Marbled Murrelet Habitat Enhancement Experiment: 600 Road Project Site

As-Built Report

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Report Summary:

The objective of this marbled murrelet habitat enhancement experimental project is to determine if active habitat restoration techniques can facilitate the development of marbled murrelet nesting habitat in second-growth forest. These techniques are intended to be implemented in a variety of environmental conditions (e.g., soil, aspect, elevation, tree species, etc.) to determine how they might impact the results. Similar treatments have already been utilized in the ecological and restoration thinning programs in the Cedar River Municipal Watershed (CRMW), and this project can be implemented in conjunction with those programs to both offset costs and extend the range of monitoring of results. This plan outlines the initial installation of the experiment, which can then be replicated in other areas based on positive financial, logistical, and ecological results.

This report summarizes the implementation of a habitat enhancement project for marbled murrelets at a project site on the 600 Road in the CRMW. Project implementation was conducted from October 5-20, 2010. Resampling is planned for 2020. Project goals include:

- Quantitatively explore the efficacy of silviculturally enhancing murrelet nesting habitat, including the following hypothesis:
  - Creating gaps around dominant and co-dominant trees will maintain/increase branch growth compared to similar trees in the untreated matrix;
  - Topping dominant and co-dominant trees will increase remnant branch growth (reiteration of juvenile growth morphology within the mature crown); and,
  - Topping dominant and co-dominant trees in gaps will result in greater remnant branch growth than gapping or topping trees alone.
- Install the project on the landscape where it has the highest probability of benefiting the murrelet population.

1.0 Marbled Murrelet Background:

1.1 Introduction: The marbled murrelet (*Brachyramphus marmoratus*) in Washington State is listed as a threatened species by both the U.S. Fish and Wildlife Service and the Washington State Department of Fish and Wildlife primarily because of the loss of old-growth forest nesting habitat (WDFW, 1993). As such, murrelets are also a "species of greatest concern" in the Cedar River Watershed Habitat Conservation Plan (CRW-HCP), which seeks to protect (or retain) existing old-growth forest in the watershed and restore old-growth forest structure and function to second-growth forest through both active and passive management. Included in the forest restoration program funded under the CRW-HCP is an experimental exploration of methods to enhance marbled murrelet nesting habitat in selected second-growth forest stands. Since few land management agencies are actively attempting to specifically restore murrelet habitat, which would likely require decades to develop under any treatment, the experimental approach of this program will address specific questions on active habitat development.

1.2 Marbled Murrelet Habitat: In Washington State, marbled murrelets typically nest on large branches (4-18 inches) in the upper canopy (65-190 feet) of old-growth forest trees within 52 miles of marine foraging habitat, a distance that encompasses the entire Cedar River Municipal Watershed (CRMW). Though it appears that murrelets key-in on appropriate structures in individual trees, occupancy is typically associated with old-growth stands greater than five acres in size. On the Olympic Peninsula, where the most comprehensive murrelet nesting data in Washington State was developed (Hamer 1998), murrelet nests are associated with western hemlock (18 nests), Douglas fir (two nests), and Sitka spruce (two nests). Though over 80% of the nests found were in western hemlock, that species also dominated the search landscape (72% of the trees climbed). Though Sitka spruce had a much higher nest per tree ratio (0.057) than either western hemlock (0.017) or Douglas fir (0.015), the relative low abundance of spruce in both the peninsula and in the CRMW makes utilizing it for habitat restoration problematic. In the Olympic Peninsula study, no murrelets were found to nest in western red cedar, Pacific silver fir, or noble fir, which typically have small or downward sloping branches that will not support a nest. Most nests in western hemlock were associated with dwarf mistletoe, which can provide both nesting structure and hiding cover around a nest. Large trees in stands with broken canopies (e.g., areas of high "roughness" or rumple, on slopes, along roads) may provide murrelets with greater access to potential nesting sites.

1.3 The Cedar River Municipal Watershed: For a period of 50 years, the CRW-HCP effectively placed nearly 85,500 acres of forests in the CRMW in reserve status by protecting all remaining native forest, prohibiting the harvest of timber for commercial purposes, and by committing to a variety of conservation measures intended to protect, restore, or improve habitat for 83 species of concern. Many of these species, such as the marbled murrelet, depend on late-successional and old-growth forest habitats. Forest habitat restoration efforts are aimed at facilitating and restoring natural forest processes while increasing the habitat available for species dependent on late-successional forests. Second-growth forests occupy lands that were logged prior to the adoption of the CRW-HCP and make up 71,500 acres of the CRMW, while the remaining 14,000 acres are late-successional or old-growth forest. Intervention for the purpose of habitat restoration will only occur within the second-growth forest.

The historic pattern of forest fire and clearcut timber harvest is evident today by the juxtaposition of forest stand ages in the CRMW. Remnant old-growth forest ranges in age from 250 years to greater than 700 years, largely originating from the last stand-replacement fires, with the oldest trees found in the Rex River basin. Old-growth forest is typically found at the higher elevations at the eastern end of the watershed and is surrounded by the youngest second-growth forest (15-30 years old). The oldest second-growth forest (70-150 years old) is typically found at the lower elevations at the western end of the watershed. Forest habitat restoration under the CRW-HCP has generally concentrated on increasing the connectivity between patches of old-growth forest and between patches of old-growth forest and older second-growth forest.

1.4 Marbled Murrelets in the CRMW: Marbled murrelets were first identified in the CRMW in the Rex River basin in the mid-1990s, but systematic surveys were not initiated until after the adoption of the CRW-HCP. During radar and audio/visual surveys conducted in the watershed from 2005- 2007 marbled murrelets were shown to occupy two old-growth forest stands in the watershed, including in the Rex River basin and along the South Fork Cedar River in the upper (eastern) watershed. Since detecting behavior associated with nesting is difficult on a landscape scale, stand occupancy may be more extensive than currently documented. Audio/visual surveys are ongoing in potential habitat adjacent to restoration thinning projects to minimize the potential impacts of those projects on possible murrelet nesting. For more information on murrelets in the CRMW, please see:

http://www.cityofseattle.net/UTIL/About_SPU/Water_System/Water_Sources_&_Treatment/CedarRiverBiodiversity/Birds/SPU01_003069.asp

2.0 Habitat Enhancement Techniques

Based on observations in the Oregon Coast Range where murrelets seem to key-in on large branching structures of individual trees, treatment techniques in the CRMW will also concentrate on developing nesting platforms in individual trees across a forest stand. Two potential strategies were considered:

1) *Artificial nesting platforms:* Though evaluating the efficacy of artificial nesting platforms is an interesting topic, the rate of nesting on available nesting platforms makes this strategy unlikely to provide much data. Hamer (pers. comm.) found 22 murrelet nests on the Olympic Peninsula after climbing almost 1,500 trees in known occupied sites that had a total of almost 23,000 potential nesting platforms. At this rate it would take roughly 1,000 artificial platforms to generate one nest in an already occupied site, which is unlikely to be cost effective.

2) *Stimulate large branch structure*: There is much evidence that silvicultural thinning during the stem exclusion stage of forest succession can maintain or increase the growth of the remaining trees. Thinning may also facilitate development of large branch structure as a result of maintaining or increasing that growth, but the effects of intervention directed specifically at individual branches are unknown. In developing marbled murrelet nesting habitat restoration recommendations in the redwood region, Franklin *et al* (2007) suggested exploring "approaches to stimulating development of reiterated boles and large branches by mechanically treating selected potential nest trees." Trees have also been observed in our region that have had their tops previously broken by storms and where the reiteration of new leader branches is creating large branching structure. Combining thinning around selected trees and topping them to stimulate potential nesting platforms may shorten the time needed to naturally create such structure. The increased canopy variability (or rumple) resulting from thinning and topping may also attract murrelets in search of nesting structure. This project concentrates on the efficacy of this second method.

2.1 Landscape Restoration Strategies: This project considered second-growth forest for treatment that was either in proximity to the two known occupied murrelet sites in the CRMW or was along suspected flight paths from marine foraging habitat (as identified by the 2005-2007 radar data). If we can silviculturally facilitate potential murrelet nest sites this strategy will directly increase nesting possibilities for the existing population of murrelets. Areas of high productivity were generally not considered for treatment, since habitat will likely develop quickly in those areas without active enhancement. Instead, 40 to 70 year-old stands were targeted where tree growth is slowed from density-dependent competition, and have significant components of dominant or co-dominant western hemlock and Douglas fir (Sitka spruce is relatively rare in uplands on the CRMW landscape). The live crowns of these trees must also be deep enough to likely respond to proposed treatments. Stands with existing dwarf mistletoe infestations are also preferred, though facilitating the propagation of mistletoe is being explored in a separate project.

3.0 Marbled Murrelet Habitat Restoration Project

3.1 The Treatment Stand: The target stand selected for the initial installment of this experimental treatment is located in the Upper Cedar River sub-basin, adjacent to the river, and roughly a mile downriver from one of the known occupied murrelet sites in the CRMW (Figure 1). The location provides habitat connectivity between known nesting habitat and potential resting/foraging habitat of Chester Morse Lake.

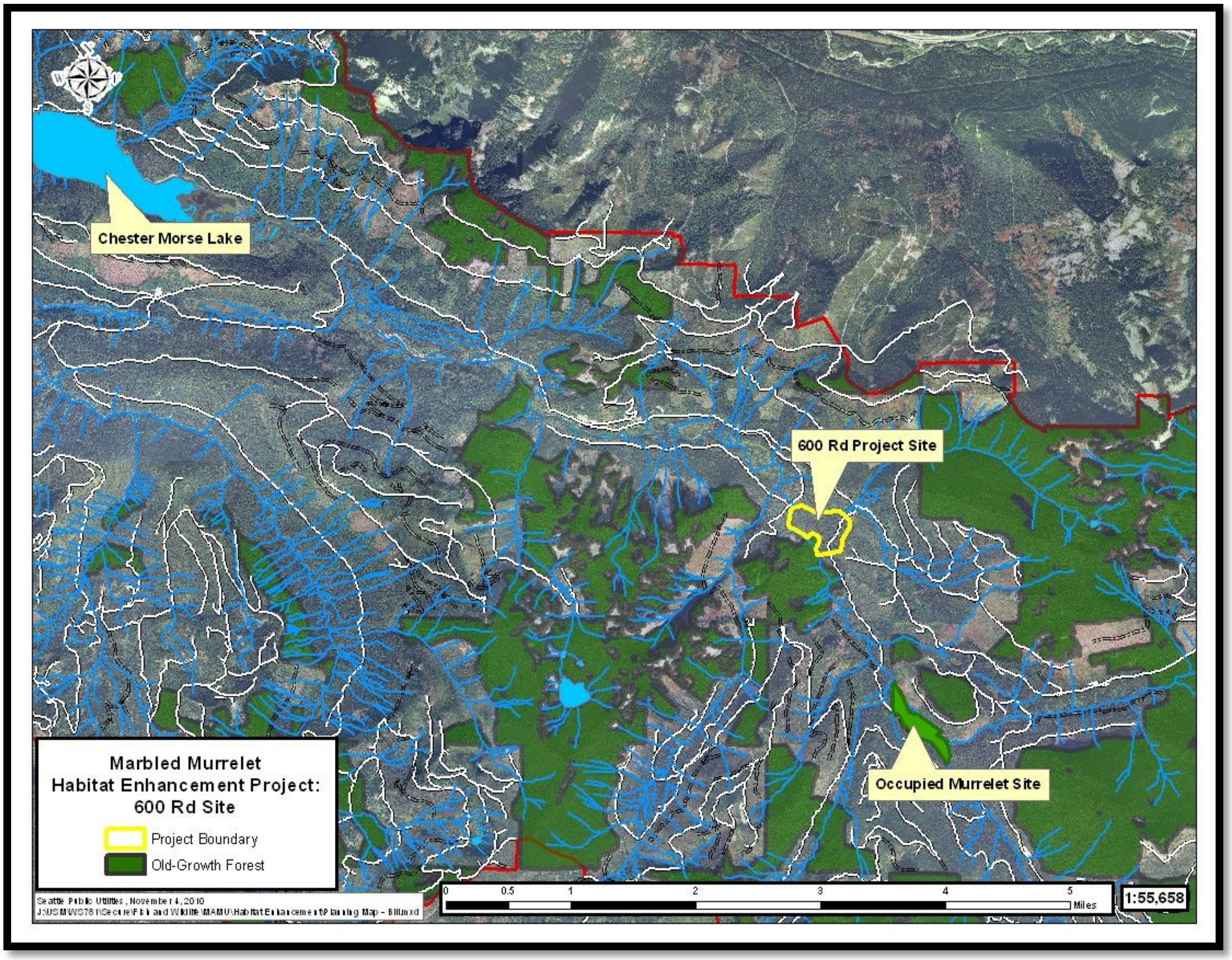

Figure 1. Landscape of proposed 75-acre project area in the Upper Cedar River Basin bounded by the Upper Cedar River, Bear Creek, and 600 Road.

The stand has relatively flat topography and sits in a triangle between the Cedar River, Bear Creek, and the 600 Road, which provides easy treatment and monitoring access. It is roughly 75 acres in size, approximately 65 years old, undergoing density dependent mortality, and dominated by Douglas fir, Pacific silver fir, and western hemlock. Timber cruise information is currently unavailable for the stand, but the dominant trees are <26” dbh and tree density is severely limiting the growth of understory vegetation. The relatively low elevation (1,900-2,200 feet above sea level), moderate growing site (site class 3), tree species ages, abundance, and density, and landscape considerations, make the stand an ideal candidate for experimental enhancement.

3.2 Treatments: Two treatment methods were implemented to actively enhance large-branch murrelet nesting structure in individual western hemlock and Douglas fir trees:

- **Gaps:** In the gap treatment, all canopy competitors from within 40 feet of targeted dominant/co-dominant trees were removed, effectively leaving a single target tree in a gap. This method is intended to increase light availability in the tree canopy to increase/maintain overall branch growth. It allows for 20-foot branches growing from the target tree and the trees surrounding the gap before direct competition recommences. Epicormic branching on Douglas fir trees may also be stimulated.

  All trees cut were left as downed wood and cut to be within six feet of the ground. Wood in varying contact with the ground will allow for differential decay rates, with the intended purpose of slowing the decay rate and lengthening the longevity of the ecological value of the wood.

- **Topping:** The topping treatment entailed removing the tops from targeted dominant/co-dominant trees. This method is intended to stimulate repartitioning of resources within the tree toward the topmost branches as they compete to become the new “leader,” thereby increasing branch growth and creating unique branching structure in the upper canopy. Trees were topped at 4-6 inch tree bole diameter, to maximize the residual live crown while limiting the safety concerns for the tree climber.

  Residual damage to the tree during the topping process was minimized by using certified arborists to do the work and by limiting the use of climbing spurs. Top cuts were angled toward the north to shed water, stimulate scaring, and minimize decay.

The resulting experimental design has eight blocks, including controls where no treatments were applied:

1) Western hemlock, gapped
2) Western hemlock, topped
3) Western hemlock, gapped and topped
4) Western hemlock, control
5) Douglas fir, gapped
6) Douglas fir, topped
7) Douglas fir, gapped and topped
8) Douglas fir, control

The 2010 budget for this project of roughly $12,000 limited the number of target trees. After consultation with several potential contractors it was determined that the budget would support a sample size of 48 target trees as follows:

	Gapped	Topped	Gapped and Topped	Control
Western hemlock	6	6	6	6
Douglas fir	6	6	6	6

Figure 2 illustrates the layout of the treatments. Distances between trees and ecotones (e.g., roads and streams) were intended to provide at least a 100 foot buffer between gaps and from edges. Seven transects were laid out northwest of the 600 Road approximately 180 feet apart on a bearing of 304°. An eighth transect was added southwest of the road at 20°. Relatively steep slopes adjacent to the streams were avoided to limit the risk of soil erosion. Healthy dominant or co-dominant western hemlock or Douglas fir trees were identified at roughly 180 foot intervals along each transect (intervals were measured with a hip chain and marked with temporary orange flagging). In reality, target trees were identified 2 to 80 feet from the associated transect line (see Table 1).

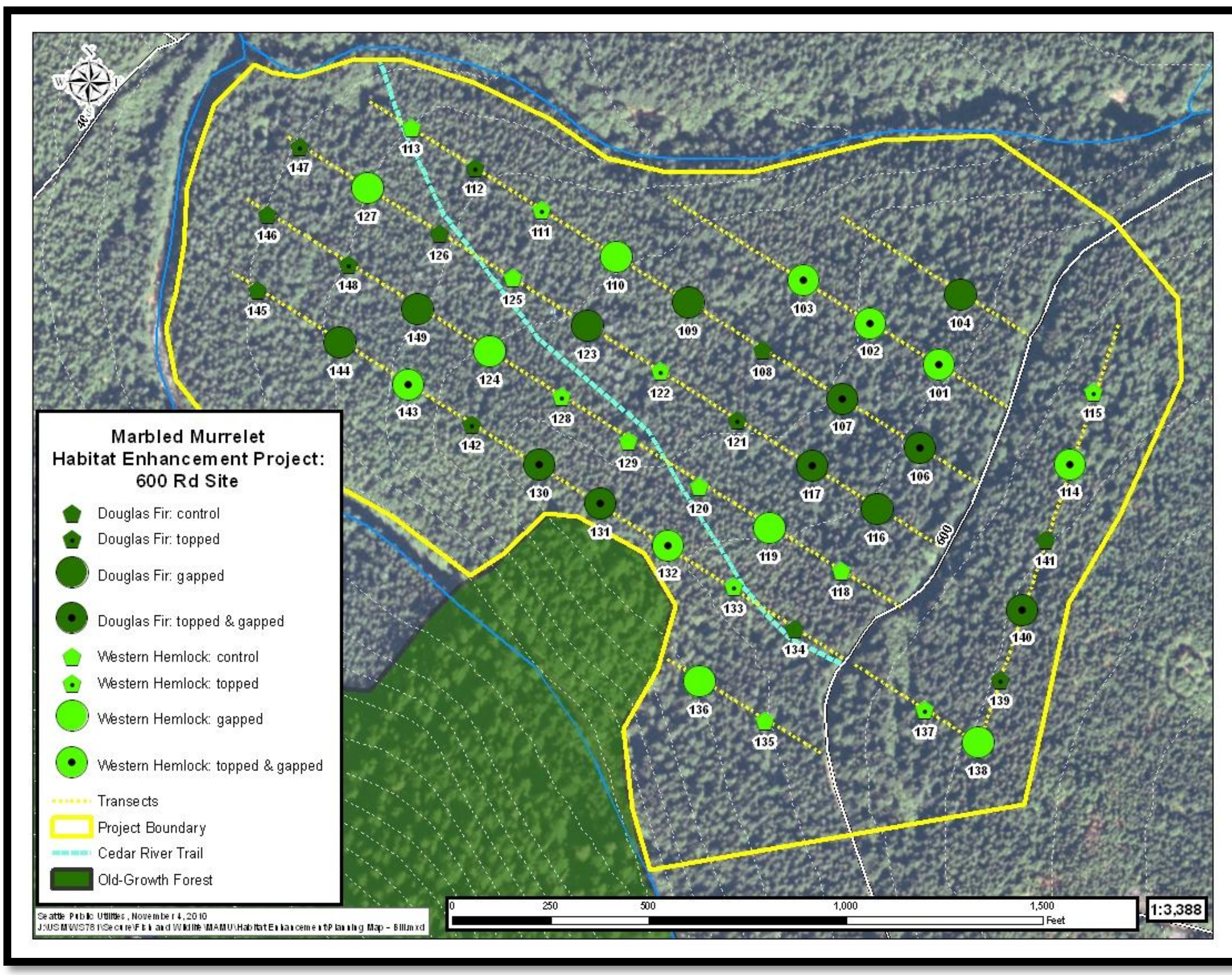

Figure 2. Map of the 75-acre study area showing 48 target trees and their associated treatments (marking tag numbers shown). The 24 circular gaps account for <4% of the area (2.8 acres).

All trees were marked with a metal number tag nailed at breast height on the uphill side of the tree, a ring of yellow paint, and temporary white flagging (GPS points were not obtained due to the GPS not working well under the tree canopy). Treatments were randomly assigned to the 48 target trees in accordance with the block design, except where protecting a historic Native American trail necessitated prohibiting the gap treatment on seven trees. All treatment trees (even those not topped) were climbed to measure branches: either the five branches immediately below the topping site, or the five branches immediately below where the topping might have occurred if that treatment were assigned. This fictional topping site for the 24 target trees that were not topped was marked both with yellow paint and a nailed tag. All measurements were taken from October 5-19, 2010. Autumn was chosen for implementation to minimize potential climbing damage when sap is not flowing.

Table 1. Location of target trees along transects at the 600 Road project site. Transects are marked with temporary orange flagging where they meet the 600 Road.

Transect	Tag Number	Species	DBH (inches)	Transect Distance (feet)	Distance off Transect (feet)	Direction from Orange Transect Flag
	Transect 1 starts at the 600 rd on bearing of 304°.					
1	134†	DF	15.0	153	20	S
1	133†	WH	15.7	183	38	E
1	132	WH	15.9	184	80	S
1	131	DF	19.1	182	23	E
1	130	DF	18.3	182	16	S
1	142	DF	16.3	191	53	SW
1	143	WH	14.0	186	21	SE
1	144	DF	17.8	178	20	NE
1	145	DF	22.7	274	48	N
	Transect 2 starts 190' at bearing of 34° from Tree 145. From Tree 146, transect continues on a bearing of 56° toward the 600 rd.					
2	146	DF	21.4	-	29	NNW
2	148	DF	22.9	185	20	E
2	149	DF	18.4	179	48	SE
2	124	WH	17.8	187	28	E
2	128	WH	23.2	189	39	NW
2	129†	WH	23.0	181	56	SSW
2	120†	WH	19.4	180	54	S
2	119	WH	18.3	178	21	S
2	118	WH	19.2	182	29	NW
2	To Road			140		
	Transect 3 starts at the 600 rd on bearing of 304°.					
3	116	DF	23.3	152	17	NNE
3	117	DF	25.1	181	30	W
3	121	DF	25.1	177	38	NW

3	122	WH	17.4	185	15	WNW
3	123	DF	20.0	186	2	S
3	125†	WH	17.2	178	29	S
3	126†	DF	21.9	185	12	NW
3	127	WH	14.3	187	33	ESE
3	147	DF	22.2	222	5	NW
	Transect 4 starts 182' at bearing of 34° from Tree 47. From Tree 113, transect continues on a bearing of 56°to the 600 rd.					
4	113†	WH	15.1	97	19	N
4	112	DF	18.4	186	20	WSW
4	111	WH	13.9	182	53	S
4	110	WH	17.3	180	43	SW
4	109	DF	17.4	191	41	N
4	108	DF	23.8	194	70	NNE
4	107	DF	17.3	176	36	NW
4	106	DF	18.8	175	17	WSW
4	To Road			102		
	Transect 5 starts at the 600 rd on bearing of 304°.					
5	101	WH	20.0	150	27	W
5	102	WH	18.3	178	39	S
5	103	WH	13.8	181	27	SW
	Transect 6 starts at the 600 rd on bearing of 304°.					
6	104	DF	18.5	150	39	SW
	Transect 7 starts at the 600 rd on bearing of 304°.					
7	135	WH	20.1	156	33	SW
7	136	WH	21.0	181	16	WNW
	Transect 8 starts at the 600 rd on the bearing of 113° for 200' to Tree 137, then 200' along the same bearing to Tree 138. From Tree 138, the transect continues on a 20° bearing.					
8	138	WH	15.6	400	29	SW
8	139	DF	17.3	178	26	WSW
8	140	DF	16.7	182	80	W
8	141	DF	23.1	187	13	N
8	114	WH	19.6	180	7	NNE
8	115	WH	15.5	190	36	W
8	137	WH	14.5	200	19	N

†Near Cedar River Trail

Implementation of the treatment plan was seamless. Stressing safety as the paramount concern, the tree climbing and felling occurred as planned and without incident. SPU staff monitored the buffering of the Cedar River Trail by being on site when the cutting of adjacent gaps was initiated. Weather posed little problems with slight winds being a felling factor on one of the days. The climbers and fellers seemed highly motivated to do a good job since this work is different from their ordinary responsibilities and there is the possibility of additional similar work in the future.

3.5 Measured Variables:

The following variables were measured for all target trees:

- Tree species
- Tree diameter at breast height (by dbh tape to the tenth of an inch) – measured just above the nail holding the number tag.
- Tree height before topping (by laser rangefinder to the foot)
- Live crown length before topping (by laser rangefinder to the foot)
- Tree diameter at the topping site (by dbh tape to the tenth of an inch)
- Branch diameter of five branches just below topping site (by dbh tape to the tenth of an inch) – measured six inches from the tree bole.
- Tree height above the topping site (to the foot) - estimated for the trees not topped and measured with tape for tops that fell to the ground.
- Slope (degrees)
- Aspect
- Canopy moss presence/absence
- Mistletoe abundance presence/absence
- Epicormic branching presence/absence
- Unique structures (e.g., tree defects)
- Tag number
- Comments

The data are included in Table 2 and summarized in Table 3.

Table 2. Raw target tree data.

Tree #	Trans #	Tag #	Spp	DBH (")	Topped Diameter (")	Slope (°)	Aspect (°)	Treatment (Y/N)		Height (')		Live Crown (')	Branch Diameters (")					Moss (Y/N)	Date Sampled	Comments
								Topped	Gapped	Tree	Top		1	2	3	4	5			
1	1	134	DF	15.0	5.1	4	225	N	N	114	16	45	1.0	1.1	0.8	1.1	0.8	N	14-Oct	Chose easier tree to climb
2	1	133	WH	15.7	4.7	4	207	Y	N	105	17	58	1.3	1.0	0.8	1.1	0.7	N	14-Oct	
3	1	132	WH	15.9	4.9	6	322	Y	Y	105	18	67	1.2	1.3	1.5	0.7	0.3	Y	14-Oct	Left adjacent snag
4	1	131	DF	19.1	4.7	17	328	Y	Y	128	22	62	0.8	0.9	1.0	1.0	1.3	Y	14-Oct	Left adjacent snag
5	1	130	DF	18.3	4.3	11	256	Y	Y	111	20	43	1.1	1.6	1.3	1.3	1.4	Y	8-Oct	
6	1	142	DF	16.3	4.0	16	270	Y	N	105	21	51	1.1	1.1	1.4	1.5	1.0	Y	8-Oct	
7	1	143	WH	14.0	4.3	10	276	Y	Y	101	24	56	1.4	1.4	0.5	0.5	0.2	N	8-Oct	
8	1	144	DF	17.8	4.0	18	305	N	Y	124	14	55	0.8	1.0	1.1	0.9	1.0	N	8-Oct	
9	1	145	DF	22.7	5.2	15	295	N	N	131	19	53	1.3	1.3	1.3	1.3	0.8	N	8-Oct	
10	2	146	DF	21.4	4.8	2	352	N	N	146	19	63	1.3	1.3	1.2	0.8	0.5	N	8-Oct	
11	2	148	DF	22.9	4.0	8	265	Y	N	151	25	69	1.1	1.3	1.3	1.4	1.0	N	8-Oct	
12	2	149	DF	18.4	4.1	11	322	N	Y	133	18	54	1.0	1.2	1.3	1.3	1.4	N	8-Oct	
13	2	124	WH	17.8	4.5	14	348	N	Y	120	19	59	1.5	1.1	1.5	0.9	0.3	N	7-Oct	130' from trail
14	2	128	WH	23.2	4.0	12	355	Y	N	120	19	61	1.0	1.1	1.2	1.4	1.5	N	14-Oct	
15	2	129	WH	23.0	5.1	6	342	N	N	129	20	99	1.5	1.1	1.2	0.9	0.5	N	14-Oct	
16	2	120	WH	19.4	5.2	4	333	N	N	116	20	55	1.3	1.0	1.0	1.0	0.1	N	7-Oct	
17	2	119	WH	18.3	5.2	11	355	N	Y	125	21	66	0.7	1.5	1.0	1.0	0.6	N	7-Oct	
18	2	118	WH	19.2	5.2	10	312	N	N	108	16	68	1.2	1.2	1.3	1.3	1.4	N	7-Oct	
19	3	116	DF	23.3	5.9	6	315	N	Y	131	19	75	0.8	0.8	1.2	1.2	1.0	N	6-Oct	No paint at top
20	3	117	DF	25.1	5.1	8	335	Y	Y	138	21	74	1.3	1.4	1.4	1.5	0.9	N	6-Oct	
21	3	121	DF	25.1	5.7	3	330	Y	N	127	19	68	1.5	1.5	1.5	1.5	0.1	N	7-Oct	
22	3	122	WH	17.4	5.3	3	352	Y	N	116	26	90	1.5	1.2	1.1	1.0	0.8	N	7-Oct	
23	3	123	DF	20.0	5.5	7	276	N	Y	130	18	66	1.2	1.1	1.0	1.0	0.9	N	7-Oct	90' from trail
24	3	125	WH	17.2	5.9	2	270	N	N	113	21	76	1.1	1.1	0.7	0.7	0.4	N	7-Oct	
25	3	126	DF	21.9	5.9	5	325	N	N	134	21	72	1.6	1.4	1.3	0.6	1.2	N	7-Oct	

Tree #	Trans #	Tag #	Spp	DBH (")	Topped Diameter (")	Slope (°)	Aspect (°)	Treatment (Y/N) Topped	Treatment (Y/N) Gapped	Height (') Tree	Height (') Top	Live Crown (')	Branch Diameters (") 1	2	3	4	5	Moss (Y/N)	Date Sampled	Comments
26	3	127	WH	14.3	4.8	8	348	N	Y	98	21	58	1.0	0.5	0.8	0.6	1.3	N	7-Oct	155' to trail
27	3	147	DF	22.2	5.2	5	320	Y	N	144	20	63	1.4	1.4	1.5	1.0	0.8	N	8-Oct	
28	4	113	WH	15.1	5.0	8	10	N	N	108	21	58	1.5	1.4	1.4	1.3	1.2	N	5-Oct	
29	4	112	DF	18.4	4.6	12	325	Y	N	138	20	81	1.2	1.2	1.1	1.0	0.7	N	5-Oct	
30	4	111	WH	13.9	5.9	5	34	Y	N	106	24	72	1.4	1.2	0.2	0.8	0.7	N	5-Oct	
31	4	110	WH	17.3	5.3	16	65	N	Y	107	19	63	1.3	1.3	1.1	0.9	0.7	N	5-Oct	Nearby creek bed
32	4	109	DF	17.4	5.2	6	320	N	Y	128	18	50	1.2	1.2	1.2	1.0	0.1	N	5-Oct	
33	4	108	DF	23.8	5.5	4	294	N	N	133	20	65	0.8	0.8	1.1	1.2	0.9	N	5-Oct	No paint at top
34	4	107	DF	17.3	5.2	5	295	Y	Y	126	21	50	0.8	0.8	1.0	1.0	1.4	N	5-Oct	
35	4	106	DF	18.8	5.1	18	310	Y	Y	127	19	50	1.2	1.2	1.1	1.1	0.9	N	5-Oct	
36	5	101	WH	20.0	6.0	8	300	Y	Y	117	23	90	1.3	0.8	1.3	1.0	0.5	N	5-Oct	Branches measured w/ regular tape
37	5	102	WH	18.3	5.0	4	304	Y	Y	131	21	103	1.4	1.6	0.4	0.6	1.6	N	5-Oct	
38	5	103	WH	13.8	5.3	7	320	Y	Y	105	22	54	1.4	1.5	0.5	0.4	0.5	N	5-Oct	
39	6	104	DF	18.5	5.6	5	255	N	Y	125	20	54	1.1	1.1	0.7	0.2	0.2	N	5-Oct	
40	7	135	WH	20.1	4.8/4.7	4	275	N	N	115	25	92	1.2	1.1	0.6	1.0	1.3	N	14-Oct	Two tops
41	7	136	WH	21.0	5.3	19	222	N	Y	105	16	76	0.8	0.9	0.2	0.6	1.1	Y	14-Oct	Vine maple understory
42	8	138	WH	15.6	4.9	11	284	N	Y	96	20	57	1.4	1.3	0.7	0.9	0.5	N	14-Oct	Bole crack
43	8	139	DF	17.3	5.7	11	335	Y	N	113	21	51	1.0	1.4	1.3	0.9	0.7	N	14-Oct	
44	8	140	DF	16.7	5.1	11	246	Y	Y	98	15	41	1.1	0.8	1.0	1.2	1.3	N	14-Oct	Small WRC in area
45	8	141	DF	23.1	5.3	1	320	N	N	115	18	67	1.3	1.2	1.4	1.3	0.7	N	14-Oct	
46	8	114	WH	19.6	5.7	3	6	Y	Y	95	20	65	1.4	1.4	1.3	0.7	1.0	N	6-Oct	Free-climbed from bottom
47	8	115	WH	15.5	5.2	0	6	Y	N	104	24	80	1.0	0.6	1.5	0.8	1.5	N	6-Oct	
48	8	137	WH	14.5	4.0	11	340	Y	N	112	26	46	1.1	1.0	1.2	1.1	1.5	N	14-Oct	

Table 3. Summary of target tree data.

		Western Hemlock					Douglas Fir				
		Topped		Not Topped			Topped		Not Topped		
		Gap	No Gap	Gap	No Gap	**Total**	Gap	No Gap	Gap	No Gap	**Total**
DBH (inches)	ave	16.9	16.7	17.4	19.0	17.5	19.2	20.4	19.2	21.3	20.0
	min	13.8	13.9	14.3	15.1	13.8	16.7	16.3	17.4	15.0	15.0
	max	20.0	23.2	21.0	23.0	23.2	25.1	25.1	23.3	23.8	25.1
Height Before Cut (feet)	ave	109	111	109	115	111	121	130	129	129	127
	min	95	104	96	108	95	98	105	124	114	98
	max	131	120	125	129	131	138	151	133	146	151
Height After Cut (feet)	ave	88	88			88	102	109			105
	min	75	80			75	83	85			83
	max	110	101			110	107	126			126
Live Crown Before Cut (feet)	ave	73	68	63	75	70	53	64	59	61	59
	min	54	46	57	55	46	41	51	50	45	41
	max	103	90	76	99	103	74	81	75	72	81
Live Crown After Cut (feet)	ave	51	45			48	34	43			38
	min	32	20			20	26	30			26
	max	82	64			82	53	61			61
Diameter at Cut (inches)	ave	5.2	4.9	5.0	5.1	5.0	4.9	4.9	5.1	5.3	5.0
	min	4.3	4.0	4.5	4.7	4.0	4.3	4.0	4.0	4.8	4.0
	max	6.0	5.9	5.3	5.9	6.0	5.2	5.7	5.9	5.9	5.9
Top Height (feet)	ave	21	23	19	21	21	20	21	18	19	19
	min	18	17	16	16	16	15	19	14	16	14
	max	24	26	21	25	26	22	25	20	21	25
Branch Diameter (inches)	ave	1.0	1.1	0.9	1.1	1.0	1.1	1.2	1.0	1.1	1.1
	min	0.2	0.2	0.2	0.1	0.1	0.8	0.1	0.1	0.5	0.1
	max	1.6	1.5	1.5	1.5	1.6	1.6	1.5	1.4	1.6	1.6
Moss (presence)		1/6	0/6	1/6	0/6	2/24	2/6	1/6	0/6	0/6	3/24

There were no epicormic branches or dwarf mistletoe in any of the target trees. Within SPU, the data files for this project can be found here and on SIC:

J:\USM\WS781\Secure\Fish and Wildlife\MAMU\Habitat Enhancement\Experiment Plan\MAMU Tree Data.xlsx

3.6 Phases of Implementation:

Phase:	Completion Date:
1) Develop study plan with internal and external expert review.	2008 - Spring 2010
2) Develop tree inventory.	Not yet completed
3) Get ball-park cost estimates from potential contractors.	Spring 2010
4) Determine treatment levels consistent with block design.	June 2010
5) Identify and mark target trees in the field using transect method.	Summer 2010 (4-5 days)
6) Randomly select treatments for target trees considering Cedar River Trail limitations.	September 2010
7) Hold field visits with potential contractors and get bids.	August 2010
8) Choose contractor (Northwest Arboriculture LLC).	September 2010
9) Implement treatments and collect data.	October 2010 (6 days)
10) Write as-built report.	November 2010
11) Re-measure at 10-year intervals.	2020
12) Prepare and publish research results.	2021
13) Implement elsewhere if successful.	?

3.7 Contactor Budget Analysis:

The proposed contractor implementation budget for this project was $12,000. A prevailing wage of $70/hour was required for the contractor because the work was being conducted under the CRW-HCP as mitigation for water removal from the Cedar River. The City also does not need to charge sales tax. The contractor budgeted for six days of work for three people (one climber and two fallers), assuming that one city employee would also be on site directing the work and collecting the data.

The final contractor billing was for exactly $12,000, which encompassed 171 hours of contractor time over six days (climbing was completed in five days) plus a $30 fuel surcharge. Though it is difficult to allocate precise costs, each tree climbed cost roughly $72 and each gap cost about $360. The number of trees cut per gap was typically 40 to 50, but ranged from 12 to 85. Most of the cut trees were less than 15 inches dbh, however a few were up to 22 inches. There was a negligible cost difference for trees topped versus those not topped.

4.0 The Next Phase

This “pilot” installation of this study design was implemented successfully. Suggested project sites for continuation of this project using money budgeted by the CRW-HCP for 2011-2012 include the moraine north of Chester Morse Lake, the upper Taylor basin, and along the 200 Road (Figure 3).

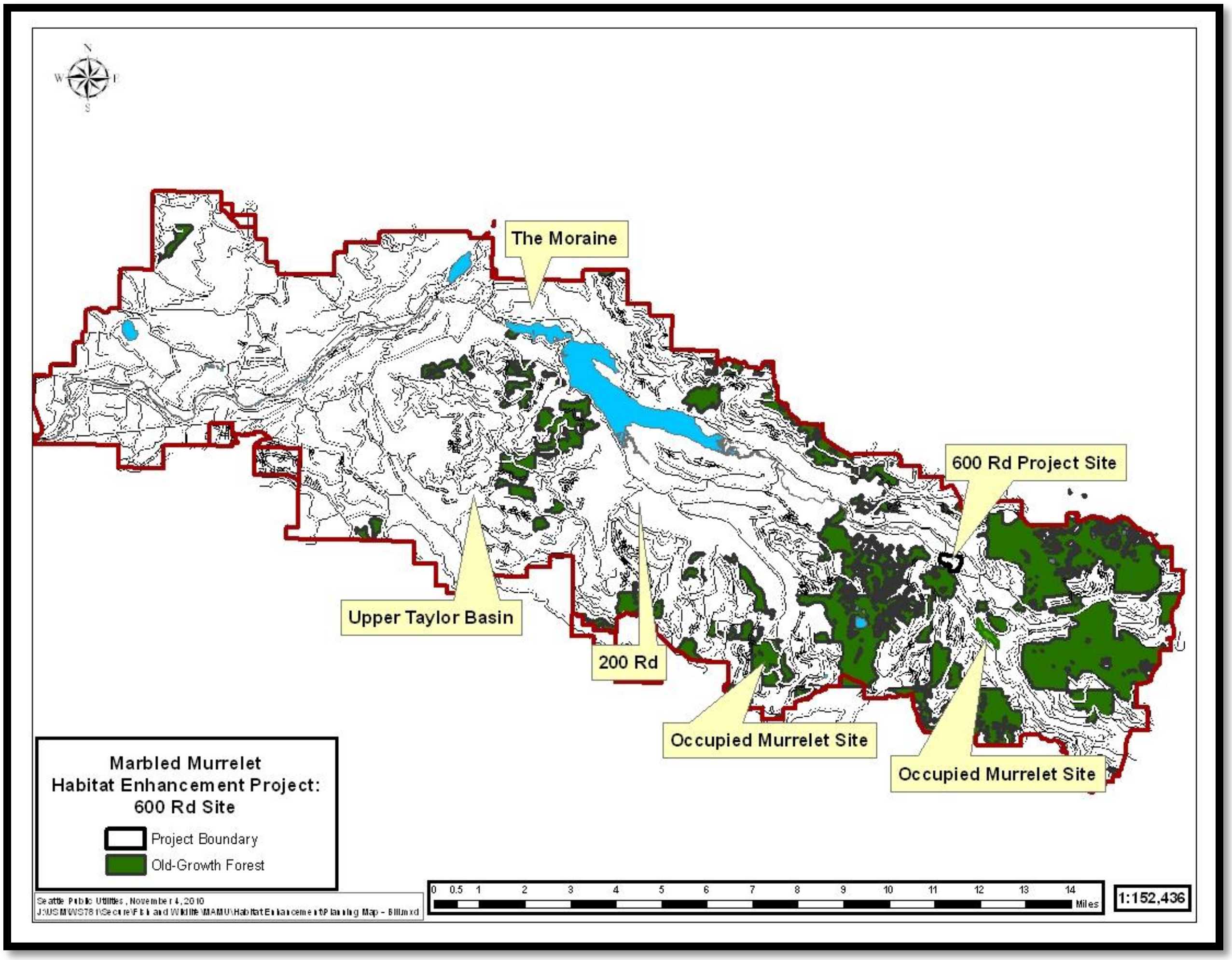

Figure 3. Location of potential sites for future installations of this project.

This report and other associated documents can be found in this file and the SIC:

J:\USM\WS781\Secure\Fish and Wildlife\MAMU\Habitat Enhancement\Experiment Plan

5.0 Outside Contacts

- Peter Harrison, Washington Department of Natural Resources, (360) 902-1383
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- Martin Raphael, United States Forest Service, Pacific Northwest Research Station, (360) 753-7662

- Phyllis Reed, United States Forest Service, Mt. Baker-Snoqualmie National Forest, (360) 436-1155
- Bill Ritchie, United States Fish and Wildlife Service, Willapa National Wildlife Refuge, (360) 484-3482, ext. 46
- Ed “Mooch” Smith, Smith Logging and Tree Service, (253) 312-3842
- Clint Smith, Oregon Department of Forestry, Tillamook Region, (503) 815-7008

6.0 Citations

- Washington Department of Wildlife. 1993. Status of the marbled murrelet (*Brachyramphus marmoratus*) in Washington. Unpublished report. Olympia, WA.
- Hamer, T.E. (personal communication) Referenced nest data developed in 1998.
- Franklin, J.F., A.B. Carey, S.P. Courtney, J.M. Marzluff, M.G. Raphael, J.C. Tappeiner, and D.A. Thornburgh. 2007. Managing second-growth forests in the Redwood Region to enhance marbled murrelet habitat. White paper emanating from USDA Forest Service PSW-GTR-194.

Notes:

6/6/2012: All target trees are alive and standing. The yellow paint marking the trees is not aging well in some cases. There is some blowdown in the stand, but it is difficult to determine if it is related to the created gaps.