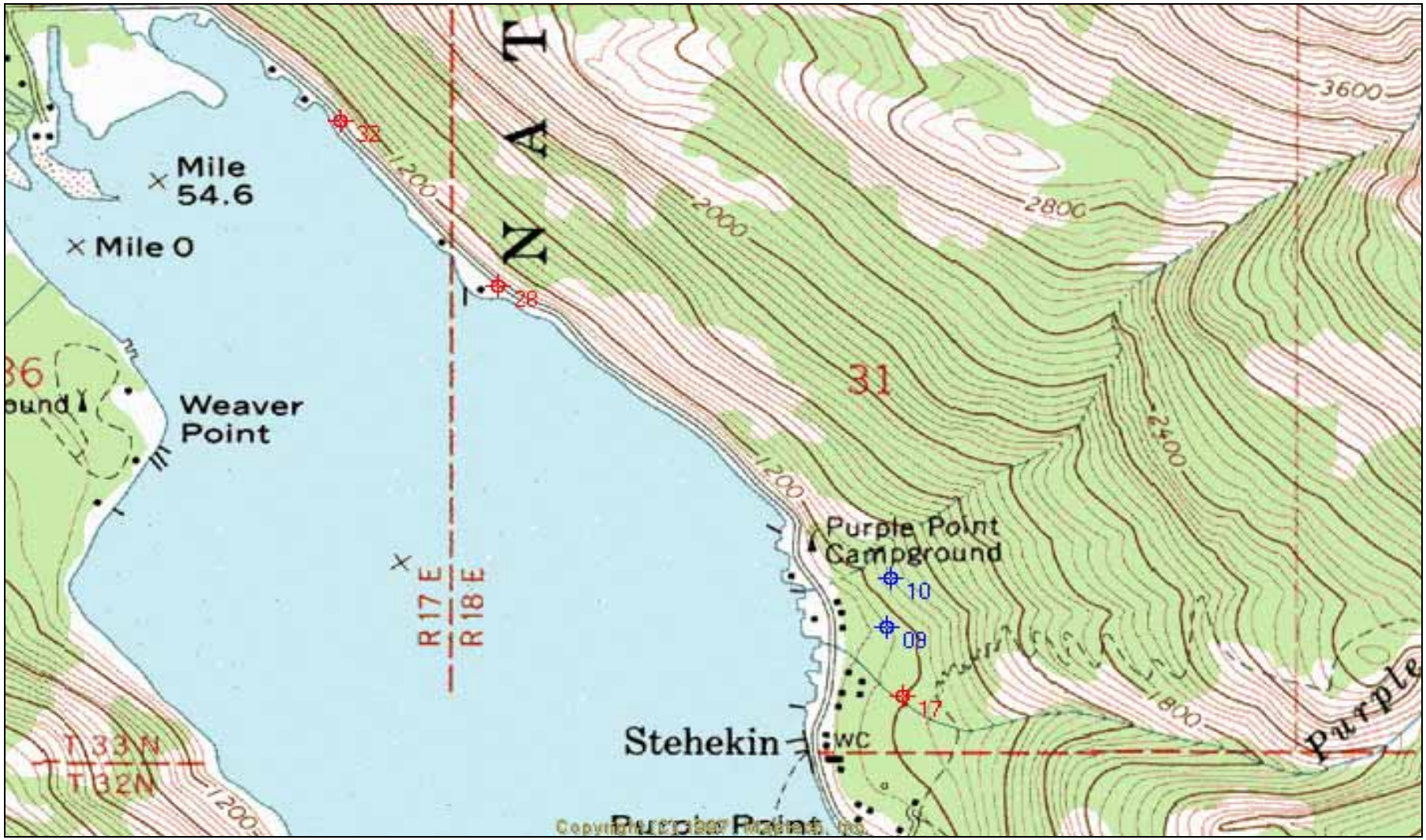
Appendix B, Figure 3. Company Creek western gray squirrel locations. (⊕ Nest sites)



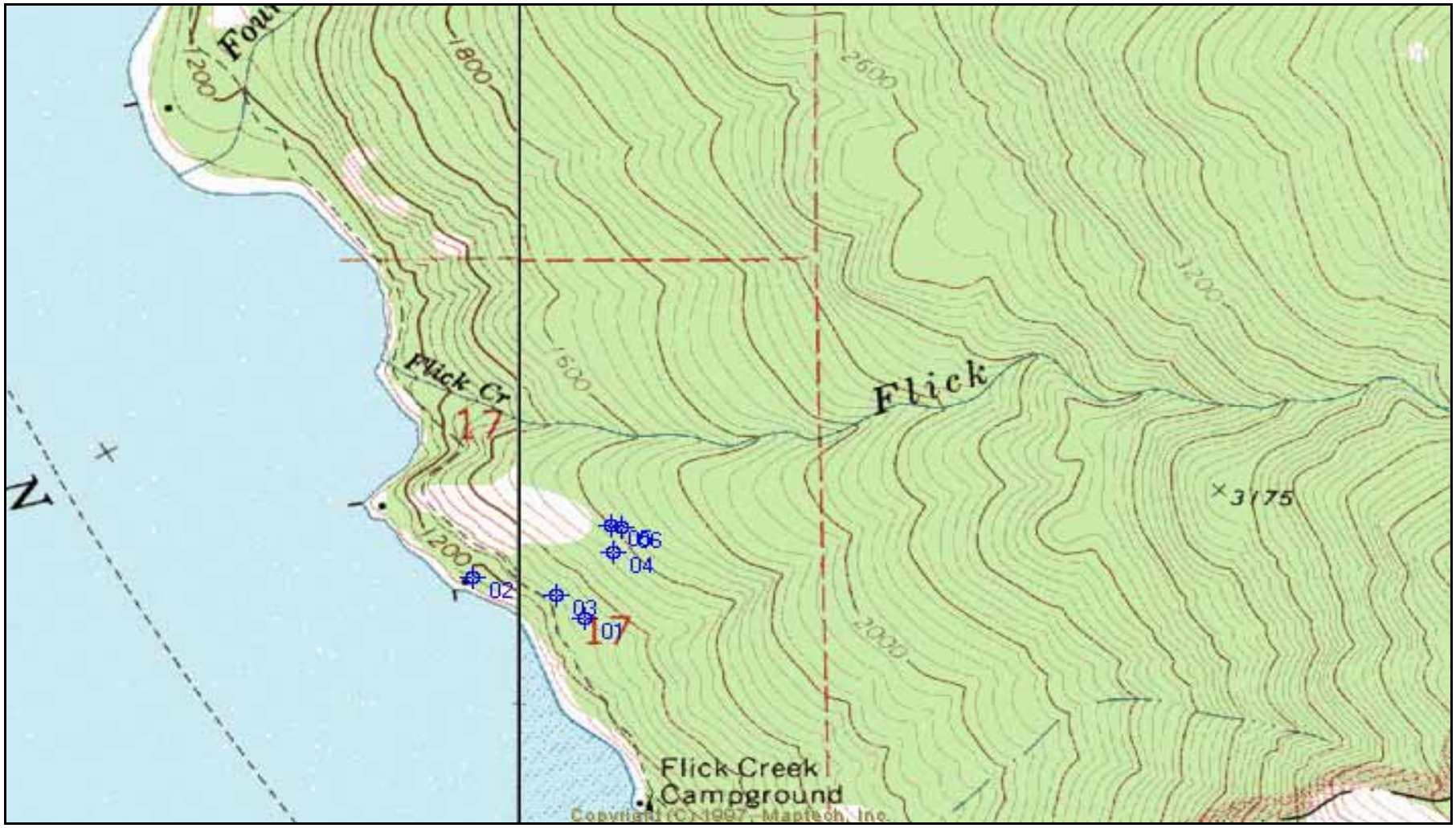
Appendix B, Figure 4. Buckner Orchard western gray squirrel locations. (⊕ Nest sites ⊕ Sightings)



Appendix B, Figure 5. Stehekin Landing western gray squirrel locations. (⊕ Nest sites ⊕ Sightings)



Appendix B, Figure 6. Flick Creek western gray squirrel locations. (⊕ Nest sites)



APPENDIX C

Western Gray Squirrel Survey Protocol Data Sheet Instructions.

General Info	Indicate name of crew members, date of survey, and county of survey.
Site name	Indicate survey location.
Plot type	Indicate type of plot: **N**est, **R**andom tree, **T**rap site, **S**quirrel sighting.
Plot ID/Nest #	Center a 10.6-m radius plot on a nest or random tree, or where a squirrel was first observed. Lay 2 transects in rough cardinal directions.
Easting/Northing	UTM location. Be sure to indicate the datum (e.g., NAD 1927).
Aspect	Bearing of general downslope direction, or **flat** if no slope (<5%) or gently rolling.
Photo ID	Indicate roll number and photo number for plot photo.
Bearing/Distance/Lens	Bearing and distance from nest tree to photo point and lens size used, i.e. 50mm.
Nest	If no nest then skip to next section.
Nest type	Stick, cavity, or summer (deciduous leaf nest).
Nest color	G - Green (any amount); R - Red or Rusty (any amount, but no green); N - Neither (brown/black)
Nest condition	A = A fully constructed nest or a partially constructed nest that contains some green/yellow material; B = Nest appears to have lost material and is beginning to fall out of tree; C = Much material is gone, but material size and composition indicates western gray squirrel.
Nest tree dbh	Measure the diameter-at breast-height of the nest tree in cm.

Height of nest tree	Record height of nest tree using a Biltmore stick or clinometer.
Canopy dominance-nest tree	**I**solated-Crown receives full light from above and on sides; may be well above canopy height.
	Dominant-Crown receives full light on top and partial light on sides; above average canopy height.
	Codominant-Crown receives full sun on top but little on sides; at general canopy height.
	N-Intermediate-These crowns occupy a subordinate position and are subject to strong lateral competition from crowns of dominants and codominants.
	Overtopped-Crown receives no light from above or on sides; below average canopy height.
Tree position	**I**solated-Tree free to grow on all sides and is ≥ 9 m. from other trees, measured bole to bole.
	Open-Tree is detached from a group of trees, but is closer than 9 m.
	Marginal-Tree is growing on the edge of a group of trees.
	N-Interior-Tree is growing inside a group of trees.
Type of deformity	**0) None; 1)** Broken/dead tops; 2) Split or forked tops; 3) Epicormic branching; 4) Mistletoe; 5) Kink in trunk not caused by loss of terminal leader.
at nest?	Yes/No - Is the nest located at the deformity?
Height of nest tree	Record height of nest tree using a Biltmore stick or clinometer.
Overstory Trees	
# Interlocking crowns	At plot center and 4 quarter points, find the nearest live overstory tree (≥10cm dbh) and tally the number of overstory trees (live or dead) whose crown is ≤1m from the focal tree; use nest or random tree @ center.
% Canopy cover - total	Ocular estimate of tree canopy using the following classes: 1) 0-1%, 2) 2-5%, 3) 6-25%, 4) 26-50%, 51-75%, 6) >75%. Train observers on sites where canopy has been estimated with a Moosehorn cover scope.
% Conifer vs. deciduous	Ocular estimate of tree canopy by category using the above cover classes; total cover may exceed 100%.
Tree tally-dbh by species - 10.6-m plot	Measure diameter of each overstory tree at breast height (1.36m); record in proper column. If species is "Other", write 4-letter code under "Species". Record dead trees under "Other"

	(e.g., dead PIPO)".
Understory Vegetation	
Sapling tally-pine/oak/fir/other in 5.6 m plot	Tally number of saplings (5.0 to <10 cm dbh and >1 m in ht), according to species. If many stems, tally on back of data sheet and enter totals in spaces provided.
% Shrub and ground cover	Estimate % cover of seedlings/shrubs/ferns/forbs/grass/moss/litter/rock&bare/AWD (all woody debris) on 5.6-m plot using the following cover classes: 1) 0-1%, 2) 2-5%, 3) 6-25%, 4) 26-50%, 51-75%, 6) >75%. Estimate to the nearest 1%; total may be >100%; 0-1% is trace. Oak seedling-a single shoot >1 m high.
Predominant shrub height	0) 0 - 0.5 m; 1) 0.5 - 1 m; 2)1.1 - 2 m; 3) >2m
% Cover of masting shrubs	Record percent cover of masting shrubs by species using the above cover classes.
CWD	Tally CWD $\geq$10 cm at the largest end by dbh and decay class. Downed wood includes all horizontal stems or branches <2 m. in height.
Plant Association	Key out the plant association using a local guide; record the name in the space provided.

APPENDIX D

WESTERN GRAY SQUIRREL SURVEY - COVER DATA SHEET

Use one cover sheet per stand surveyed. Attach the map(s) on which you mark squirrel nests and show the transect(s) or area(s) surveyed. For each map, attach one Map Label and one or more Western Gray Squirrel Survey Data Sheets. If you see or hear a western gray squirrel please fill
out a wildlife observation form and attach.

Mark Water Sources and Survey Transect or Survey Polygon on Attached Map.

Name of Area Surveyed:
(Use a generic geographic name like "Yahne Canyon". Add the timber sale name/number if available.)

Location (UTM):

Date(s) Surveyed:
Start/Stop time(s):

Surveyor Names and Affiliations:

Contact Name, Address, & Phone:
Hamer Environmental
19997 Highway 9
Mount Vernon, WA 98274
(360) 422-6510

Directions to Site:

Description of Habitat at Site:

Site name	**Nest type**			**Confidence rating:**	
Plot type	**Nest color**			nest cluster	4
Plot ID/Nest #	**Nest condition**			size ≥1.5 ft mix of	3
Easting:	**Nest/center tree dbh**			materials	2
Northing	**Tree height**			in pine	1
Photo ID	**Canopy dominance**			**WGS observed?**	
Bear/Dist/ Lens	**Tree position**				
Aspect	**Type of deformity**			**at nest?**	
Overstory trees	**Center tree**	**1**	**2**	**3**	**4**
# Interlocking crowns					
% Canopy cover - total	**Tree tally - record dbh (>10 cm) by species on 10.6-m plot**				
	Ponderosa pine	**Big-leaf maple**	**Douglas-fir**	**Other - dbh**	**Other - species**
% Canopy in conifer vs. deciduous					
C: D:					
Sapling tally-pine/oak/fir; 5.6 m plot					
P- Big maple-					
F- Other-					
% Shrub and ground cover-5.6 m plot					
seedlings-					
Ferns-					
Forbs-					
grass-					
moss-					
Rock/bare-					
Litter-					
AWD-					
All shrubs-					
Predominant shrub height:					
% Cover masting shrubs-5.6 m plot					
Snowberry-					
Hazel-					
Plant community					
Comments:					

	CWD-5.6 m plot		**Class 1**	**Class 2**	**Class 3**
	10-25 cm dbh				
	26-50 cm dbh				
	>50 cm dbh				