RADAR AND AUDIO-VISUAL SURVEYS FOR MARBLED MURRELETS IN THE CEDAR RIVER MUNICIPAL WATERSHED, WASHINGTON, 2005

FINAL REPORT

Prepared for
City of Seattle
Watershed Management Division
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EXECUTIVE SUMMARY

- This report summarizes the results from the first year of surveys that used a combination of ornithological radar and standard audio-visual (AV) methods to collect initial baseline information on distribution and abundance of Marbled Murrelets (*Brachyramphus marmoratus*) in the Cedar River Municipal Watershed (CRMW).
- The purpose of this study was to use radar and audio-visual techniques to monitor trends in the distribution and abundance of murrelets in the CRMW. Specifically, the objectives of the 2005 study were to: (1) collect baseline radar information on numbers of Marbled Murrelets using the watershed in 2005 as the first year of a long-term monitoring effort; (2) collect radar information on the presence of murrelets at the scale of sub-basins to help determine the distribution of murrelets in the CRMW and to focus future (2006–2007) audio-visual survey efforts; and (3) to conduct audio-visual surveys for murrelets in the Rex Creek sub-basin, the only location where murrelets previously have been detected in the CRMW.
- We conducted a total of 35 mornings of radar observation and 5 mornings of audio-visual observations during summer 2005. We used radar to sample four long-term sites used for monitoring purposes and 13 short-term sites to determine presence of murrelets in a particular sub-basin or timber stand. Radar sampling was conducted for 3–4 mornings at long-term sites and for one morning at all short-term sites, from late June to July. Radar sampling occurred during the morning activity period for Marbled Murrelets, from 105 min before sunrise to 75 min after sunrise.
- We recorded a total of 65 murrelet targets on 26 mornings of radar observation in the CRMW during summer 2005. An additional nine mornings of radar sampling were cancelled by inclement weather and other factors. Of the 65 radar targets, 40 (61%) were flying in a landward direction, 22 (34%) were flying in a seaward direction, and 3 (5%) were flying in “other” directions. We had no audio-visual observations of Marbled Murrelets during radar sampling, but we did detect murrelets during standard audio-visual surveys in the upper Rex River drainage.
- Radar counts varied widely among sampling sites, with those sites located closer to the ocean and lower in altitude generally having higher counts of landward-flying targets than sites located farther east or at sites at higher altitudes. The highest landward radar counts occurred at the Chester Morse site.
- Within the long-term radar sites, there was high among-day variation in landward counts. Coefficients of Variation (CV’s) ranged from 82% at Chester Morse and Powerline Central, to 100% at Powerline South, and 172% at Powerline North.
- Landward flight directions generally were centered along the main axis of the valley near each radar site. Other movements of targets toward old-growth stands at the Rack Creek, West Point, and South Fork sites suggested the possible presence of Marbled Murrelets at those stands.
- We conducted five standard audio-visual surveys for Marbled Murrelets in a large patch of old-growth forest in the upper Rex River drainage during summer 2005. We observed Marbled Murrelets exhibiting “occupied behavior” on our 17 July visit to station AV2: of the eight detections on that date, seven were of paired or single birds flying at or below tree canopy height.

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ACKNOWLEDGMENTS

Seattle Public Utilities provided funds for this survey under the auspices of the Cedar River Managed Watershed Habitat Conservation Plan. We thank their biologist, Bill Richards, for his help with access, logistics, and study design. We also thank Robert Day of ABR for reviewing this report.

INTRODUCTION

The Marbled Murrelet (*Brachyramphus marmoratus*) is a seabird that nests in large trees in old-growth coastal forests throughout most of its range in North America (Nelson 1997). Marbled Murrelets fly at high speeds, visit their nests primarily during periods of low ambient light, and nest up to ~80 km inland. Because of their secretive behaviors, their semicolonial nesting behavior, and the difficulty of locating their nests in large trees, only limited information is available on their nesting behavior, habitat associations, population size in specific areas, and demography. The Washington, Oregon, and California population of the Marbled Murrelet was federally listed as a Threatened Species in 1992 because of excessive loss and fragmentation of nesting habitat and because of mortality associated with oil spills and gill-net fishing (USFWS 1992, 1997). The species also is classified as endangered at the state level in California and as threatened at the state level in Washington and Oregon and is listed as threatened in Canada. Comparison of historical and current data suggest that Marbled Murrelets have disappeared or become rare over much of their range south of Alaska, but current population trends of the species in the Pacific Northwest are unknown (Nelson 1997).

The current ground-based Inland Forest Survey Protocol (IFSP) for Marbled Murrelets depends on the use of audio-visual cues to detect birds in flight (Evans Mack et al. 2003). Collecting information on murrelets this way is difficult because of the low light conditions during their dawn and dusk peaks in inland activity and their small size, cryptic coloration, rapid flight speed, and habitat preference for old-growth, closed canopy forests. Further, because 85% of the murrelet detections are auditory (Paton et al. 1990), it is difficult to determine with accuracy the number of birds that actually are flying over a particular survey area. In fact, audio-visual surveys (Evans Mack et al. 2003) were not designed to provide an index of abundance and, even if they were used, the high variation in audio-visual counts would require a massive survey effort to detect trends (Jodice et al. 2001, Bigger et al., in press).

Several studies have shown that radar is an excellent tool for observing Marbled Murrelets (Hamer et al. 1995; Cooper et al. 2001; Cooper and Blaha 2002; Cooper and Hamer 2003; Burger 1997, 2001; Raphael et al. 2002; Burger et al. 2004). The main advantages of using radar for inventorying murrelets are that it works under all light conditions, does not have the auditory bias of audio-visual surveys, and can sample a large area. Although radar cannot be used at all stands because certain terrain types preclude its use, it can be used in appropriate locations to determine quickly and accurately whether murrelets are present in a forest stand. Radar is particularly useful for detecting birds at low-use sites, where murrelets often are missed completely by audio-visual observers (Cooper and Blaha 2002). Radar data also can be used to focus ground observers' efforts toward "hot-spots" of murrelet activity. Further, radar can improve survey efficiency because it samples a much larger area (up to a 1,500-m radius) than audio-visual observers do (up to a 200-m radius).

In addition to determining presence of murrelets in an area, radar can provide a good index of abundance for Marbled Murrelets on several scales, including a river-drainage-sized scale that can be used for monitoring (Hamer et al. 1995; Burger 1997, 2001; Cooper et al. 2001, 2005; Raphael et al. 2002; Cooper and Blaha 2002; Evans Mack et al. 2003). Power analyses have revealed that radar-based monitoring of murrelets can produce statistically-sensitive results in a timely, cost-effective fashion because of the low among-day variation in counts (Cooper et al. 2001, in review; Cooper and Augenfeld 2001, Burger et al. 2004; Bigger et al., in press).

The Cedar River Watershed Habitat Conservation Plan commits Seattle Public Utilities to managing the Cedar River Municipal Watershed (CRMW) as an ecological reserve with active forest restoration. Monitoring Marbled Murrelet activity in the CRMW is designated by the Habitat Conservation Plan: over the 50-year course of the HCP, local population indices of murrelets is expected to provide a barometer to gauge how well the old-growth forests are being restored. In this program, the activity of murrelets will be assessed within both old-growth and second-growth forests of the CRMW during three time periods: 2005–2007, 2025–2028, and 2045–2048. This report summarizes the results from the first year of the 2005–2007 effort to use radar and audio-visual methods to collect initial baseline information on murrelet distribution and abundance in the CRMW.

OBJECTIVES

The purpose of this study was to use radar and audio-visual techniques to monitor trends in the distribution and abundance of murrelets in the CRMW. Specifically, the objectives of the 2005 study were to: (1) collect baseline radar information on numbers of Marbled Murrelets using the watershed in 2005 as the first year of a long-term monitoring effort; (2) collect radar information on the presence of murrelets at the scale of sub-basins to help determine the distribution of murrelets in the CRMW and to focus future (2006–2007) audio-visual survey efforts; and (3) to conduct audio-visual surveys for murrelets in the Rex Creek sub-basin, the only location where murrelets previously have been detected in the CRMW.

STUDY AREA

The entire 90,546-acre Cedar River Municipal Watershed (CRMW) lies within 45 miles of Puget Sound and encompasses roughly 14,000 acres of old-growth forest and 71,500 acres of second-growth forest (Fig. 1). The elevation of the area ranges from ~400 to ~1,500 m above sea level. Currently managed under the 50-year Cedar River Watershed Habitat Conservation Plan, old-growth forest in the watershed is protected as a reserve and the second-growth forests are subject to limited habitat restoration with the objective of shortening the time to old-growth forest conditions. Marbled Murrelets were detected at one location in the CRMW in the mid-1990s (W. P. Ritchie, WDFW, pers. comm.); however, there has been no other systematic assessment of use of this area by murrelets until the current study. During summer 2005, we conducted radar-based sampling for Marbled Murrelets at 17 sites in the study area that provided good radar coverage over areas of interest (Table 1). We also conducted audio-visual observations for murrelets from three stations in the large patch of old growth forest in the upper Rex River drainage where a Marbled Murrelet was detected in the mid-1990s (Fig. 2, Table 1).

METHODS

DATA COLLECTION

We conducted a total of 35 mornings of radar observation and 5 mornings of audio-visual observations during summer 2005 (Tables 2 and 3). We used radar to sample (1) four long-term sites used for monitoring purposes (i.e., the Powerline North, Powerline Central, Powerline South, and Chester Morse sites) and (2) 13 short-term sites to determine presence of murrelets in a particular sub-basin or timber stand. Radar sampling was conducted for 3–4 mornings at long-term sites and for one morning at all short-term sites, from late June to July (Table 2). Radar sampling occurred during the morning activity period for Marbled Murrelets, from 105 min before sunrise to 75 min after sunrise. This period encompasses the known peak of daily murrelet activity (Burger 1997, Cooper et al. 2001, Cooper and Blaha 2002, Cooper and Hamer 2003).

During sampling, a single observer set up the radar and video recorder, then attempted to obtain an audio-visual confirmation of each radar target to confirm the species identity of Marbled Murrelets and other species likely to be confused with murrelets on radar. Audio-visual observations were transmitted by voice directly to the videotape of the radar screen. For each radar target, we recorded date, time, flight direction (to the nearest 1°), transect quadrant, minimal distance to target, groundspeed (mi/h), flight behavior (straight-line, erratic, circling), overlap category (recorded only on radar, recorded only by audio-visual observer, recorded by both radar and audio-visual observer), species (if known), number of birds represented by that radar echo (if known), flight altitude (if known), and audio-visual detection category (not detected by audio-visual observer, heard only, seen only, both seen and heard). We also plotted the flight path of each murrelet target on a transparency overlay of the radar screen. We recorded the following weather information at the beginning of each session or when conditions changed during a session: wind direction, average wind speed at ground level, estimated cloud cover (%), average ceiling height (in meters) above ground level at the radar sampling site, visibility, precipitation, and air temperature (ºC). See

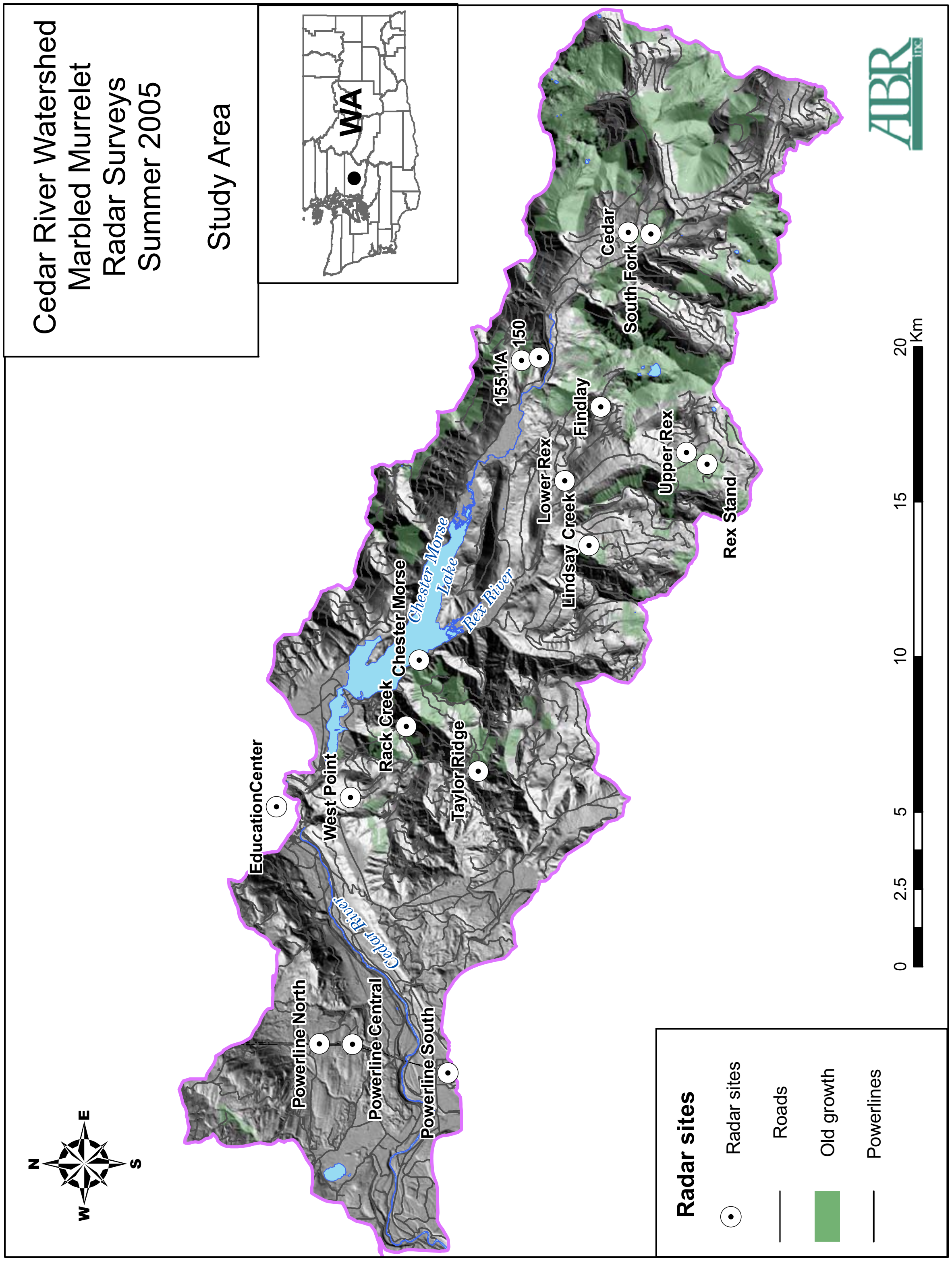

Figure 1. Map showing the locations of radar sampling sites in the Cedar River Municipal Watershed, Washington, during summer 2005.

Table 1. Location of summer 2005 radar and audio-visual sampling sites in the Cedar River watershed, Washington.

Site type/site name	UTM coordinates[1]		Elevation	Comments
LONG-TERM SITES				
Powerline North	584934 E	5251791 N	408 m	1.07 km north of Powerline Central.
Powerline Central	584945 E	5250723 N	333 m	At end of road, 3.15 km from Powerline South.
Powerline South	584115 E	5247628 N	280 m	On north side of Line 1, Mile 22, Tower 1; northern side of third set of poles south of road.
Chester Morse	597393 E	5248917 N	502 m	In largest pullout on lake side of road.
SHORT-TERM SITES				
Education Center	592538 E	5253385 N	275 m	In middle of northern lot at Education Center.
West Point	592897 E	5251013 N	799 m	On large landing at end of Road 820.
Taylor Ridge	593869 E	5246922 N	1065 m	At end of Spur Road #815.5.
Rack Creek	595244 E	5249277 N	961 m	Along Road 811, ~100 m before fork.
Lindsay	601245 E	5243557 N	817 m	100 m from end of Spur Road 205, adjacent to large log pile.
Upper Rex	604331 E	5240500 N	1,033 m	At end of Spur Road 730.1.
REX Stand	603962 E	5239832 N	954 m	In opening next to log pile.
Lower Rex	603301 E	5244402 N	888 m	At end of Road 310.
Findlay	605714 E	5243307 N	1,076 m	At end of Road 354.
155.1A	607146 E	5245901 N	872 m	Park in Spur Road 155.1a.
150	607248 E	5245332 N	761 m	Park along road with downhill slant toward the east.
Cedar	611373 E	5242572 N	748 m	Western end of opening with few trees alongside road.
South Fork	611339 E	5241839 N	767 m	At landing at end of Road 521.
AUDIO-VISUAL SITES				
Rex AV1	603432 E	5240777 N	871 m	Observe from middle of the road.
Rex AV2	603645 E	5239650 N	965 m	Near Culvert 720-18.
Rex AV3	603390 E	5239890 N	912 m	Near two large logs along road just west of creek on road past Rex AV2.

[1] UTM Zone 10

Appendix 1 for categories for each target and weather variable.

During summer 2005, we also conducted five mornings of standard audio-visual surveys in the best murrelet habitat near where the historical murrelet detection occurred in Rex Creek. All five surveys occurred from late June to July (Table 3). Except for the seasonal timing of surveys, the audio-visual survey methods followed standard protocols (Evans Mack et al. 2003).

RADAR EQUIPMENT AND OPERATION

Our mobile radar laboratories consisted of a marine surveillance radars mounted on vans. The radars scanned the entire area around the labs and were used to obtain information on flight paths,

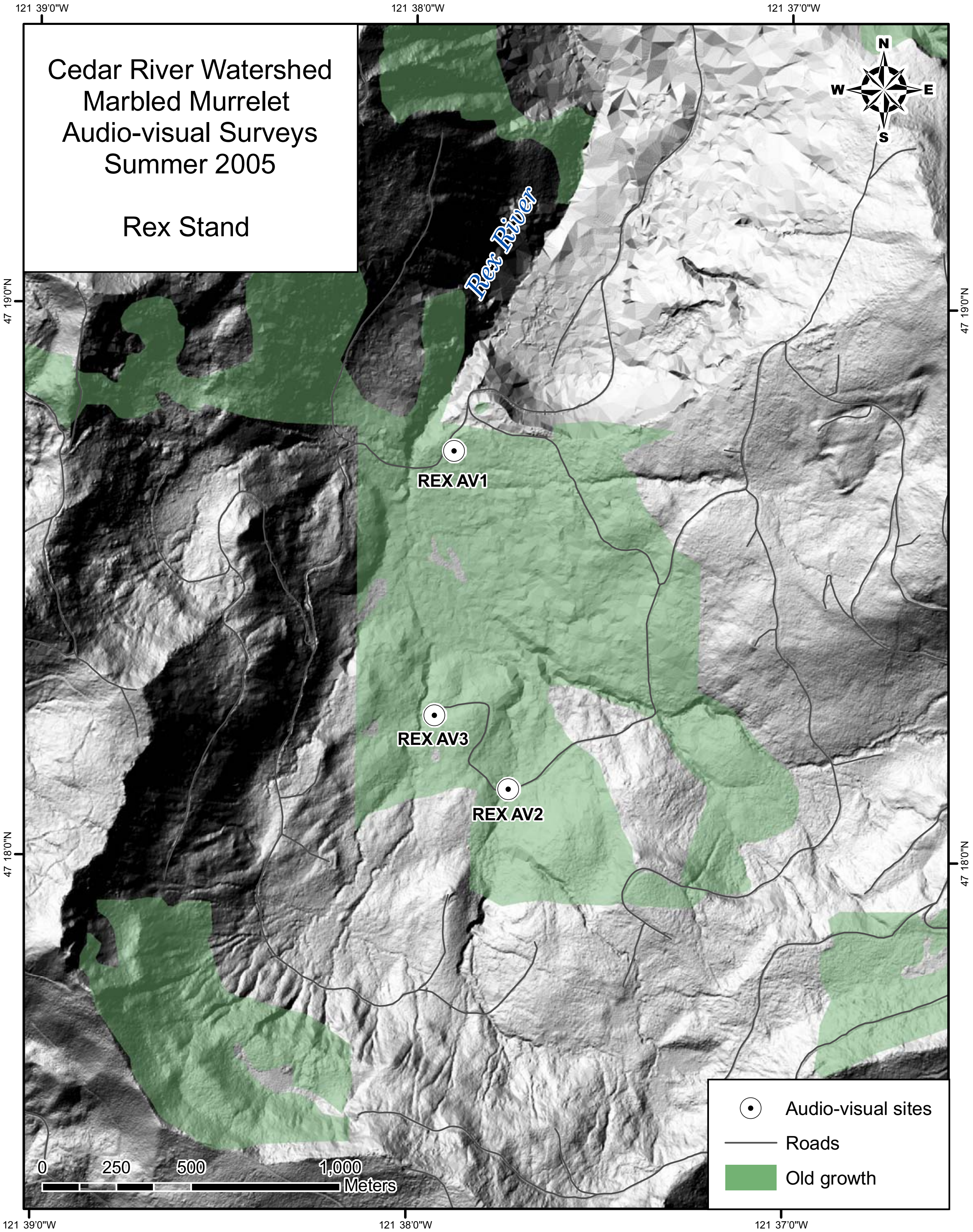

Figure 2. Map showing the locations of audio-visual sampling sites in the upper Rex Creek drainage of the Cedar River Municipal Watershed, Washington, during summer 2005.

Table 2. Daily counts of radar targets and audio-visual observations of murrelets at sites in the Cedar River watershed, Washington, during summer 2005, by flight direction. Table counts include only targets recorded before sunrise.

			Number of targets recorded on radar			
Date	Site	Sampling hours	Landward-flying	Seaward-flying	Other directions	# Audio-visual detections
28 June	Powerline South*	0329–0629*	--	--	--	--
	Powerline North*	0329–0629*	--	--	--	--
	Powerline Central*	0328–0629*	--	--	--	--
29 June	Cedar*	0455–0630*	--	--	--	--
	Chester Morse	0330–0630	13	0	0	0
30 June	Powerline North	0330–0630	0	0	0	0
	Powerline South	0330–0630	0	0	0	0
	Powerline Central	0330–0630	1	4	0	0
1 July	Powerline South	0331–0631	2	1	0	0
	Powerline North	0331–0631	0	0	0	0
2 July	Chester Morse	0331–0631	1	3	0	0
3 July	South Fork*	0332–0632*	--	--	--	--
10 July	Powerline Central	0337–0637	2	1	0	0
	Chester Morse	0337–0637	8	5	0	0
11 July	Powerline South	0338–0638	1	0	1	0
12 July	Powerline North*	0339–0639*	--	--	--	--
	Powerline Central*	0339–0639*	--	--	--	--
13 July	Powerline North	0340–0640	2	0	0	0
	Powerline Central	0340–0640	1	0	0	0
14 July	Powerline Central	0341–0641	0	2	0	0
	West Point	0349–0641	1	2	0	0
15 July	Lower Rex	0342–0642	0	0	1	0
16 July	Upper Rex	0343–0643	1	0	0	0
17 July	South Fork	0344–0644	0	1	1	0
18 July	Rack Creek	0345–0645	4	0	0	0
	Taylor Ridge	0345–0645	0	0	0	0
19 July	Rex Stand	0346–0646	0	1	0	0
20 July	Site 155.1A	0347–0647	2	0	0	0
	Site 150	0347–0647	0	0	0	0
21 July	Lindsay	0349–0649	0	0	0	0
	Education Center	0349–0649	1	2	0	0
22 July	Findley*	0350–0650*	--	--	--	--
	Cedar*	0350–0650*	--	--	--	--
23 July	Findley	0351–0651	0	0	0	0
	Cedar	0351–0651	0	0	0	0

* Sampling session cancelled by rain, wind, or other.

Table 3. Daily counts of Marbled Murrelets recorded during audio-visual surveys of the Rex Stand, Cedar River watershed, Washington, during summer 2005.

			Number of detections	
Date	Station	Sampling Time	Presence[1]	Occupied[1]
29 June[2]	Rex AV1	0429–0644	0	0
2 July	Rex AV1	0419–0630[3]	0	0
11 July	Rex AV1	0438–0638	0	0
17 July	Rex AV2	0440–0644	1	7
19 July	Rex AV3	0431–0646[3]	0	0

[1] Murrelet detections, as defined by the PSG survey protocol (Evans Mack et al. 2003).
[2] Survey not to protocol because of poor visibility.
[3] Survey started before official start time.

movement rates, and ground speeds of murrelets. A similar radar laboratory is described in Gauthreaux (1985a, 1985b) and Cooper et al. (1991). The lab was powered by four 6-V batteries that were linked in series. The surveillance radar (Furuno Model FCR-1510; Furuno Electric Company, Nishinomiya, Japan) is a standard marine radar transmitting at 9,410 MHz (i.e., X-band) through a slotted wave guide (i.e., antenna) 2 m long with a peak power output of 12 kW. The radar was operated at the 1.5-km range with the pulselength set at 0.07 µsec and the forward edge of the antenna elevated by ~15°. Figure 3 shows the approximate murrelet-sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons, which are similar in size to Marbled Murrelets.

Whenever energy is reflected from the ground, surrounding vegetation, or other objects that surround the radar unit, a ground-clutter echo appears on the display screen. Because ground clutter can obscure bird targets on the radar display screen, we attempted to minimize it by parking the radar laboratory in a location that was surrounded closely by trees or low hills. These objects acted as a radar fence that shielded the radar from low-lying objects farther away from the lab and that produced only a small amount of ground clutter in the center of the display screen. For further discussion of radar fences, see Eastwood (1967), Williams et al. (1972), and Skolnik (1980).

Maximal distances of detection of birds by the surveillance radar depends on body size of the birds, flock size, flight profile of the birds, distance between flying birds, atmospheric conditions, and, to some extent, the amount and location of ground clutter. Marbled Murrelets usually are detectable to at least 1.5 km, whereas single, small passerines are detectable to ~1 km (Cooper et al. 1991, 2001; Cooper, unpubl. data).

DATA ANALYSIS

For all analyses, we classified targets as “landward” or “seaward” if they were flying within 60° of the main axis of the valley in an landward (i.e., inbound flights from the ocean) or seaward (i.e., outbound) direction, respectively, and classified targets as “other” if they were not flying in a landward or seaward direction. The exceptions to this rule occurred at the Rack, Rex Stand, Upper Rex, Lindsay, Cedar, and South Fork sites. Those drainages had more of a North–South orientation, plus there was habitat to the east of the sampling sites, so we broadened our landward and seaward categories at those sites to include flight paths beyond 60° of the main axis of the valley. Following Cooper et al. (2001), we used radar counts of landward-flying targets as our daily index of murrelet abundance at a site.

Marbled Murrelet targets detected on radar were distinguished from other species by their flight speed, timing, and (sometimes) target signature. We have determined that a >40-mi/h (64-km/h) speed cutoff minimizes the number of non-murrelet species while eliminating a small percentage (~3%) of Marbled Murrelets (Cooper and Blaha 2002, Cooper et al. 2001). Thus, all targets with a flight speed greater than 40 mi/h (64 km/h) were considered to be Marbled Murrelets,

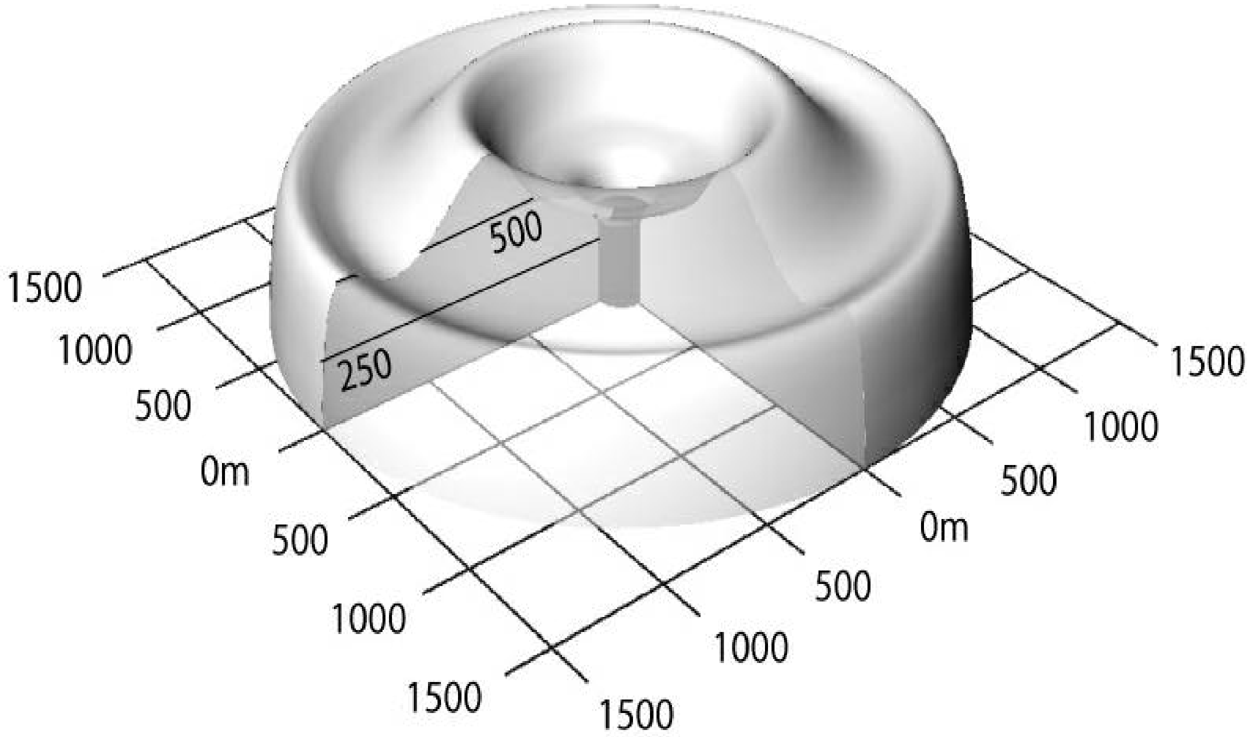

Figure 3. Approximate murrelet-sampling airspace for the Furuno FR–1510 marine radar at the 1.5-km range setting, as determined by field trials with Rock Pigeons, which are similar in size to Marbled Murrelets. Note that the configuration of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

unless the target signature was typical of a flock of Band-tailed Pigeons or the target was observed after sunrise. Band-tailed Pigeon flocks sometimes exhibit a characteristic signature that is large and composed of multiple targets that repeatedly break apart, then coalesce. These targets are easily distinguished from a typical Marbled Murrelet target. In addition, we eliminated targets that were observed after sunrise to help eliminate single Band-tailed Pigeons from the data set. We have found that Band-tailed Pigeon activity generally does not start until a few minutes after sunrise (i.e., 105 min after our radar surveys begin), so we have a great degree of confidence in the radar identification of murrelets before sunrise but lower confidence after sunrise in areas like this study area where Band-tailed Pigeons are common. Nearly all murrelets fly into nesting stands well before sunrise (Cooper et al. 2001, Burger 1997). Further, a precedent for this method has been set by Burger (2001) and Burger et al. (2005), who used sunrise for their cutoff period to count murrelets.

RESULTS

We recorded a total of 65 murrelet targets on 26 mornings of radar observation in the CRMW during summer 2005 (Table 2, Appendix 3). An additional nine mornings of radar sampling were cancelled by inclement weather and other factors. Of the 65 radar targets, 40 (61%) were flying in a landward direction, 22 (34%) were flying in a seaward direction, and 3 (5%) were flying in “other” directions. We had no audio-visual observations of Marbled Murrelets during radar sampling, but we did detect murrelets during standard audio-visual surveys in the upper Rex River drainage.

DISTRIBUTION AND ABUNDANCE

Morning counts of radar targets varied widely among sampling sites, with those sites located closer to the ocean and lower in altitude generally having higher counts of landward-flying targets than sites located farther east or at sites at higher altitudes (Fig. 4, Table 4). The highest landward counts occurred at the Chester Morse site, which is situated at the bottleneck formed by the valley along Chester Morse Lake. No landward targets were observed at 8 of the 17 radar sites.

Within the long-term radar sites, there was high among-day variation in landward counts (Table 4). Coefficients of Variation (CV's) ranged from 82% at Chester Morse and Powerline Central, to 100% at Powerline South, and 172% at Powerline North. CV's are not available for the short-term sites, because they only were sampled for a single morning.

FLIGHT PATHS

As expected, landward flight directions generally were centered along the main axis of the valley near each radar site (Fig. 5). An exception to this pattern occurred at Rack Creek, where the mean flight direction was toward a patch of old-growth habitat, rather than along the main axis of the creek valley.

We also examined specific flight paths of all murrelet targets to obtain information on smaller-scale patterns of movement and information on movements toward/near old-growth habitat that might be suggestive of use of that habitat by Marbled Murrelets (Figs. 6–13). At Powerline North, Powerline Central, and

Table 4. Mean counts (targets or flocks/day ± 1 SE) of radar targets and audio-visual observations of murrelets at sites in the Cedar River watershed, Washington, during summer 2005, by flight direction. Table excludes data for days with high winds or persistent precipitation; counts only include targets recorded before sunrise. *n*=number of sampling days.

	Mean number of targets recorded on radar				
Site	Landward-flying	Seaward-flying	Other directions	Audio-visual	*n*
LONG-TERM SITES					
Powerline North	0.7 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	0 ± 0	3
Powerline Central	1.0 ± 0.4	1.8 ± 0.9	0.0 ± 0.0	0 ± 0	4
Powerline South	1.0 ± 0.6	0.3 ± 0.3	0.3 ± 0.3	0 ± 0	3
Chester Morse	7.3 ± 3.5	2.7 ± 1.5	0.0 ± 0.0	0 ± 0	3
SHORT-TERM SITES					
Education Center	1	2	0	0	1
West Point	1	2	0	0	1
Taylor Ridge	0	0	0	0	1
Rack Creek	4	0	0	0	1
Lindsay	0	0	0	0	1
Upper Rex	1	0	0	0	1
Rex Stand	0	1	0	0	1
Lower Rex	0	0	1	0	1
Findley	0	0	0	0	1
Site 155.1A	2	0	0	0	1
Site 150	0	0	0	0	1
Cedar	0	0	0	0	1
South Fork	0	1	1	0	1

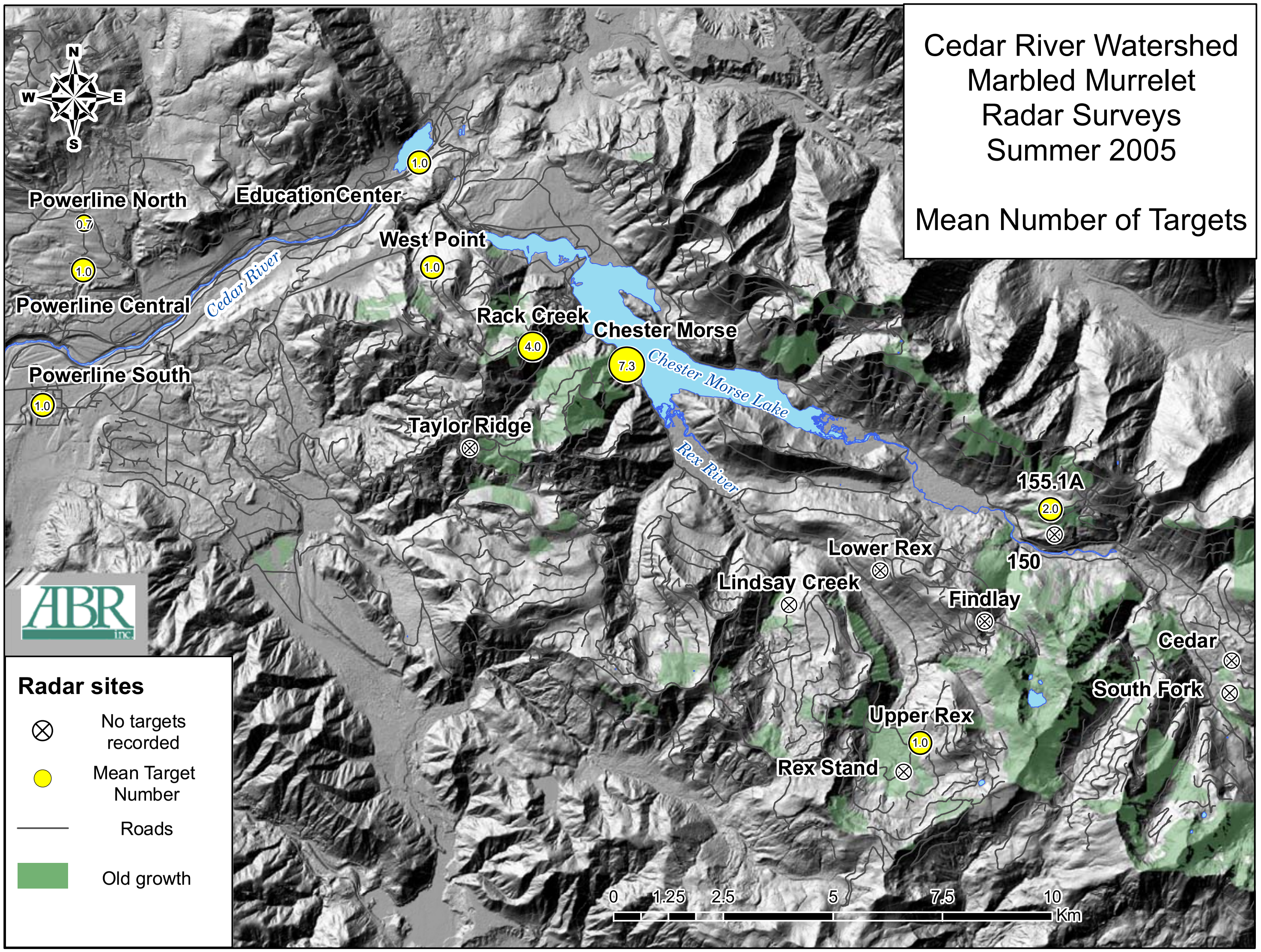

Figure 4. Map showing the mean number of landward targets/day observed at each site during radar sampling in the Cedar River Municipal Watershed, Washington, summer 2005. Size of circles are proportional to the mean rate; numbers within the circles are the actual means.

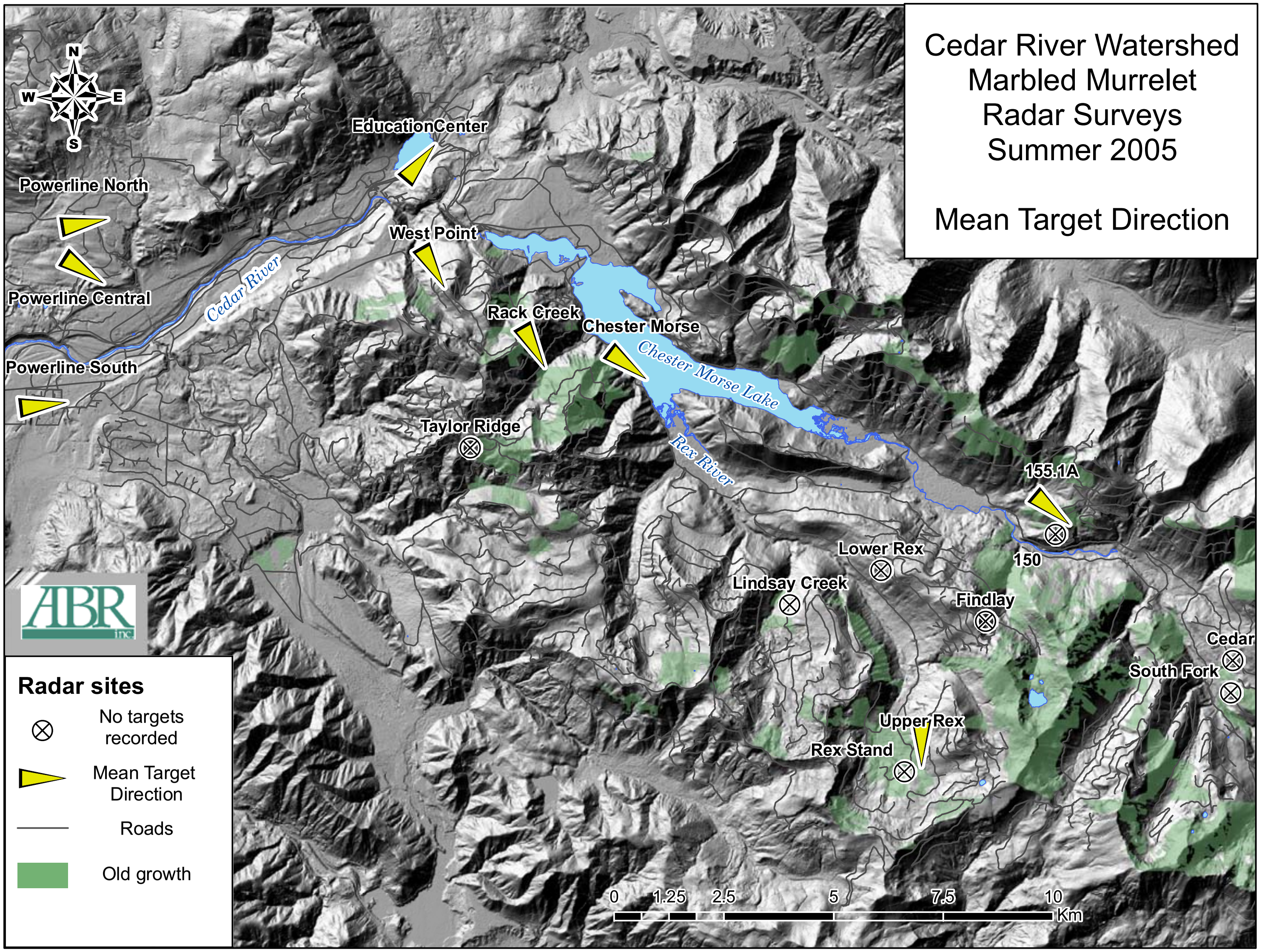

Figure 5. Map showing the mean flight direction of landward targets observed on radar at each site in the Cedar River Municipal Watershed, Washington, summer 2005. Arrows indicate the mean direction of flight; sites without an arrow are locations where no landward targets were detected.

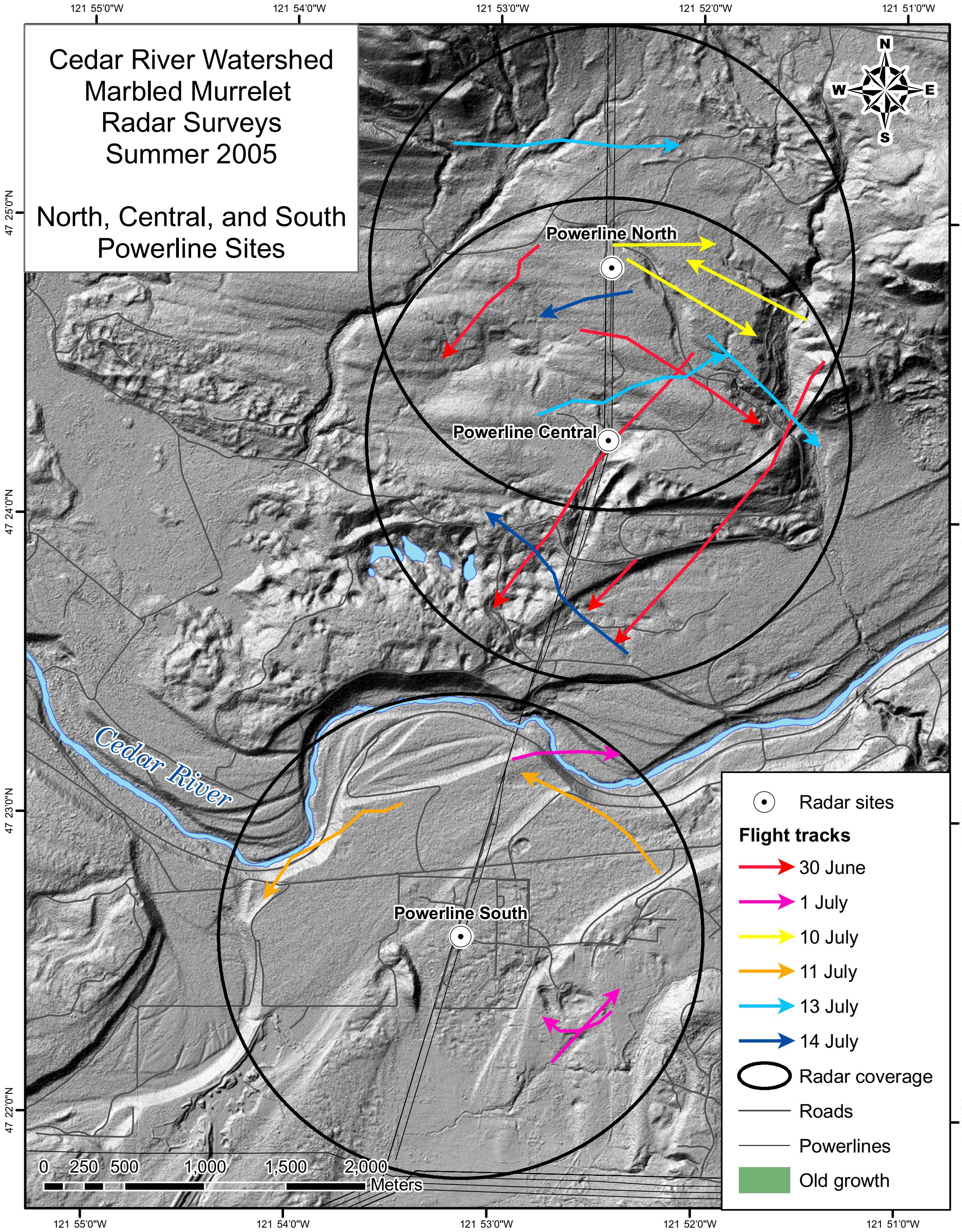

Figure 6. Map showing the flight paths of radar targets observed before sunrise at the Powerline North, Powerline Central, and Powerline South sites in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes the maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

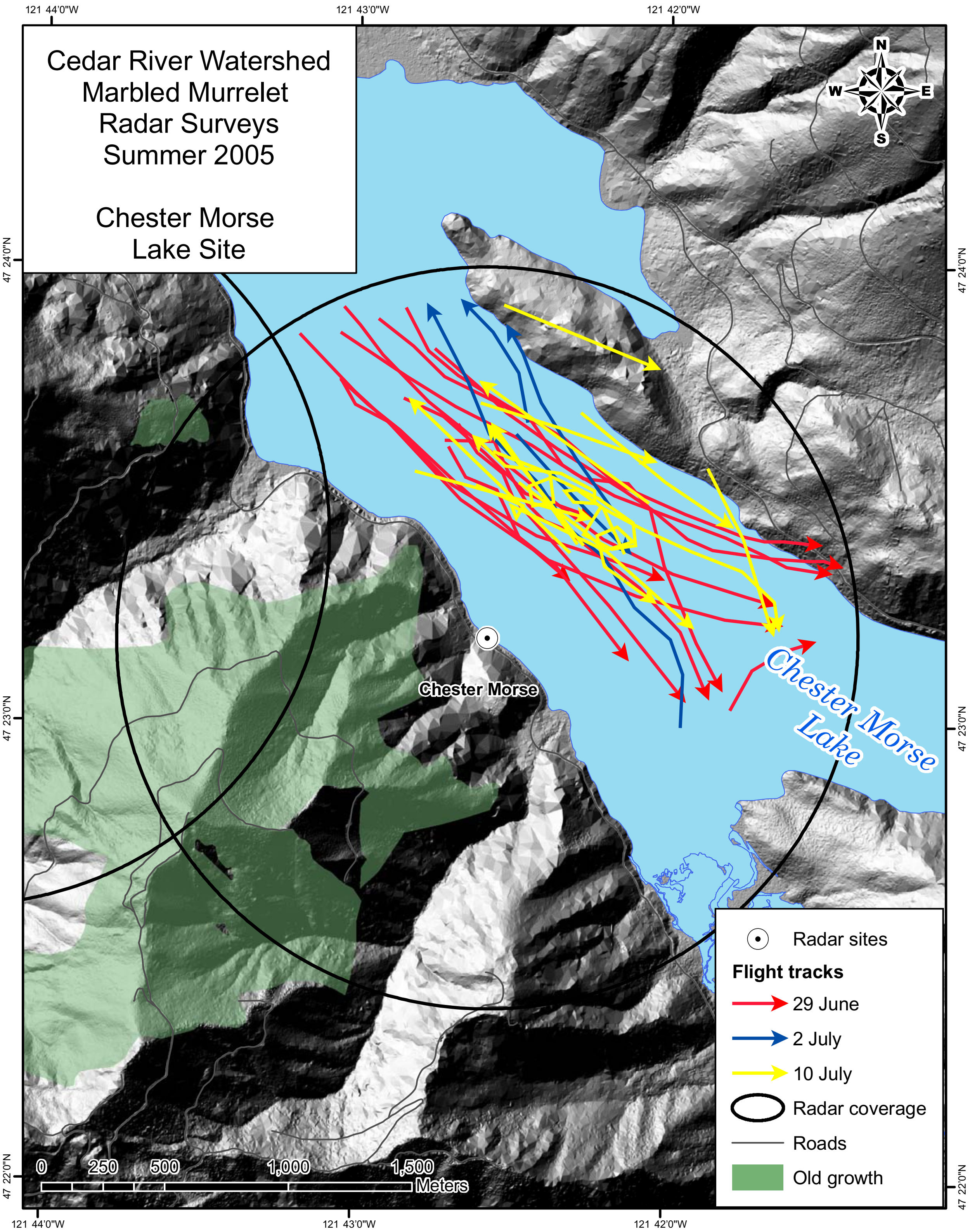

Figure 7. Map showing the flight paths of radar targets recorded before sunrise at the Chester Morse site in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

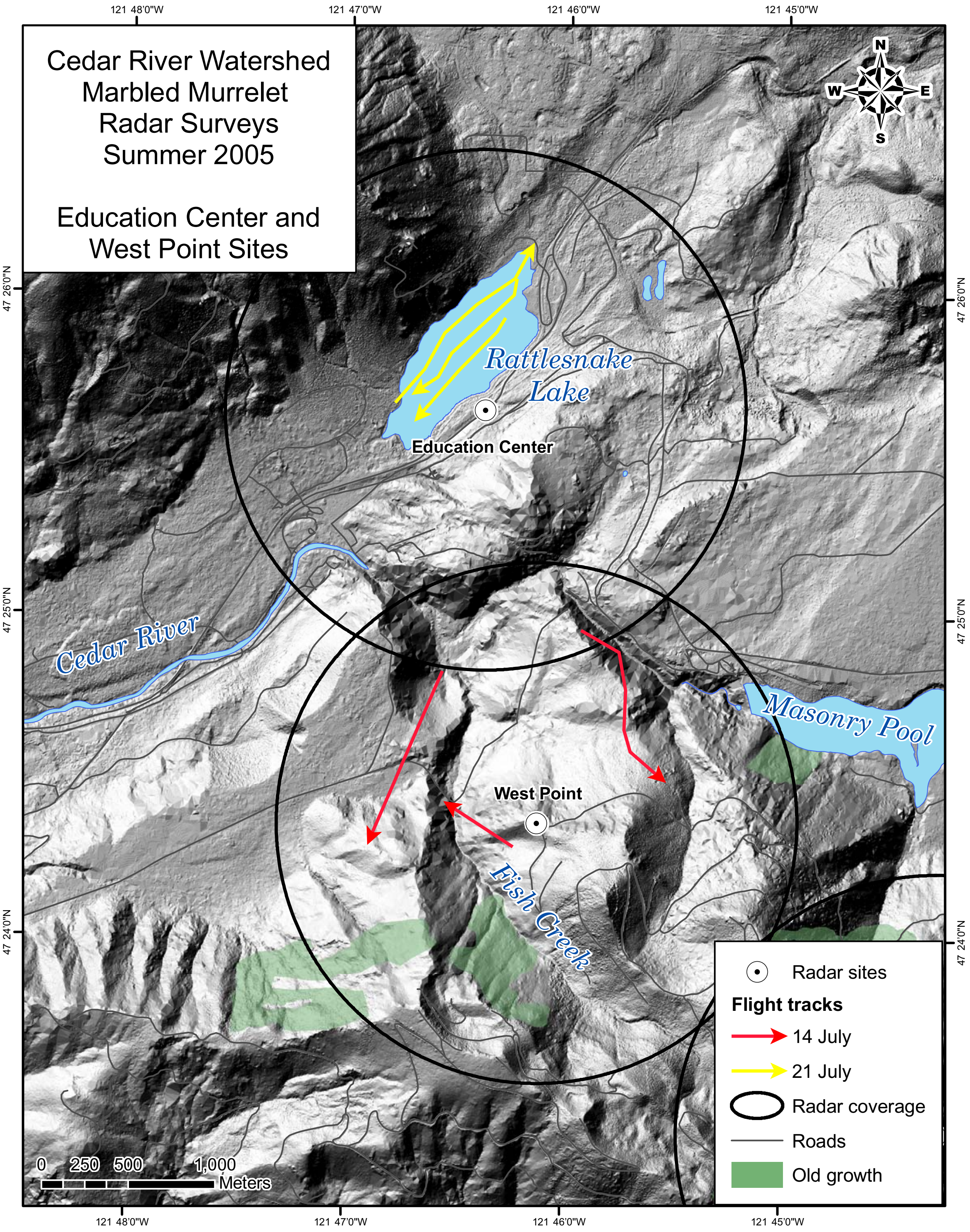

Figure 8. Map showing the flight paths of radar targets observed before sunrise at the Education Center and West Point sites in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

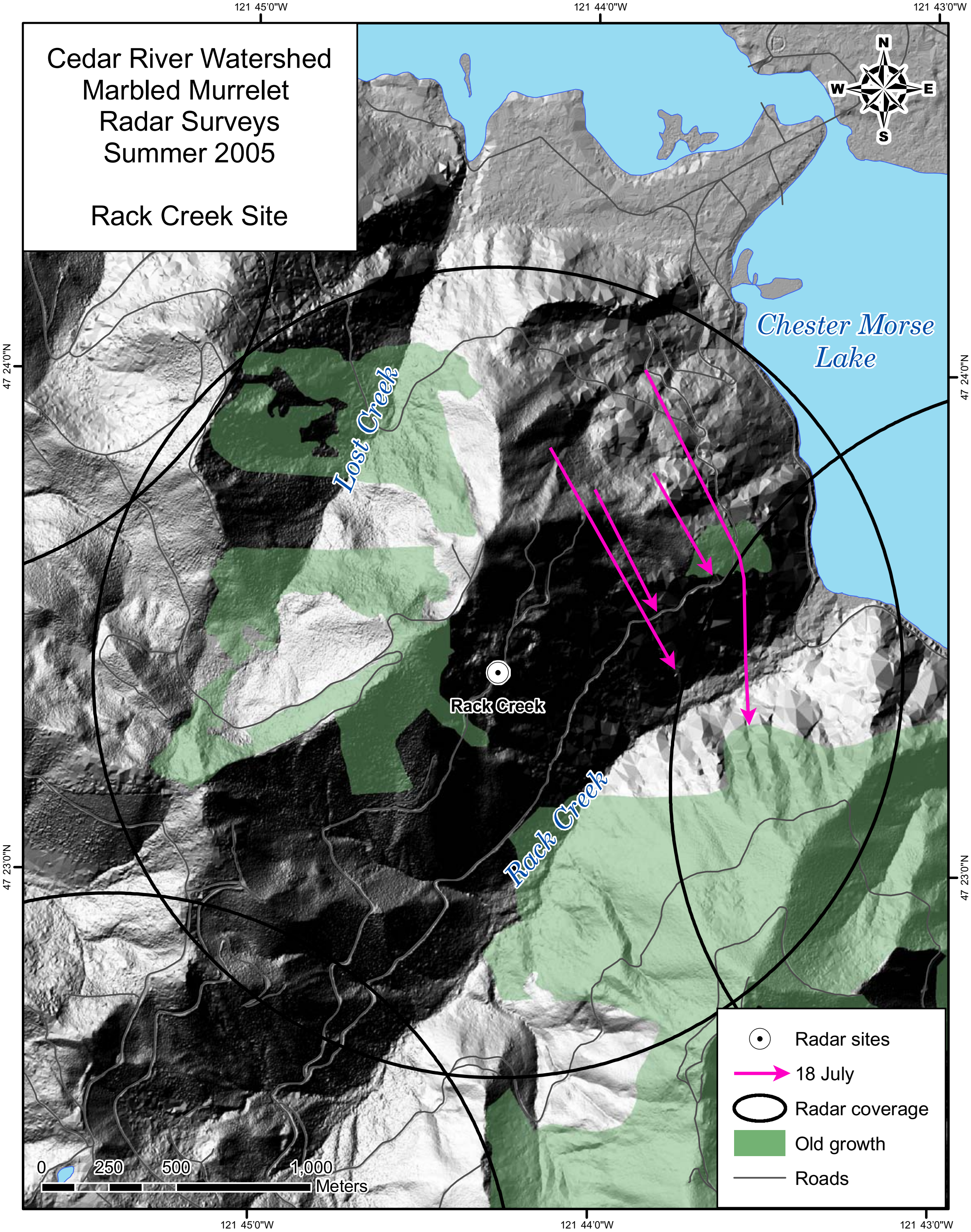

Figure 9. Map showing the flight paths of radar targets observed before sunrise at the Rack Creek site in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

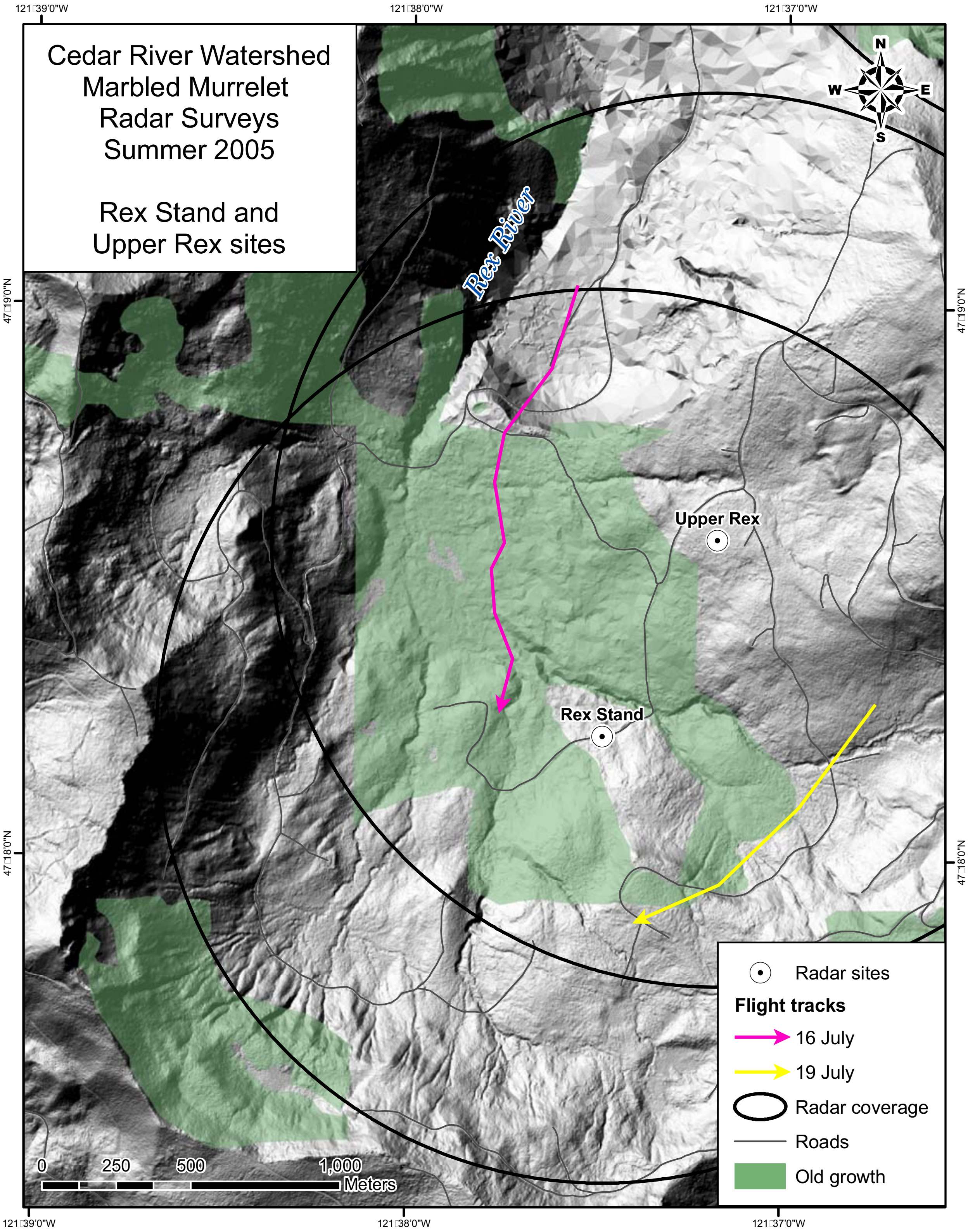

Figure 10. Map showing the flight paths of radar targets observed before sunrise at the Upper Rex and Rex Stand sites in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

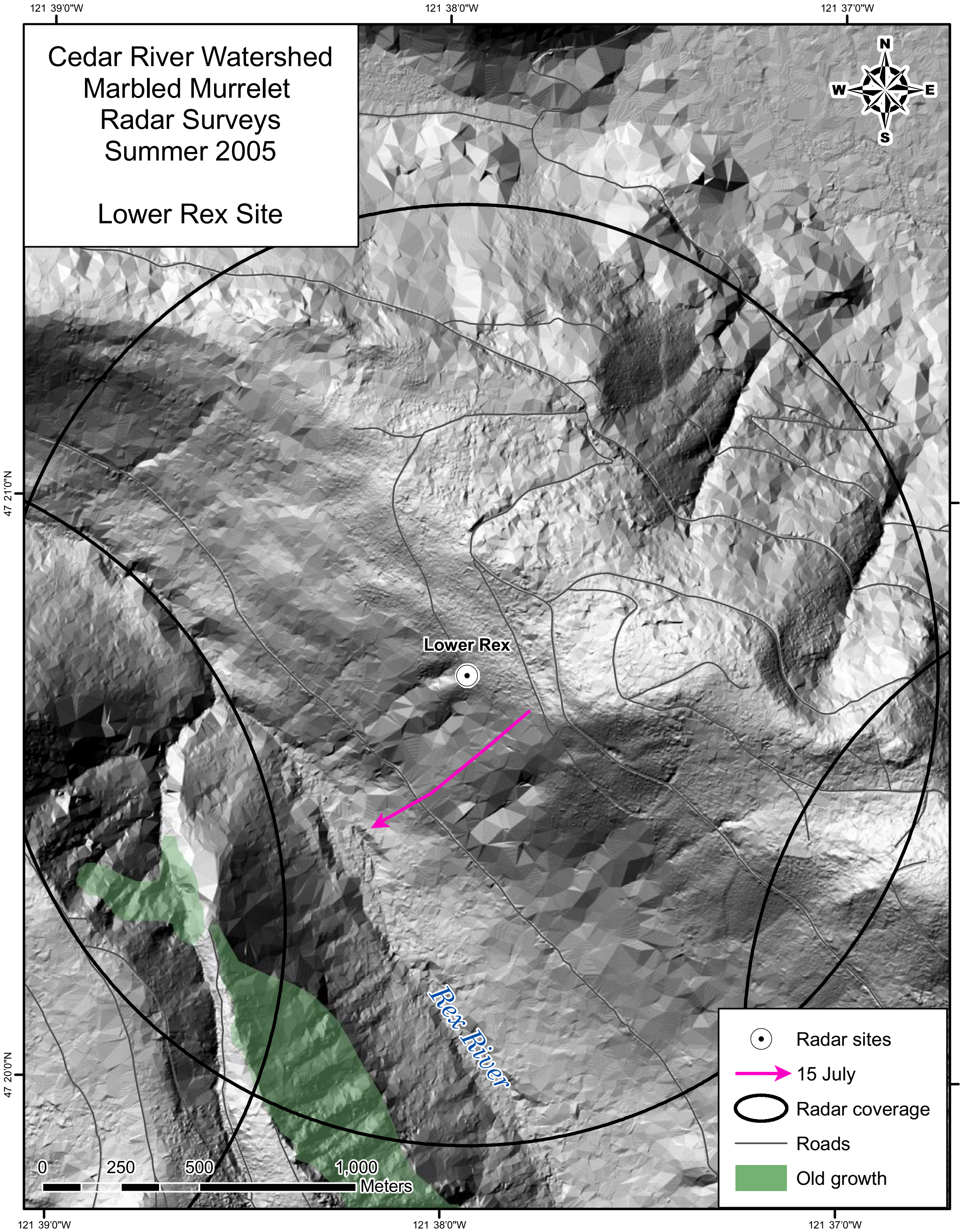

Figure 11. Map showing the flight paths of radar targets observed before sunrise at the Lower Rex site in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

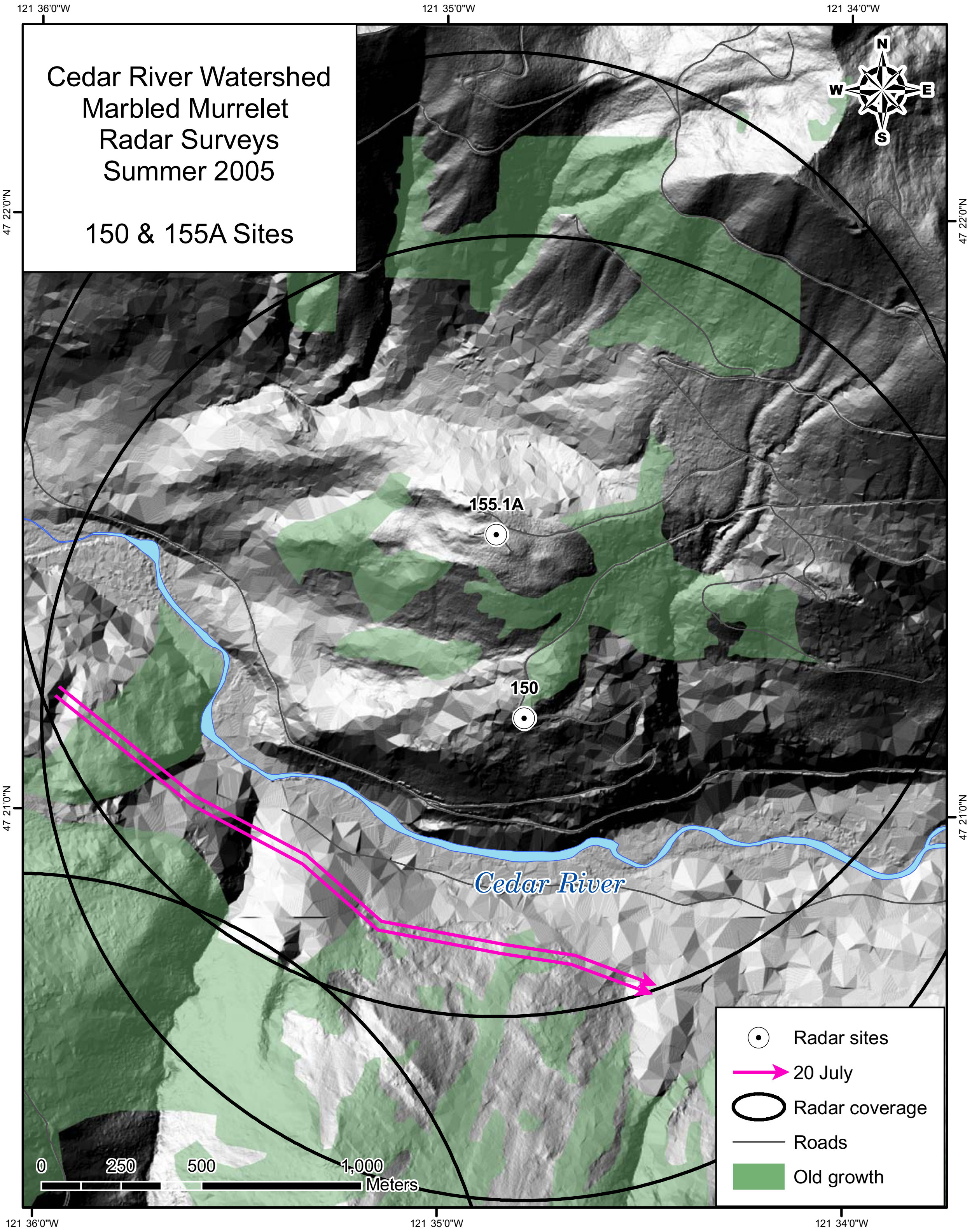

Figure 12. Map showing the flight paths of radar targets observed before sunrise at the 150 and 155.1A sites in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

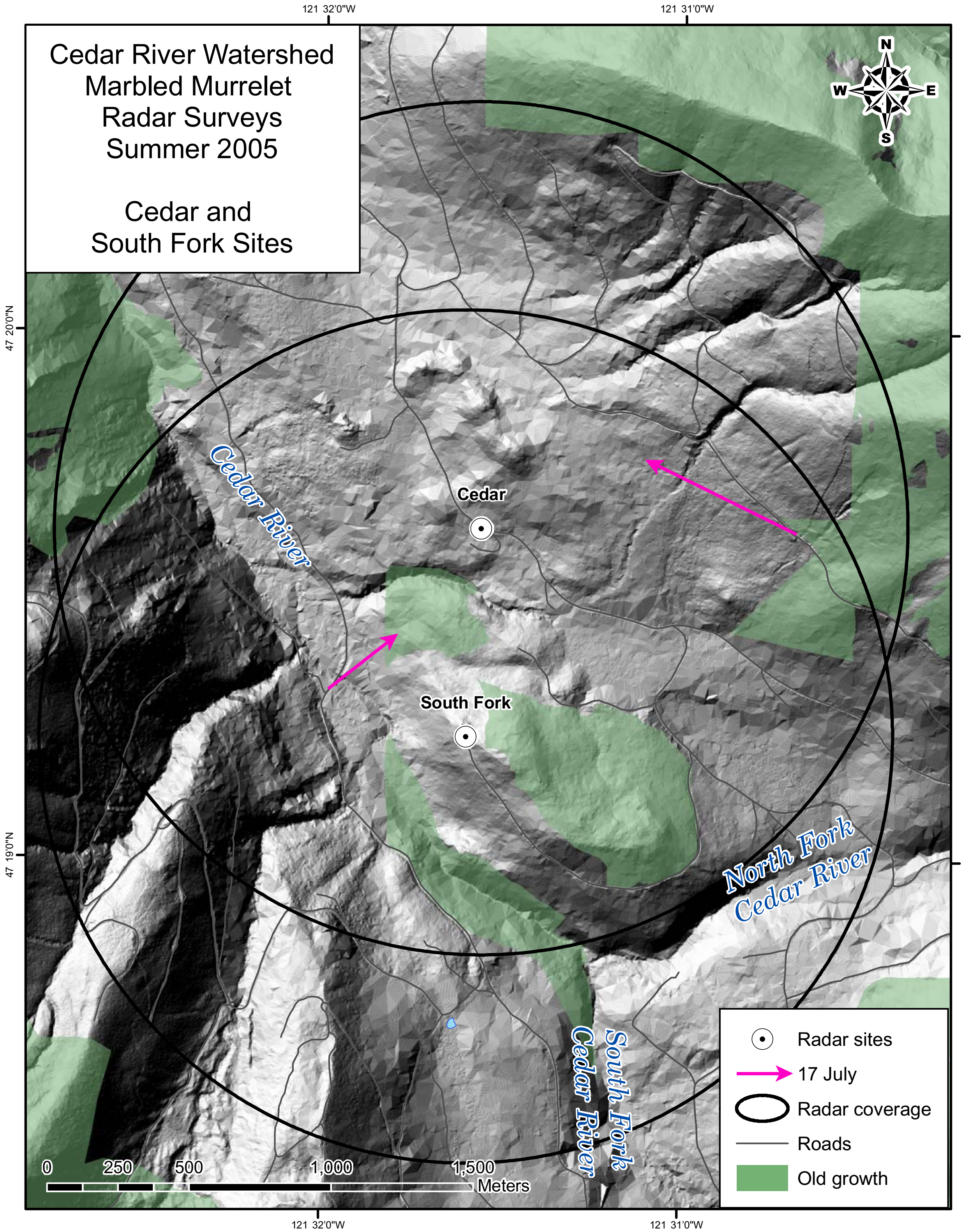

Figure 13. Map showing the flight paths of radar targets observed before sunrise at the Cedar and South Fork sites in the Cedar River Municipal Watershed, Washington, during summer 2005. Note that the 1.5-km ring denotes maximal range of the radar, but there were gaps in radar coverage within that range because of radar shadows and ground clutter.

Powerline South, most movements were either inbound or outbound birds flying along the approximate axis of the Cedar River valley (Fig. 6). Nearly all of the targets at Chester Morse were flying over the lake, and most flew along the approximate axis of the valley (Fig. 7). Some of those targets were oriented slightly south of the axis, however, suggesting that they were using the Rex River drainage, rather than the main Cedar River valley. All of the targets observed at the Education Center site were flying along the main axis of Rattlesnake Lake, heading toward/from the low pass between the lake and the Snoqualmie drainage, to the northeast (Fig. 8). Of the three targets observed at West Point, at least two of the flight paths were headed into/out of areas in the vicinity of old-growth forests to the south-southwest (Fig. 8). Similarly, all four of the targets at Rack Creek were headed southwest, in the direction of a large stand of old growth forest, rather than along the main axis of Rack Creek (Fig. 9). Both targets observed at Upper Rex and Rex Stand were headed toward the upper (i.e., southern) end of the large patch of old-growth forest in the area, where we ultimately found murrelets on our audio-visual surveys of the area (Fig. 10). One target was observed at Lower Rex, heading southwest across the Rex River, in the general direction of a patch of old-growth forest on the western side of the river (Fig. 11). Two targets were recorded flying together along the Cedar River from Site 155.1A, but no targets were observed flying in the vicinity of the patch of old-growth forest surrounding sites 155.1A and 150 (Fig. 12). Two targets were observed from the South Fork site, both of which were flying away from, or toward, a patch of old-growth forest (Fig. 13). One of those South Fork targets was following the axis of the valley, however, so it is more questionable whether that target was associated with the old-growth forest patch than the other target that was not flying along the valley (i.e., the first target may have been in transit and just happened to be detected at the point where the old-growth patch ended). No targets were recorded near the three remaining study sites (i.e., Taylor Ridge, Lindsay, and Findley), so no figures are presented for those sites.

AUDIO-VISUAL SURVEYS

We conducted five standard audio-visual (AV) surveys for Marbled Murrelets in a large patch of old-growth forest in the upper Rex River drainage during summer 2005 (Fig. 2, Table 3, Appendix 3). Visibility was limited during one of the five surveys, but we did observe Marbled Murrelets exhibiting “occupied behavior” on our 17 July visit to station AV2. Of the eight detections on that date, seven were of paired or single birds flying at or below tree canopy height. All the observations occurred within 40 m of the observation station (Appendix 3).

DISCUSSION

SUITABILITY OF CMRW FOR RADAR OBSERVATIONS

The CRMW is heavily forested and has very few natural or human-made openings, so there are few good radar sampling sites in the area. Fortunately, we were able to find excellent sites at key locations for long-term sampling as well as at several locations for short-term radar sampling. The three long-term sites located along the wide powerline corridor near the western border of the CRMW (i.e., Powerline North, Powerline Central, and Powerline South) are good sampling sites but will have good radar-sampling views in the future only if there is long-term maintenance of a wide powerline corridor. The Chester Morse site offers an excellent view over Chester Morse Lake, across the entire width of the Cedar River Valley, and should remain a good sampling site well into the future. Along with the good radar view over the lake, an additional benefit of the Chester Morse site is that is located at a topographical bottleneck that probably funnels all Marbled Murrelets in the area through the radar-sampling zone.

The three Powerline sites were placed to provide the best possible radar coverage of the western edge of the CRMW. The Powerline North and Powerline Central sites are within 1.5 km of each other, so there is some overlap in radar coverage, but there was no spatial overlap in targets detected at the two sites in 2005. For example, on the one day that targets were recorded at Powerline North (13 July 2005), none of those three targets also were recorded at the Powerline

Central site. This apparent lack of overlapping targets probably occurred because of differences in altitudinal bands that were sampled and because ground-clutter patterns obscured different parts of the area between the two sites, depending upon which site one was at. Nevertheless, we suggest concurrent sampling at the Powerline North and Powerline Central sites until we determine with more certainty whether any targets are getting double-counted at the two sites.

Judging by the higher counts at Chester Morse (~7 targets/day) than at all three powerline sites combined (~3 targets/day), it is clear that some murrelets are entering and exiting the western end of the CRMW to the north or south of the Powerline sites. Unfortunately, no additional radar sites were available to cover those areas to the north or south of the existing sites. The Powerline sites still provide a good index for monitoring, however, and there are methods for correcting the number of murrelets that pass undetected to the north or south of the combined Powerline sites (see below).

In addition to the four existing sites, the South Fork and/or 155.1A sites would be good choices for additional long-term monitoring sites, if it ultimately was deemed important to monitor trends in the far eastern end of the upper CRMW. There would be problems with longevity of either site, however, unless the surrounding forest was actively managed to maintain a good radar-sampling view. Similarly, all short-term sites were in locations where trees will grow large enough to obscure the radar view within a few years. Further, there are only a few additional sites where radar observations currently are possible in the CRMW besides the sites sampled in 2005, and those sites also are likely to be obscured by tree cover in the future. Those additional sites also tended to be located in the uppermost reaches of the watershed, so they probably are of minimal value for sampling in 2006 and 2007.

SPECIES IDENTIFICATION

Band-tailed Pigeons were common in the CRWM, and Common Loons (*Gavia immer*) were seen flying over Chester Morse Lake. Both of these species can be confused with Marbled Murrelet targets on radar, suggesting the need to continue the dawn cutoff time for observations and the continued need for target confirmation by audio-visual observers during radar surveys. We have found that Band-tailed Pigeon activity generally does not start until a few minutes after sunrise (i.e., 105 min after our radar surveys begin), so a sunrise cutoff time is very effective in minimizing contamination of the radar data. Further, nearly all murrelets fly into nesting stands well before sunrise (Burger 1997, Cooper et al. 2001), so there is little risk of missing the majority of landward flights, even with a sampling-cutoff time of sunrise. Others also have used sunrise for their cutoff time for radar monitoring of Marbled Murrelets (Burger 2001, Burger et al. 2005).

USE OF RADAR TO MONITOR TRENDS OF MURRELETS

In this first year of study, we found high Coefficients of Variation (CVs) in landward radar counts at our long-term sites (i.e., 82–172%), indicating that there was high among-day variation in those counts compared to counts at many other locations. For example, CVs of landward radar counts were 28% in the Olympic Peninsula (Cooper et al. 2001), 10–55% in Oregon (Cooper et al. 2000, Cooper and Augenfeld 2001), and 23–25% in California (Cooper et al. 2005, Bigger et al., in press). Note that most of the sites in these cited studies had much higher daily counts than the extremely low counts that we observed in this study, which could have contributed to the higher percent variation. To help put some of those CV's into perspective, power analyses on the Olympic Peninsula radar data (Cooper et al., in review) indicated that they had high power (80%) to detect a 2%/yr decline in 11 years with ~3 surveys/year at their seven sites, and Bigger et al. (in press) did a radar study in northern California and determined it would take 22 sites surveyed 4 times/yr to detect a 2.5%/yr decline in 10 years, with the same (80%) power. Our CVs suggest that we have much lower power than other radar studies to detect changes in radar counts. The long, 40-year interval between the first and last radar counts planned for CRMW should help reduce the impact of that higher variation on our ability to detect a change in the number of murrelets in the area, however, it still might be difficult to detect small annual changes in the population size even after 40 years. The radar data collected at our long-term sites in 2006 and 2007 will help determine if the variation in counts observed in 2005 was unusually high.

Because the western portion of the CRMW currently is largely devoid of Marbled Murrelet nesting habitat, there is interest in being able to separately determine local population trends of murrelets in both that western portion and the eastern portion of the watershed. In the future, it will be possible to separate trends in radar counts from the portion of CRMW west of the Chester Morse site (i.e., the western side), with trends east of the Chester Morse site (i.e., the eastern side). Put simply, this calculation would use the mean landward count at Chester Morse as an index of murrelet levels in the eastern side of the CRMW and the difference between the Chester Morse site and the sum of the three Powerline sites as an index of murrelet abundance in the western side. To separate eastern-side trends from western-side trends, however, it would first be necessary to correct the Powerline counts for a "detectability" factor to account for the proportion of birds flying into the western portion of CRMW that enter beyond the radar coverage of the three powerline sites (i.e., either north or south of the three sites). Based on 2005 data, the correction factor would be 4.3X (Correction factor = (((mean landward count at Chester Morse) + (the number of targets that were observed at sites between the Powerline sites and Chester Morse that could be assumed to have stopped before getting to Chester Morse))/(sum of the mean landward counts at the three Powerline sites)) = (7+6)/3 = 4.3). By subtracting the mean number of targets observed at Chester Morse from the corrected sum of the mean radar count at the Powerline sites, one obtains the mean number of targets observed in the western side of the CRMW. Thus, in 2005, our abundance index for murrelets using the portion the CRMW west of the Chester Morse site would be 6 (= ((3*4.3) – 7)), and our index for the number using the portion of CRMW east of Chester Morse would be 7 (i.e., our radar mean daily rate at the Chester Morse site).

To illustrate how this index could be used in the future, let us provide an example assuming that, in 2045, the sum of mean landward counts at the three Powerline sites was 12 targets and the Chester Morse count was 14 targets. Obviously, the murrelet index for that portion of the CRMW east of the Chester Morse site is then 14 in 2045 (a 200%, or 7-bird, increase over the 2005 index of 7 birds). The murrelet index for that portion of the CRMW lying between the Powerline sites and Chester Morse is more difficult to compute (i.e., 2005 index = ((3 *4.3) – 7) = 6 murrelets and 2045 index = ((12*4.3) –14) = ~38 murrelets), which would be a 32-bird increase for the western portion of the CRMW between 2005 and 2045. The murrelet indices could be used to make separate trend lines for the western and eastern portions of the CRMW. Further radar observations during 2006 at the long-term sites and at the short-term sites between the Powerline sites and Chester Morse (i.e., at Education Center, West Point, Rack Creek, and Taylor Ridge) will be necessary to help refine the correction factor for the powerline sites.

DISTRIBUTION AND ABUNDANCE

Our radar counts in the CRMW were lower than those at many locations on the Olympic Peninsula (Cooper et al. 2001; in review), the Oregon coast (Cooper et al. 2000), and California (Cooper et al. 2005), which is no surprise given the much smaller amount of nesting habitat in the CRMW. In contrast, our CRMW radar counts generally were similar to those at other sites far inland in the Washington Cascades (Cooper et al. 1999; Cooper and Blaha 2001a, 2001b; ABR, Inc. 2005).

Our landward radar counts varied widely among sampling sites, with those sites located closer to the ocean (i.e., in the western part of the watershed) and lower in altitude generally having higher counts than sites located in the eastern part of the watershed or at higher altitudes. In Washington, the most-inland known Marbled Murrelet nest location is 35 km, and the most-inland occupied site is 84 km (Evans Mack et al. 2003). The upper reaches of the CRMW is ~70 km inland (i.e., approaching the limit of murrelet distribution in Washington).

The lack of nesting platforms in higher altitudes is another possible explanation for the lack of targets in those upper areas. For example, the Findley site (where no targets were detected in 2005) is adjacent to a huge patch of old-growth forest, but nearly all of that habitat is located >1,000 m asl in elevation and a cursory examination of the habitat suggested that it contained few nesting platforms. Similarly, much of the old-growth habitat in CRMW is above 1,000 m in elevation. Nests normally occur below 1,000 m because the trees at higher elevations often lack the structural features that form platforms (Nelson 1997, Burger 2002). Nests have been found up to 1,530 m asl, however, so elevation per se should not be used to assess habitat suitability. Instead, habitat suitability should be based on the availability of nesting platforms and other features common to known nest sites. For example, sites with the highest likelihood of nesting murrelets generally have more potential nesting platforms, larger trees, and greater moss cover on tree limbs than do other sites (Grenier and Nelson 1995, Hamer 1995, Kuletz et al. 1995, Nelson 1997, Burger 2002). Specifically, murrelet nesting and activity usually is positively associated with: older stands of trees, tree diameter (dbh), density of large (dbh >80 cm) trees/ha, areas with larger basal area of trees, areas with greater vertical complexity in canopy structure, areas with greater epiphyte cover on branches, areas with a higher density of potential nesting platforms, areas in lower elevations and areas >500 m from the coastline. It would be beneficial to conduct murrelet habitat assessments in the CRMW to help determine which of the high altitude stands of old-growth forest are not suitable for nesting murrelets. That habitat information then could be used to help predict murrelet distribution in the CRMW and (along with radar information) help focus future audio-visual survey efforts.

The flight directions that we observed on radar mostly followed the main axis of valleys, except in some cases where local movements into patches of old growth suggested possible use of those patches by nesting or prospecting murrelets. For example, our 2005 radar data suggested that Marbled Murrelets might be using old-growth patches in West Point, Rack Creek, and South Fork (and perhaps the old-growth patch southwest of the lower Rex site). Audio-visual surveys would be needed to verify use of those stands by murrelets, however. Further radar observations in 2006 also will be necessary to verify an absence of murrelets at the remaining short-term radar sites with nesting habitat in the zone of coverage that did not have any targets in 2005 (i.e., Taylor Ridge, Lindsay, 155.1A, and Findley sites), because we made only one day of radar observations at each of those sites.

Audio-visual observers found Marbled Murrelets in the Rex Stand during 2006, verifying current occupancy of that stand. Murrelets also were detected during a single visit to the Rex Stand in the mid-1990s (W. P. Ritchie, WDFW, pers. comm.). Radar counts at Rex Stand and Upper Rex suggest that the number of murrelets using the stand in 2005 was low; however, more than two mornings of radar data would be needed to determine with greater certainty whether or not the low 2005 counts are representative of annual use of that stand by Marbled Murrelets.

RECOMMENDATIONS FOR 2006

In 2006, we suggest continued radar sampling at the existing long-term sites and suggest consideration of adding the South Fork or 155.1A site as a long-term site, if it is determined that it would be beneficial to monitor the upper CRMW separately from the western or central portions of the watershed. Continued sampling at the short-term sites between the three Powerline sites and Chester Morse would help provide data to fine tune the correction factor for targets that pass undetected by the Powerline sites. Radar surveys at Powerline North and Powerline Central should be conducted concurrently to minimize chances of double-counting targets observed in the zone of overlapping range between the two sites.

We suggest continuing to use the sunrise sampling cut-off time to eliminate Band-tailed Pigeons from the data. Further, we suggest continued efforts to get visual confirmation of all radar targets to help eliminate waterfowl (e.g., loons) over Chester Morse Lake and the occasional Band-tailed Pigeon that is active prior to sunrise.

Site 150 could be dropped in 2006 because Site 155.1A covers most of the area covered by Site 150, plus it does a better job of sampling the old-growth habitat in the area. The Cedar Site also could be dropped in 2006 because South Fork provides better coverage of that part of the watershed.

The 2005 and 2006 radar data could be used to focus audio-visual survey efforts in 2006 and 2007, much like we used the radar data at Rex Creek in 2005 to locate the audio-visual sampling site where we detected murrelets. If possible, we recommend conducting at least two sampling mornings at each short-term site in 2006 and three counts at each of the long-term sites. Audio-visual surveys could be conducted in old-growth stands near the Rack Creek, West Point, and South Fork sites (and perhaps Lower Rex), where 2005 radar observations suggested the presence of Marbled Murrelets. We also suggest conducting habitat assessments in old-growth habitat to help determine which stands do not have platform densities that are likely to support murrelets (especially for the old-growth habitat >1,000 m asl). These habitat assessments would provide further help pinpointing AV surveys and help avoid surveys of old-growth forest habitat that murrelets are unlikely to use.

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Appendix 1. Coding information for radar surveys of Marbled Murrelets in the Cedar River Municipal Watershed, Washington, summer 2005.

GENERAL CODES

OBSERVER
1 = Brian A. Cooper (BAC)
2 = Richard J. Blaha (RJB)
3 = Peter M. Sanzenbacher (PMS)
4 = Jeff Barna (JBB)
5 =
6 =
7 =
8=

STUDY SITE
1 = Chester Morse
2 =Main Cedar
3 =Power Line South
4 = Power Line Central
5 = Power Line North
6 =South Fork
7 =Cedar Long Term
8 =Upper Rex
9 = Lower Rex
10 =West Point
11 = Taylor Ridge
12 =Site 150
13 = Rex Stand
14 = Rack Creek
15 = Findley
16 = Site 155.1A
17 = Lindsay
18 = Education Center
19 =AV1
20 =AV2
21 = AV3

SESSION NUMBER (IF USED AT ALL)
(Write as the three-digit Julian date, a decimal point, and a two-digit number counting from 1 through *n* that represents the sequential sample taken. For example, the fifth sampling period on Julian date 182 would be 182.05. Format is XXX.XX; write XXX.00 if the session has to be canceled [e.g., because of weather], then continue the next session with the same number that you had been trying to use.)

TIME
(Write in 24-hour clock. Remember--midnight is 0000 h, **not** 2400 h.)

DATE
(People writing on forms should enter as, for example, “6 MAR” or “8 APR.” Keypunchers should enter as mo/dy/yr, as in 9/30/95.)

JDATE
(Enter the Julian date + 2,005,000. See calendar)

Appendix 1, continued.

WEATHER CODES AND MEASUREMENTS

WIND DIRECTION

(**Direction** on the ground **from which the wind is blowing**, to the nearest ordinal point. Be sure to use the local declination to correct the compass reading.)

0 = unknown/default
1 = North
2 = Northeast
3 = East
4 = Southeast
5 = South
6 = Southwest
7 = West
8 = Northwest
9 = direction is variable or no wind

WIND SPEED (mph)

(Sustained average speed at ground level, -9 = default/unknown)

0 = Calm
1 = 1-5 mph
2 = 6-10 mph
3 = 11-15 mph
4 = 16-20 mph
5 = 21-25 mph
6 = 26-30 mph
7 = 31-35 mph
etc., etc............

ESTIMATED CLOUD COVER (to the nearest 5%)

(Estimated for the area from the coast to the mountains north of the site.)

-9 = unknown/default

CEILING HEIGHT

(An average height, taken from where you are in m agl, so either in a particular section or at the radar lab. Haze that allows a distinct shadow to be cast is counted as clear sky, whereas haze that causes indistinct shadows is counted as clouds. The same is true at night, when you can see stars and the moon through the haze.)

-9 = clear sky -99 = unknown/default

MINIMAL VISIBILITY

(Record the minimal distance you can see. If you are high on a ridge, use the minimal horizontal distance, for you may be able to see lower elevations clearly but nothing up high.)

0 = unknown/default
1 = 0-50 m
2 = 51-100 m
3 = 101-500 m
4 = 501-1000 m
5 = 1001-2500 m
6 = 2501-5000 m
7 = >5000 m

Appendix 1, continued.

WEATHER CODES AND MEASUREMENTS (CONTINUED)

PRECIPITATION
(Precipitation is considered to occur if it is recorded anywhere within ~5 km of the site.)
99 = unknown/default
0 = none
1 = fog
2 = drizzle (heavy mist)
3 = light rain (continuous drops of rain)
4 = heavy rain
5 = scattered showers
6 = snow flurries
7 = light snowfall
8 = heavy snowfall
9 = sleet
10 = hail

AIR TEMPERATURE (to the nearest 1°C)
(Be sure to keep the thermometer out of direct sunlight.)
99 = unknown/default

RADAR CODES AND MEASUREMENTS

TIME
(Write in 24-hour clock. Remember--midnight is 0000 h, **not** 2400 h. If movement rates are high and you have to tally-whack the number of targets crossing different transects, do so and write the time for those data as the **end** of the 5-minute period for which you are counting [e.g., 1709, 1714, . . . 1729--not 1710, 1715, . . . 1730.].)

TARGET MULTIPLIER
(Record the number of targets flying "in a similar direction and fashion" and crossing the same segment. This category will be "1" for times when movement rates are so slow that you can record data for individual targets but will be, for example, "7" for seven targets flying the same direction and fashion during periods of high movement rates.)
0 = default

DIRECTION OF FLIGHT (to the nearest 1°)
(Measured on the radar display with the Electronic Bearing Line [EBL].)
999 = default

TRANSECT CROSSED
(That primary transect line that a bird did cross or would have crossed if you extrapolated its directional flight pattern. **Transect lines are extrapolated all the way off the screen.**)
0 = default
1 = Northern Transect
3 = Eastern Transect
5 = Southern Transect
7 = Western Transect

MINIMAL DISTANCE (to the nearest meter)
(The smallest distance to the radar lab that a target became or would become if you extrapolated its flight direction.)
999 = default

VELOCITY (to the nearest 5 **mph**) Speeds **NOT to be recorded in KPH!!**
(Measured on the radar display with the hand-held speed scales.) 0 = default

Appendix 1, Continued.

RADAR MEASUREMENTS AND CODES (CONTINUED)

FLIGHT BEHAVIOR
(Some erratically-flying or circling birds still may have an overall direction of movement; if so, record that overall direction. Otherwise, their direction is 999.)

0 = default/unknown
1 = straight-line (directional)
2 = circling (NOTE: Direction may be 999.)
3 = erratic (NOTE: Direction may be 999.)
4 =
5 =
6 =
7 =

OVERLAP
0 = default/unknown
1 = seen on radar only
2 = observed on radar and audiovisually
3 = observed audiovisually only

SPECIES (if known)
(Write in the 4-letter code in the field; **If the species is unknown, leave the space blank. If have a target that is fast enough to be a murrelet (i.e., >40 mph), but you have a strong indication by target shape or behavior that it is not, enter "NOMU" and note reasons for classification in margin.**)

NUMBER OF BIRDS IN THAT TARGET (if known)
0 = default (**If the number of birds is not counted, leave the space blank.**)

DATE

JDATE (add a 9 before the jdate, e.g., 1 Jan 1999 = 9001)

OBSERVER 1 (BAC = 1, RJB = 2, RHD=3, etc.).

OBSERVER 2 (Enter 0 if only one observer.)

FLIGHT ALTITUDE **If flight altitude is ≤25 m agl, estimate it as closely as possible to the nearest meter; if it is 26-50 m, estimate it to the nearest 2-3 m; if it is >50 m agl, your estimate will be more approximate and in categories of at least 5 m.**) 0 = default

HEARSEE
Was bird heard, seen, or both? (0 = default or radar only, S = seen only, H = Heard only, B = Both seen and heard)

Appendix 2. Data file for Marbled Murrelet targets recorded on radar in the Cedar River Municipal Watershed, Washington, during summer 2005. See Appendix 1 for coding information. Also, note that this appendix does not contain the weather data, data on targets that were non-murrelets or that were recorded after sunrise, or data from dates when weather or other factors cancelled sampling.

TIME	MULT	DIR	TRAN	MINDIS	VEL	BEH	OVLAP	SPP	NO	ALT	HEARSEE	DATE	JDATE	SITE
329	0	999	0	999	0	0	0	WDAT	0	0	0	6/29/05	2005180	1
350	1	120	1	618	41	1	1		0	0	0	6/29/05	2005180	1
408	1	150	1	456	45	1	1		0	0	0	6/29/05	2005180	1
411	1	90	1	1025	41	1	1		0	0	0	6/29/05	2005180	1
421	1	155	1	400	50	1	1		0	0	0	6/29/05	2005180	1
427	1	115	1	740	50	1	1		0	0	0	6/29/05	2005180	1
429	1	115	1	410	45	1	1		0	0	0	6/29/05	2005180	1
438	1	110	1	767	50	1	1		0	0	0	6/29/05	2005180	1
441	1	110	1	780	50	1	1		0	0	0	6/29/05	2005180	1
441	1	163	1	817	50	1	1		0	0	0	6/29/05	2005180	1
442	1	110	1	614	50	1	1		0	0	0	6/29/05	2005180	1
444	1	120	1	460	41	1	1		0	0	0	6/29/05	2005180	1
447	1	130	1	299	50	1	1		0	0	0	6/29/05	2005180	1
458	1	145	1	474	41	1	1		0	0	0	6/29/05	2005180	1
300	0	999	0	999	0	0	0	WDAT	0	0	0	6/30/05	2005181	3
330	0	999	0	999	0	0	0	WDAT	0	0	0	6/30/05	2005181	4
353	1	116	1	636	45	1	1		0	0	0	6/30/05	2005181	4
507	1	223	1	767	50	1	1		0	0	0	6/30/05	2005181	4
509	1	220	1	1046	45	1	1		0	0	0	6/30/05	2005181	4
512	1	249	1	30	50	1	1		0	0	0	6/30/05	2005181	4
513	1	228	1	593	60	1	1		0	0	0	6/30/05	2005181	4
330	0	999	0	0	0	0	0	WDAT	0	0	0	6/30/05	2005181	5
331	0	999	0	0	0	0	0	WDAT	0	0	0	7/1/05	2005182	3
347	1	40	5	824	50	1	1		0	0	0	7/1/05	2005182	3
412	1	80	3	1042	47	1	1		0	0	0	7/1/05	2005182	3
450	1	300	5	827	50	1	1		0	0	0	7/1/05	2005182	3
330	0	999	0	999	0	0	0	WDAT	0	0	0	7/1/05	2005182	5
331	0	999	0	0	0	0	0	WDAT	0	0	0	7/2/05	2005183	1
341	0	999	0	0	0	0	0	WDAT	0	0	0	7/2/05	2005183	1
346	1	150	1	614	47	1	1		0	0	0	7/2/05	2005183	1
350	0	999	0	0	0	0	0	WDAT	0	0	0	7/2/05	2005183	1
414	0	999	0	0	0	0	0	WDAT	0	0	0	7/2/05	2005183	1
425	1	340	1	669	41	1	1		0	0	0	7/2/05	2005183	1
448	0	999	0	0	0	0	0	WDAT	0	0	0	7/2/05	2005183	1
456	1	320	1	777	43	1	1		0	0	0	7/2/05	2005183	1
457	1	330	1	519	41	1	1		0	0	0	7/2/05	2005183	1
458	0	999	0	0	0	0	0	WDAT	0	0	0	7/2/05	2005183	1
337	0	999	0	999	0	0	0	WDAT	0	0	0	7/10/05	2005191	1
411	1	120	1	600	50	1	1		0	0	0	7/10/05	2005191	1
418	1	330	1	500	45	1	1		0	0	0	7/10/05	2005191	1
426	1	315	1	800	45	1	1		0	0	0	7/10/05	2005191	1

Appendix 2. Continued.

TIME	MULT	DIR	TRAN	MINDIS	VEL	BEH	OVLAP	SPP	NO	ALT	HEARSEE	DATE	JDATE	SITE
430	1	330	1	500	45	1	1		0	0	0	7/10/05	2005191	1
432	1	120	1	1300	50	1	1		0	0	0	7/10/05	2005191	1
434	1	160	3	900	50	1	1		0	0	0	7/10/05	2005191	1
442	1	310	1	500	45	2	1		0	0	0	7/10/05	2005191	1
442	1	110	1	900	45	1	1		0	0	0	7/10/05	2005191	1
443	1	135	1	500	50	1	1		0	0	0	7/10/05	2005191	1
446	1	120	1	1000	50	1	1		0	0	0	7/10/05	2005191	1
501	1	120	1	700	60	2	1		0	0	0	7/10/05	2005191	1
512	1	120	1	500	55	2	1		0	0	0	7/10/05	2005191	1
513	1	330	1	500	70	2	1		0	0	0	7/10/05	2005191	1
337	0	999	0	0	0	0	0	WDAT	0	0	0	7/10/05	2005191	4
411	1	135	3	1171	47	1	1		0	0	0	7/10/05	2005191	4
428	0	999	0	0	0	0	0	WDAT	0	0	0	7/10/05	2005191	4
428	0	999	0	0	0	0	0	WDAT	0	0	0	7/10/05	2005191	4
434	1	105	3	1146	50	1	1		0	0	0	7/10/05	2005191	4
513	0	999	0	0	0	0	0	WDAT	0	0	0	7/10/05	2005191	4
516	1	300	3	1057	45	1	1		0	0	0	7/10/05	2005191	4
338	0	999	0	0	0	0	0	WDAT	0	0	0	7/11/05	2005192	3
427	1	130	1	930	41	1	1		0	0	0	7/11/05	2005192	3
433	0	999	0	0	0	0	0	WDAT	0	0	0	7/11/05	2005192	3
506	1	200	7	485	50	1	1		0	0	0	7/11/05	2005192	3
340	0	999	0	999	0	0	0	WDAT	0	0	0	7/13/05	2005194	4
431	1	135	1	800	45	1	1		0	0	0	7/13/05	2005194	4
340	0	999	0	0	0	0	0	WDAT	0	0	0	7/13/05	2005194	5
421	1	70	5	731	41	1	1		0	0	0	7/13/05	2005194	5
441	1	90	1	781	57	1	1		0	0	0	7/13/05	2005194	5
341	0	999	0	0	0	0	0	WDAT	0	0	0	7/14/05	2005195	4
503	1	310	7	756	55	1	1		0	0	0	7/14/05	2005195	4
514	1	260	1	780	50	1	1		0	0	0	7/14/05	2005195	4
349	0	999	0	999	0	0	0	WDAT	0	0	0	7/14/05	2005195	10
420	1	150	3	700	50	1	1		0	0	0	7/14/05	2005195	10
437	1	210	7	1000	60	1	1		0	0	0	7/14/05	2005195	10
517	1	310	5	300	50	1	1		0	0	0	7/14/05	2005195	10
342	0	999	0	0	0	0	0	WDAT	0	0	0	7/15/05	2005196	9
445	1	240	3	279	45	1	1		0	0	0	7/15/05	2005196	9
343	0	999	0	0	0	0	0	WDAT	0	0	0	7/16/05	2005197	8
443	1	180	7	759	52	2	1		0	0	0	7/16/05	2005197	8
450	0	999	0	0	0	0	0	WDAT	0	0	0	7/16/05	2005197	8
501	0	999	0	0	0	0	0	WDAT	0	0	0	7/16/05	2005197	8
513	0	999	0	0	0	0	0	WDAT	0	0	0	7/16/05	2005197	8
521	0	999	0	0	0	0	0	WDAT	0	0	0	7/16/05	2005197	8
525	0	999	0	0	0	0	0	WDAT	0	0	0	7/16/05	2005197	8
344	0	999	0	0	0	0	0	WDAT	0	0	0	7/17/05	2005198	6
427	1	327	1	1099	57	1	1		0	0	0	7/17/05	2005198	6
500	1	40	1	408	41	1	1		0	0	0	7/17/05	2005198	6

Appendix 2. Continued.

TIME	MULT	DIR	TRAN	MINDIS	VEL	BEH	OVLAP	SPP	NO	ALT	HEARSEE	DATE	JDATE	SITE
345	0	999	0	999	0	0	0	WDAT	0	0	0	7/18/05	2005199	11
345	0	999	0	0	0	0	0	WDAT	0	0	0	7/18/05	2005199	14
353	1	130	1	504	43	1	1		0	0	0	7/18/05	2005199	14
421	1	150	3	787	47	1	1		0	0	0	7/18/05	2005199	14
435	1	150	1	558	45	1	1		0	0	0	7/18/05	2005199	14
444	1	175	3	833	63	1	1		0	0	0	7/18/05	2005199	14
346	0	999	0	0	0	0	0	WDAT	0	0	0	7/19/05	2005200	13
444	1	240	5	563	50	1	1		0	0	0	7/19/05	2005200	13
347	0	999	0	999	0	0	0	WDAT	0	0	0	7/20/05	2005201	12
347	0	999	0	0	0	0	0	WDAT	0	0	0	7/20/05	2005201	16
439	2	130	5	1123	58	1	1		0	0	0	7/20/05	2005201	16
349	0	999	0	0	0	0	0	WDAT	0	0	0	7/21/05	2005202	17
347	0	999	0	999	0	0	0	WDAT	0	0	0	7/21/05	2005202	18
439	1	230	7	330	47	1	1		0	0	0	7/21/05	2005202	18
441	1	40	1	420	42	1	1		0	0	0	7/21/05	2005202	18
518	1	230	7	255	42	1	1		0	0	0	7/21/05	2005202	18
351	0	999	0	999	0	0	0	WDAT	0	0	0	7/23/05	2005204	7
351	0	999	0	0	0	0	0	WDAT	0	0	0	7/23/05	2005204	15
434	0	999	0	0	0	0	0	WDAT	0	0	0	7/23/05	2005204	15
500	0	999	0	0	0	0	0	WDAT	0	0	0	7/23/05	2005204	15
511	0	999	0	0	0	0	0	WDAT	0	0	0	7/23/05	2005204	15
521	0	999	0	0	0	0	0	WDAT	0	0	0	7/23/05	2005204	15
530	0	999	0	0	0	0	0	WDAT	0	0	0	7/23/05	2005204	15

Appendix 3. Data sheets for all audio-visual surveys for Marbled Murrelets in the Cedar River Municipal Watershed, summer 2005 (attached).

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Survey Visit to Protocol (Y or N, initials): N | GAK

Page 1 of 2

Total Detections: 0

Species of Concern (circle one, details on last pg.): Y or [✓ N]

Month June Day 29 Year 2005

Area Name: Cedar River Municipal Watershed Site Name / Number: Rex Creek Station Number: 1

Station Location - **T** ______ **N, R** ______ (circle one) **E** or **W** , **S** ______, **QQ (1/16)** ______, **of Q (1/4)** ______

UTM zone: 10 E (x) coordinate: 603432 N (y) coordinate: 5240777 Source: GPS Datum: NAD83 FOM: ______

Observer (s) Name: Peter Sanzenbacher Initials: PMS Affiliation: ABR, Inc. Phone: (503) 359-7525

Station Elevation: 870 **Ft** / [✓ **M**] Position on Slope (circle one): **B**ottom/plain, **L**ower 1/3, **M**id 1/3, [✓ **U**pper 1/3,] **R**idgetop

Station Placement (circle one): [✓ **I**nside,] **O**utside

Distance from Survey Site Boundary: –

Units of Measure for **ALL** Horizontal Distances: meters

Station Canopy Cover (circle one): **1** = 0 to 25%, [✓ **2** = 26 to 50%,] **3** = 51 to 75%, **4** = 76 to 100%

ENVIRONMENTAL CONDITIONS:

Official **Sunrise** Time: 0514 **Table:** Seattle **Begin Survey** Time: 0429 **End Survey** Time: 0644

Temperature at Sunrise: 11.9 ° Temperature at End of Survey: 11.9 ° (circle one) [✓ **C**] or **F** revised: 2 / 2000

TIME	VERTICAL VIEWING			HORIZ. VIS. TO 100 M	AUDIBILITY TO 200 M	PRECIPITATION			WIND	NOISE	NOTES
	CEILING	CLOUD COVER	VISIBILITY TO 2 CANOPY			RAIN	FOG	OTHER			
0429	HI	3	N	N	Y	N	H	–	0	N	begin survey
0455	HI	3	Y	Y	Y	N	M	–	0	N	
0514	HI	3	Y	Y	Y	N	M	–	0	N	sunrise
0530	HI	3	Y	Y	Y	N	L	–	0	N	
0540	HI	3	Y	Y	Y	N	M	–	0	N	
0545	HI	3	N	N	Y	N	M	–	0	N	
0603	HI	3	Y	Y	Y	N	M	–	0	N	
0608	HI	3	N	N	Y	N	M	–	1	N	
0629	HI	3	N	N	Y	N	M	–	1	N	end official survey
0644	HI	3	N	N	Y	N	M	–	1	N	end additional 15 mins

Ceiling: UL = Unlimited (clear), **HI** = >2.0 canopy height, **MID** = >1.25 to ≤ 2.0 canopy height, **LO** = ≤1.25 canopy height, **U** = Unknown.
Cloud Cover: 0 = 0%, **1** = 33%, **2** = 66%, **3** = 100%.
Vertical Visibility: N = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Horizontal Visibility: N = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Audibility: N = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection).
Precipitation - Rain & Fog: N = None, **L** = Light, **M** = Moderate, **H** = Heavy. **Other: H** = Hail, **S** = Snow. Indicate intensity using same codes for rain & fog.
Wind: 0 = <1 mph (calm), **1** = 1-3 mph (leaves barely move), **2** = 4-7 mph (leaves rustle, sm. twigs move), **3** = 8-12 mph (leaves & sm. twigs in constant motion), **4** = 13-18 mph (sm. branches move), **5** = 19-24 mph (lg. branches & sm. trees start to sway), **6** = 25-31 mph (lg. branches in constant motion), **7** = 32-38 mph (whole trees move), **8** = 39-46 mph (twigs & sm. branches break).
Noise: N = None, **A** = Aircraft, **B** = Bird song/calls, **C** = Creek/water drainage, **M** = Machinery, **P** = Rain/hail, **T** = Tree drip, **V** = Vehicle, **W** = Wind, **O** = Other (explain in Notes).

Occurrence No. ______ Data Point No. ______ Sequence No. ______ Reference No. ______
Quad. Code ______ Photo Code ______ General Location ______
Data Entry Initials ______ Data Entry Date ______ Data QC Initials ______ Data QC Date ______
Protocol Review Initials ______ Review Date ______ Highest Biological Status ______
** WDFW DATABASE USE ONLY **

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Detections - This Side Page Total: 0
Pg. 2 of 2
Area Name: Cedar River Municipal Watershed

Observer (s) Initials: PMS
Month June Day 29 Year 2005
Site Name / No: Rex Creek

Data Reference Number:
Units of Measure (circle one): U.S. / [✓ Metric]
Station Number: 1

SURVEY ACYIVITY:

Note Significant Weather Changes on Page 1

revised: 2 / 2000

STATUS - I / O	DETECTION #	DETECTON TIME	INITIAL DETECTION DIRECTION	TYPE	AUDITORY					# BIRDS SEEN	BEHAVIOR	INITIAL FLIGHT DIRECTION	BIRD HEIGHT SEEN	CLOSEST DIST. TO BIRDS SEEN	DEPART FLIGHT DIRECTION	FINAL DETECTION DIRECTION	NOTES
					VOCAL SERIES				OTHER								Heard Only Dist. To Birds (L= Loud, M= Moderate, F= Faint)
					Start	End	#	OL	W / J				Canopy= 1.0	(units)			
	/	0429	—	—	—	—	—	—	—	—	—	—	—	—	—	—	begin survey
	/	0644	—	—	—	—	—	—	—	—	—	—	—	—	—	—	end survey
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TYPE: **H** = Heard Only (no visual), **S** = Seen Only (silent), **B** = Both Seen and Heard.

AUDITORY - Vocal Series (Vocalizations): **K** = KEER calls, **G** = Groan (alternate) calls, **O** = Whistle or Soft Que calls, **U** = Unknown, **---** = None or N/A. Indicate the vocal type heard at both the start and end if calls grade between different types during the detection. Indicate the number heard **1-5** or **M** = Multiple. **OL** = Overlapping Vocalizations (**Y** or **N**).

AUDITORY - Other (Non-Vocal Sounds): **W** = Wing Sound, **J** = Jet Sound, **---** = None or N/A. If both are heard write W / J.

BEHAVIOR: **F** = Flight Over Canopy, **C** = Circle Over Canopy, **T** = Fly-Through At or Below Canopy (≤ 1.0), **B** = Circle At or Below Canopy (≤ 1.0), **L** = Seen Landing in or Departing From a Tree, **S** = Stationary Calling (fixed-point multiple calls <100 m), **U** = Unknown.

(Check Reverse Side When Using 2-Sided Forms)

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Survey Visit to Protocol (Y or N, initials): Y | BMc

Page 1 of 2

Total Detections: 0

Species of Concern (circle one, details on last pg.): Y or [✓ N]

Month July Day 02 Year 2005

Area Name: Cedar River Municipal Watershed Site Name / Number: Rex Creek Station Number: 1

Station Location - T ________ N, R ________ (circle one) E or W , S ________, QQ (1/16) ________, of Q (1/4) ________

UTM zone: 10 E (x) coordinate: 603422 N (y) coordinate: 5240777 Source: GPS Datum: NAD83 FOM: ______

Observer (s) Name: Peter Sanzenbacher Initials: PMS Affiliation: ABR, Inc. Phone: (503) 359-7525

Station Elevation: 870 Ft / [✓ M] Position on Slope (circle one): Bottom/plain, Lower 1/3, Mid 1/3, [✓ Upper 1/3,] Ridgetop

Station Placement (circle one): [✓ Inside] Outside

Distance from Survey Site Boundary: – Units of Measure for ALL Horizontal Distances: meters

Station Canopy Cover (circle one): 1 = 0 to 25%, [✓ 2 = 26 to 50%,] 3 = 51 to 75%, 4 = 76 to 100%

ENVIRONMENTAL CONDITIONS:

Official **Sunrise** Time: 0515 **Table:** Seattle **Begin Survey** Time: 0419 **End Survey** Time: 0630

Temperature at Sunrise: 10.0 ° Temperature at End of Survey: 9.1 ° (circle one) [✓ C] or F revised: 2 / 2000

TIME	VERTICAL VIEWING			HORIZ. VIS. TO 100 M	AUDIBILITY TO 200 M	PRECIPITATION			WIND	NOISE	NOTES
	CEILING	CLOUD COVER	VISIBILITY TO 2 CANOPY			RAIN	FOG	OTHER			
0419	HI	3	Y	Y	Y	L	N	–	1	N	begin survey
0502	HI	3	Y	Y	Y	N	N	–	1	N	
0515	HI	2	Y	Y	Y	N	N	–	2	N	sunrise
0630	HI	3	Y	Y	Y	L	N	–	1	N	end survey

Ceiling: **UL** = Unlimited (clear), **HI** = >2.0 canopy height, **MID** = >1.25 to ≤ 2.0 canopy height, **LO** = ≤1.25 canopy height, **U** = Unknown.
Cloud Cover: **0** = 0%, **1** = 33%, **2** = 66%, **3** = 100%.
Vertical Visibility: **N** = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Horizontal Visibility: **N** = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Audibility: **N** = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection).
Precipitation - Rain & Fog: **N** = None, **L** = Light, **M** = Moderate, **H** = Heavy. **Other:** **H** = Hail, **S** = Snow. Indicate intensity using same codes for rain & fog.
Wind: **0** = <1 mph (calm), **1** = 1-3 mph (leaves barely move), **2** = 4-7 mph (leaves rustle, sm. twigs move), **3** = 8-12 mph (leaves & sm. twigs in constant motion), **4** = 13-18 mph (sm. branches move), **5** = 19-24 mph (lg. branches & sm. trees start to sway), **6** = 25-31 mph (lg. branches in constant motion), **7** = 32-38 mph (whole trees move), **8** = 39-46 mph (twigs & sm. branches break).
Noise: **N** = None, **A** = Aircraft, **B** = Bird song/calls, **C** = Creek/water drainage, **M** = Machinery, **P** = Rain/hail, **T** = Tree drip, **V** = Vehicle, **W** = Wind, **O** = Other (explain in Notes).

Occurrence No. ________ Data Point No. ________ Sequence No. ________ Reference No. ________
Quad. Code ________ Photo Code ________ General Location ________
Data Entry Initials ________ Data Entry Date ________ Data QC Initials ________ Data QC Date ________
Protocol Review Initials ________ Review Date ________ Highest Biological Status ________
** WDFW DATABASE USE ONLY **

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Detections - This Side Page Total: 0
Pg. 2 of 2
Area Name: Cedar River Municipal Watershed

Observer (s) Initials: PMS
Month July Day 02 Year 2005
Site Name / No: Rex Creek

Data Reference Number:
Units of Measure (circle one): U.S. / [✓ Metric]
Station Number: 1

SURVEY ACYIVITY: **Note Significant Weather Changes on Page 1** revised: 2 / 2000

STATUS - I / O	DETECTION #	DETECTON TIME	INITIAL DETECTION DIRECTION	TYPE	AUDITORY					# BIRDS SEEN	BEHAVIOR	INITIAL FLIGHT DIRECTION	BIRD HEIGHT SEEN Canopy= 1.0	CLOSEST DIST. TO BIRDS SEEN (units)	DEPART FLIGHT DIRECTION	FINAL DETECTION DIRECTION	NOTES Heard Only Dist. To Birds (L= Loud, M= Moderate, F= Faint)
					VOCAL SERIES				OTHER								
					Start	End	#	OL	W / J								
	/	0419	—	—	—	—	—	—	—	—	—	—	.	—	—	—	begin survey
	/	0630	—	—	—	—	—	—	—	—	—	—	.	—	—	—	end survey
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TYPE: **H** = Heard Only (no visual), **S** = Seen Only (silent), **B** = Both Seen and Heard.
AUDITORY - Vocal Series (Vocalizations)**:** **K** = KEER calls, **G** = Groan (alternate) calls, **O** = Whistle or Soft Que calls, **U** = Unknown, **---** = None or N/A. Indicate the vocal type heard at both the start and end if calls grade between different types during the detection. Indicate the number heard **1-5** or **M** = Multiple. **OL** = Overlapping Vocalizations (**Y** or **N**).
AUDITORY - Other (Non-Vocal Sounds)**:** **W** = Wing Sound, **J** = Jet Sound, **---** = None or N/A. If both are heard write W / J.
BEHAVIOR: **F** = Flight Over Canopy, **C** = Circle Over Canopy, **T** = Fly-Through At or Below Canopy (≤ 1.0), **B** = Circle At or Below Canopy (≤ 1.0), **L** = Seen Landing in or Departing From a Tree, **S** = Stationary Calling (fixed-point multiple calls <100 m), **U** = Unknown. **(Check Reverse Side When Using 2-Sided Forms)**

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Survey Visit to Protocol (Y or N, initials): Y | BAC

Page 1 of 2

Total Detections: 0

Species of Concern (circle one, details on last pg.): Y or [✓ N]

Month 7 Day 11 Year 05

Area Name: Cedar River Watershed

Site Name / Number: AV1-Rex Creek

Station Number: 1

Station Location - T ____ N, R ____ (circle one) E or W , S ____, QQ (1/16) ____, of Q (1/4) ____

UTM zone: 10 E (x) coordinate: 603432 N (y) coordinate: 5240777 Source: GPS Datum: NAD83 FOM: ____

Observer (s) Name: Richard Blahi Initials: RJB Affiliation: ABR Inc Phone: (503) 357 7525

Station Elevation: 870 Ft / [✓ M] Position on Slope (circle one): Bottom/plain, [✓ Lower 1/3], Mid 1/3, [✓ Upper 1/3] Ridgetop

Station Placement (circle one): [✓ Inside], Outside

Distance from Survey Site Boundary: —

Units of Measure for ALL Horizontal Distances: meters

Station Canopy Cover (circle one): 1 = 0 to 25%, [✓ 2] = 26 to 50%, 3 = 51 to 75%, 4 = 76 to 100%

ENVIRONMENTAL CONDITIONS:

Official **Sunrise** Time: 0523 **Table:** Seattle **Begin Survey** Time: 438 **End Survey** Time: 638

Temperature at Sunrise: 8 ° Temperature at End of Survey: 9 ° (circle one) [✓ C] or F

revised: 2 / 2000

TIME	VERTICAL VIEWING			HORIZ. VIS. TO 100 M	AUDIBILITY TO 200 M	PRECIPITATION			WIND	NOISE	NOTES
	CEILING	CLOUD COVER	VISIBILITY TO 2 CANOPY			RAIN	FOG	OTHER			
438	HI	1	Y	Y	Y	—	—	—	0		on site @ 0430
638	—	—	—	—	—	—	—	—	—		No predators, end of
											Survey

Ceiling: **UL** = Unlimited (clear), **HI** = >2.0 canopy height, **MID** = >1.25 to < 2.0 canopy height, **LO** = <1.25 canopy height, **U** = Unknown.
Cloud Cover: **0** = 0%, **1** = 33%, **2** = 66%, **3** = 100%.
Vertical Visibility: **N** = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Horizontal Visibility: **N** = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Audibility: **N** = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection).
Precipitation - Rain & Fog: **N** = None, **L** = Light, **M** = Moderate, **H** = Heavy. **Other:** **H** = Hail, **S** = Snow. Indicate intensity using same codes for rain & fog.
Wind: **0** = <1 mph (calm), **1** = 1-3 mph (leaves barely move), **2** = 4-7 mph (leaves rustle, sm. twigs move), **3** = 8-12 mph (leaves & sm. twigs in constant motion), **4** = 13-18 mph (sm. branches move), **5** = 19-24 mph (lg. branches & sm. trees start to sway), **6** = 25-31 mph (lg. branches in constant motion), **7** = 32-38 mph (whole trees move), **8** = 39-46 mph (twigs & sm. branches break).
Noise: **N** = None, **A** = Aircraft, **B** = Bird song/calls, **C** = Creek/water drainage, **M** = Machinery, **P** = Rain/hail, **T** = Tree drip, **V** = Vehicle, **W** = Wind, **O** = Other (explain in Notes).

Occurrence No. ____ Data Point No. ____ Sequence No. ____ Reference No. ____
Quad. Code ____ Photo Code ____ General Location ____
Data Entry Initials ____ Data Entry Date ____ Data QC Initials ____ Data QC Date ____
Protocol Review Initials ____ Review Date ____ Highest Biological Status ____
** WDFW DATABASE USE ONLY **

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Detections - This Side Page Total: 0
Pg. 2 of 2
Area Name: Cedar River Municipal Watershed
Observer (s) Initials: RJB
Month 7 Day 11 Year 05
Site Name / No: Rex Creek
Data Reference Number:
Units of Measure (circle one): U.S. / [✓ Metric]
Station Number: 1

SURVEY ACYIVITY:

Note Significant Weather Changes on Page 1

revised: 2 / 2000

STATUS - I / O	DETECTION #	DETECTON TIME	INITIAL DETECTION DIRECTION	TYPE	AUDITORY					# BIRDS SEEN	BEHAVIOR	INITIAL FLIGHT DIRECTION	BIRD HEIGHT SEEN Canopy= 1.0	CLOSEST DIST. TO BIRDS SEEN (units)	DEPART FLIGHT DIRECTION	FINAL DETECTION DIRECTION	NOTES Heard Only Dist. To Birds (L= Loud, M= Moderate, F= Faint)
					VOCAL SERIES				OTHER								
					Start	End	#	OL	W / J								
	/	0438											.				begin survey
	/	0638											.				end survey
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TYPE: **H** = Heard Only (no visual), **S** = Seen Only (silent), **B** = Both Seen and Heard.

AUDITORY - Vocal Series (Vocalizations): **K** = KEER calls, **G** = Groan (alternate) calls, **O** = Whistle or Soft Que calls, **U** = Unknown, **---** = None or N/A. Indicate the vocal type heard at both the start and end if calls grade between different types during the detection. Indicate the number heard **1-5** or **M** = Multiple. **OL** = Overlapping Vocalizations (**Y** or **N**).

AUDITORY - Other (Non-Vocal Sounds): **W** = Wing Sound, **J** = Jet Sound, **---** = None or N/A. If both are heard write W / J.

BEHAVIOR: **F** = Flight Over Canopy, **C** = Circle Over Canopy, **T** = Fly-Through At or Below Canopy (≤ 1.0), **B** = Circle At or Below Canopy (≤ 1.0), **L** = Seen Landing in or Departing From a Tree, **S** = Stationary Calling (fixed-point multiple calls <100 m), **U** = Unknown.

(Check Reverse Side When Using 2-Sided Forms)

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Survey Visit to Protocol (Y or N, initials): Y PMS

Page 1 of 4

Total Detections: 8

Species of Concern (circle one, details on last pg.): [✓ Y] or N

Month July Day 17 Year 2005

Area Name: Cedar River Municipal Watershed Site Name / Number: Rex Creek Station Number: 2

Station Location - **T** ________ **N, R** ________ (circle one) **E** or **W** , **S** ________, **QQ (1/16)** ________, **of Q (1/4)** ________

UTM zone: 10 E (x) coordinate: 603645 N (y) coordinate: 5239650 Source: GPS Datum: NAD83 FOM: ______

Observer (s) Name: Peter Sanzenbacher Initials: PMS Affiliation: ABR, Inc. Phone: (503) 359-7525

Station Elevation: 965 **Ft** / [✓ **M**] Position on Slope (circle one): **B**ottom/plain, **L**ower 1/3, [✓ **M**id 1/3,] **U**pper 1/3, **R**idgetop

Station Placement (circle one): [✓ **In**side,] **Out**side

Distance from Survey Site Boundary: –

Units of Measure for **ALL** Horizontal Distances: meters

Station Canopy Cover (circle one): **1** = 0 to 25%, [✓ **2** = 26 to 50%,] **3** = 51 to 75%, **4** = 76 to 100%

ENVIRONMENTAL CONDITIONS:

Official **Sunrise** Time: 0529 **Table**: Seattle **Begin Survey** Time: 0440 **End Survey** Time: 0644

Temperature at Sunrise: 11 ° Temperature at End of Survey: 11.5 ° (circle one) [✓ **C**] or **F** revised: 2 / 2000

TIME	VERTICAL VIEWING			HORIZ. VIS. TO 100 M	AUDIBILITY TO 200 M	PRECIPITATION			WIND	NOISE	NOTES
	CEILING	CLOUD COVER	VISIBILITY TO 2 CANOPY			RAIN	FOG	OTHER			
0440	UL	0	Y	Y	Y	N	N	–	0	N	begin survey
0529	UL	0	Y	Y	Y	N	N	–	0	N	sunrise
0644	UL	0	Y	Y	Y	N	N	–	0	N	end survey

Ceiling: **UL** = Unlimited (clear), **HI** = >2.0 canopy height, **MID** = >1.25 to ≤ 2.0 canopy height, **LO** = ≤1.25 canopy height, **U** = Unknown.
Cloud Cover: 0 = 0%, **1** = 33%, **2** = 66%, **3** = 100%.
Vertical Visibility: N = Impaired (detections may be missed due to conditions), Y = Unimpaired (conditions allow for reliable detection), U = Unknown.
Horizontal Visibility: N = Impaired (detections may be missed due to conditions), Y = Unimpaired (conditions allow for reliable detection), U = Unknown.
Audibility: N = Impaired (detections may be missed due to conditions), Y = Unimpaired (conditions allow for reliable detection).
Precipitation - Rain & Fog: N = None, **L** = Light, **M** = Moderate, **H** = Heavy. **Other: H** = Hail, **S** = Snow. Indicate intensity using same codes for rain & fog.
Wind: 0 = <1 mph (calm), **1** = 1-3 mph (leaves barely move), **2** = 4-7 mph (leaves rustle, sm. twigs move), **3** = 8-12 mph (leaves & sm. twigs in constant motion), **4** = 13-18 mph (sm. branches move), **5** = 19-24 mph (lg. branches & sm. trees start to sway), **6** = 25-31 mph (lg. branches in constant motion), **7** = 32-38 mph (whole trees move), **8** = 39-46 mph (twigs & sm. branches break).
Noise: **N** = None, **A** = Aircraft, **B** = Bird song/calls, **C** = Creek/water drainage, **M** = Machinery, **P** = Rain/hail, **T** = Tree drip, **V** = Vehicle, **W** = Wind, **O** = Other (explain in Notes).

Occurrence No. ________ Data Point No. ________ Sequence No. ________ Reference No. ________
Quad Code ________ Photo Code ________ General Location ________
Data Entry Initials ________ Data Entry Date ________ Data QC Initials ________ Data QC Date ________
Protocol Review Initials ________ Review Date ________ Highest Biological Status ________
** WDFW DATABASE USE ONLY **

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Detections - This Side Page Total: 8

Pg. 2 of 4

Area Name: Cedar River Municipal Watershed

Observer (s) Initials: PMS

Month July Day 17 Year 2005

Site Name / No: Rex Creek

Data Reference Number:

Units of Measure (circle one): U.S. / [✓ Metric]

Station Number: 2

SURVEY ACYIVITY: **Note Significant Weather Changes on Page 1** revised: 2 / 2000

STATUS - I / O	DETECTION #	DETECTON TIME	INITIAL DETECTION DIRECTION	TYPE	AUDITORY VOCAL SERIES Start	AUDITORY VOCAL SERIES End	AUDITORY VOCAL SERIES #	AUDITORY VOCAL SERIES OL	AUDITORY OTHER W / J	# BIRDS SEEN	BEHAVIOR	INITIAL FLIGHT DIRECTION	BIRD HEIGHT SEEN Canopy= 1.0	CLOSEST DIST. TO BIRDS SEEN (meters) units	DEPART FLIGHT DIRECTION	FINAL DETECTION DIRECTION	NOTES Heard Only Dist. To Birds (L= Loud, M= Moderate, F= Faint)
	/	0440	—	—	—	—	—	—	—	—	—	—	.	—	—	—	begin survey
	01	0505	W	S	—	—	—	—	-	2	T	S	0.7	40	S	SW	
	02	0515	WNW	S	—	—	—	—	-	2	T	SE	0.8	30	SE	SW	
	03	0515	NNE	S	—	—	—	—	-	1	B	S	0.9	10	SW	E	
	04	0515	SE	S	—	—	—	—	-	2	B	NW	0.8	10	NNE	N	
	05	0517	WNW	S	—	—	—	—	-	2	T	SE	0.8	30	SE	SW	
	06	0518	SE	S	—	—	—	—	-	1	B	NW	0.7	5	NNE	N	
	07	0522	SW	S	—	—	—	—	-	2	F	NNE	1.1	15	NNE	N	
	08	0523	SW	B	K	K	1	N	-	2	T	N	0.9	35	N	NW	abbreviated, muffled call
	/	0644	—	—	—	—	—	—	—	—	—	—	.	—	—	—	end survey

TYPE: **H** = Heard Only (no visual), **S** = Seen Only (silent), **B** = Both Seen and Heard.

AUDITORY - Vocal Series (Vocalizations): **K** = KEER calls, **G** = Groan (alternate) calls, **O** = Whistle or Soft Que calls, **U** = Unknown, **---** = None or N/A. Indicate the vocal type heard at both the start and end if calls grade between different types during the detection. Indicate the number heard **1-5** or **M** = Multiple. **OL** = Overlapping Vocalizations (**Y** or **N**).

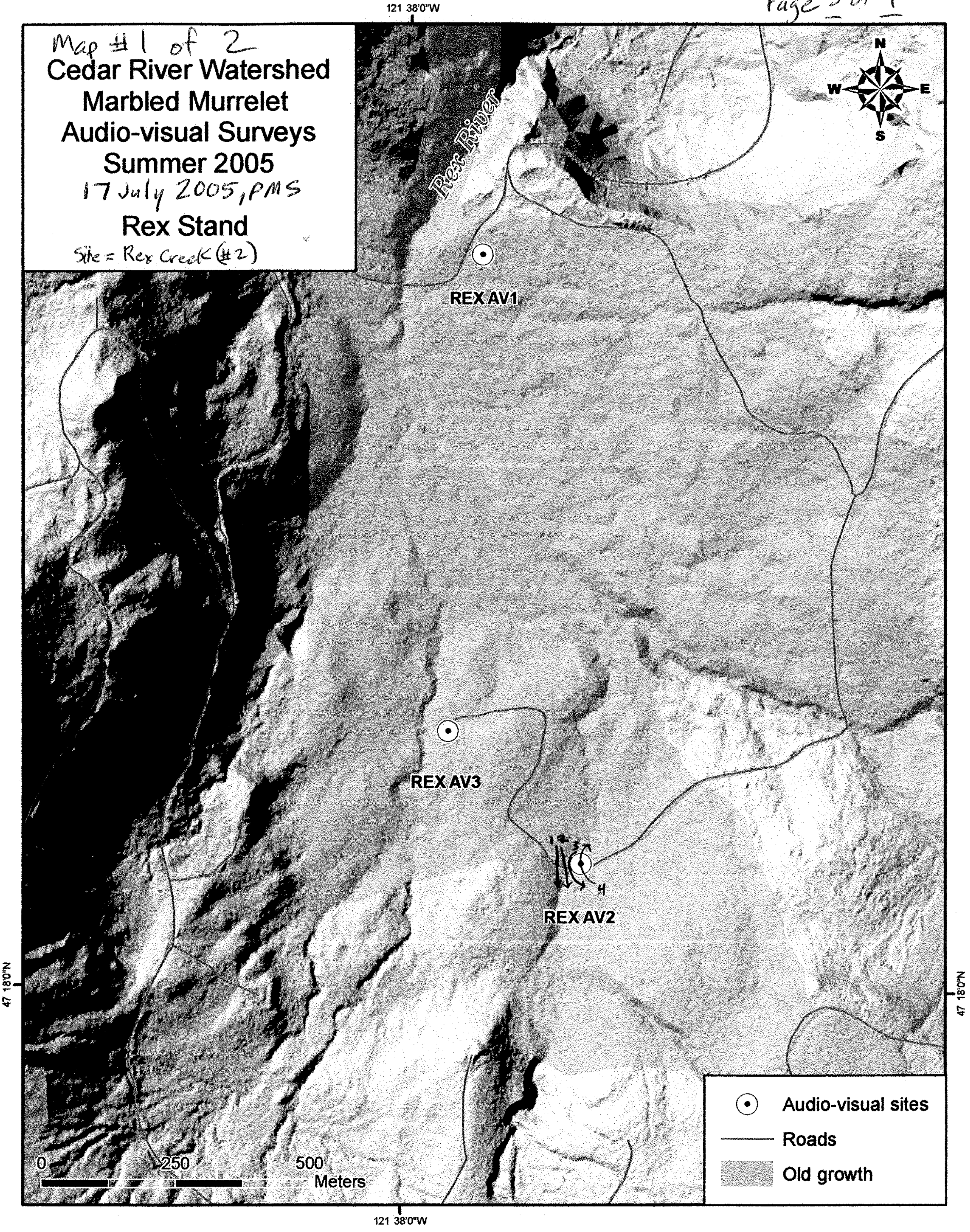
AUDITORY - Other (Non-Vocal Sounds): **W** = Wing Sound, **J** = Jet Sound, **---** = None or N/A. If both are heard write W / J.

BEHAVIOR: **F** = Flight Over Canopy, **C** = Circle Over Canopy, **T** = Fly-Through At or Below Canopy (≤ 1.0), **B** = Circle At or Below Canopy (≤ 1.0), **L** = Seen Landing in or Departing From a Tree, **S** = Stationary Calling (fixed-point multiple calls <100 m), **U** = Unknown.

(Check Reverse Side When Using 2-Sided Forms)

species of concern - MAMU potential predators - STJA, VATH

Page 3 of 4



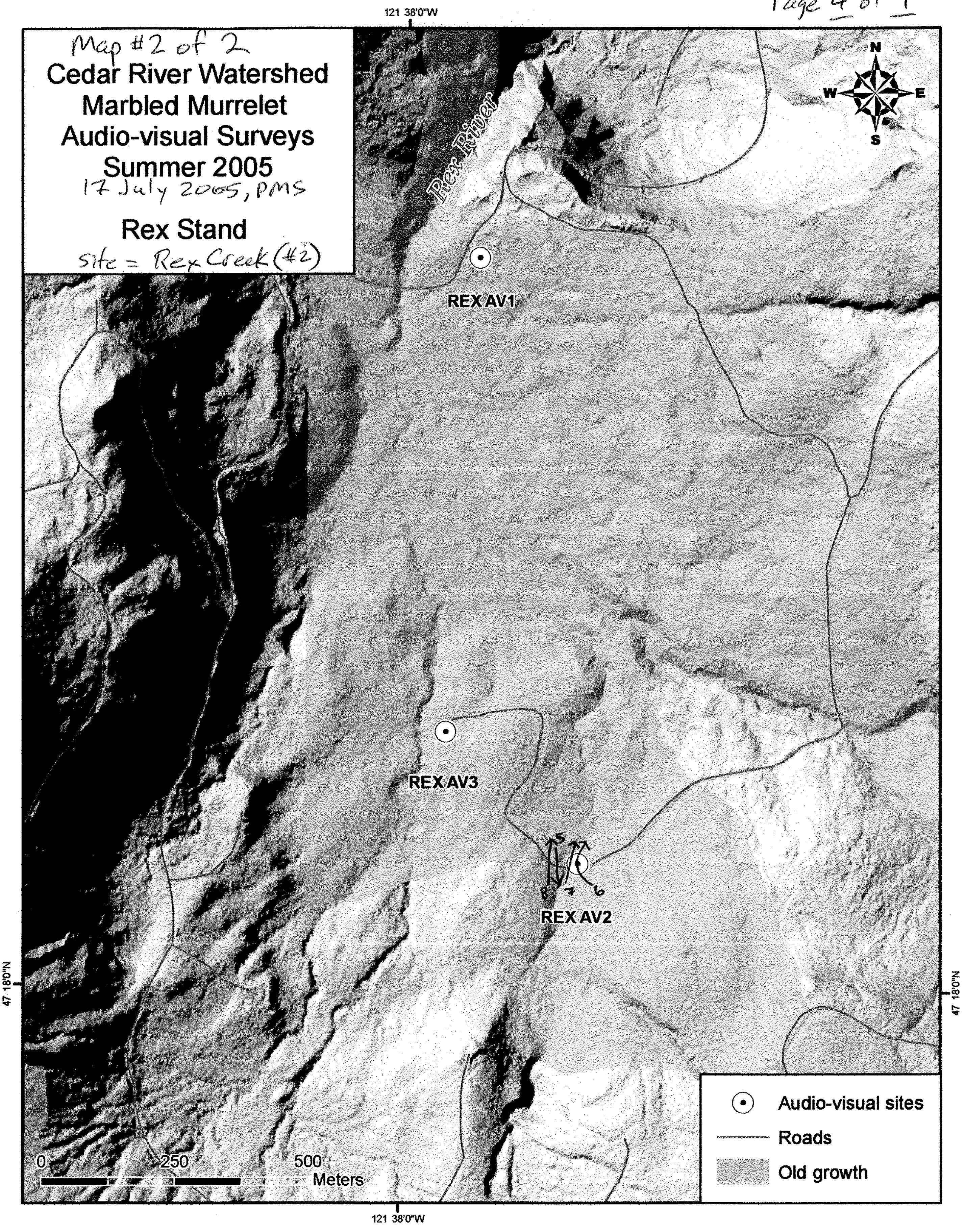
Map #1 of 2

Cedar River Watershed
Marbled Murrelet
Audio-visual Surveys
Summer 2005

17 July 2005, PMS

Rex Stand

Site = Rex Creek (#2)



Map #2 of 2

Cedar River Watershed
Marbled Murrelet
Audio-visual Surveys
Summer 2005
17 July 2005, PMS

Rex Stand
site = Rex Creek (#2)

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Survey Visit to Protocol (Y or N, initials): Y | Dlk

Page 1 of 2

Total Detections: 0

Species of Concern (circle one, details on last pg.): Y or [✓ N]

Month July Day 19 Year 2005

Area Name: Cedar River Municipal Watershed Site Name / Number: Rex Creek Station Number: 3

Station Location - **T** ________ **N, R** ________ (circle one) **E** or **W** , **S** ________, **QQ (1/16)** ________, **of Q (1/4)** ________

UTM zone: 10 E (x) coordinate: 603390 N (y) coordinate: 5239890 Source: GPS Datum: NAD83 FOM: ______

Observer (s) Name: Peter Sanzenbacher Initials: PMS Affiliation: ABR, Inc. Phone: (503) 359-7525

Station Elevation: 912 Ft / [✓ M] Position on Slope (circle one): **B**ottom/plain, **L**ower 1/3, [✓ **M**id 1/3,] **U**pper 1/3, **R**idgetop

Station Placement (circle one): [✓ **In**side] **Out**side

Distance from Survey Site Boundary: — Units of Measure for **ALL** Horizontal Distances: meters

Station Canopy Cover (circle one): **1** = 0 to 25%, [✓ **2** = 26 to 50%,] **3** = 51 to 75%, **4** = 76 to 100%

ENVIRONMENTAL CONDITIONS:

Official **Sunrise** Time: 0531 **Table:** Seattle **Begin Survey** Time: 0431 **End Survey** Time: 0646

Temperature at Sunrise: 6 ° Temperature at End of Survey: 7 ° (circle one) [✓ C] or **F** revised: 2 / 2000

TIME	VERTICAL VIEWING			HORIZ. VIS. TO 100 M	AUDIBILITY TO 200 M	PRECIPITATION			WIND	NOISE	NOTES
	CEILING	CLOUD COVER	VISIBILITY TO 2 CANOPY			RAIN	FOG	OTHER			
0431	UL	0	Y	Y	Y	N	N	–	1	N	begin survey
0531	UL	0	Y	Y	Y	N	N	–	1	N	sunrise
0646	UL	0	Y	Y	Y	N	N	–	0	N	end survey

Ceiling: UL = Unlimited (clear), **HI** = >2.0 canopy height, **MID** = >1.25 to ≤ 2.0 canopy height, **LO** = ≤1.25 canopy height, **U** = Unknown.
Cloud Cover: 0 = 0%, **1** = 33%, **2** = 66%, **3** = 100%.
Vertical Visibility: N = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Horizontal Visibility: N = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection), **U** = Unknown.
Audibility: N = Impaired (detections may be missed due to conditions), **Y** = Unimpaired (conditions allow for reliable detection).
Precipitation - Rain & Fog: N = None, **L** = Light, **M** = Moderate, **H** = Heavy. **Other: H** = Hail, **S** = Snow. Indicate intensity using same codes for rain & fog.
Wind: 0 = <1 mph (calm), **1** = 1-3 mph (leaves barely move), **2** = 4-7 mph (leaves rustle, sm. twigs move), **3** = 8-12 mph (leaves & sm. twigs in constant motion), **4** = 13-18 mph (sm. branches move), **5** = 19-24 mph (lg. branches & sm. trees start to sway), **6** = 25-31 mph (lg. branches in constant motion), **7** = 32-38 mph (whole trees move), **8** = 39-46 mph (twigs & sm. branches break).
Noise: N = None, **A** = Aircraft, **B** = Bird song/calls, **C** = Creek/water drainage, **M** = Machinery, **P** = Rain/hail, **T** = Tree drip, **V** = Vehicle, **W** = Wind, **O** = Other (explain in Notes).

Occurrence No. ________ Data Point No. ________ Sequence No. ________ Reference No. ________
Quad. Code ________ Photo Code ________ General Location ________
Data Entry Initials ________ Data Entry Date ________ Data QC Initials ________ Data QC Date ________
Protocol Review Initials ________ Review Date ________ Highest Biological Status ________
** WDFW DATABASE USE ONLY **

WASHINGTON MARBLED MURRELET FOREST SURVEY FORM

Detections - This Side Page Total: 0 Pg. 2 of 2
Area Name: Cedar River Municipal Watershed
Observer (s) Initials: PMS
Month July Day 19 Year 2005
Site Name / No: Rex Creek
Data Reference Number: ______
Units of Measure (circle one): U.S. / [✓ Metric]
Station Number: 3

SURVEY ACYIVITY: **Note Significant Weather Changes on Page 1** revised: 2 / 2000

STATUS - I / O	DETECTION #	DETECTON TIME	INITIAL DETECTION DIRECTION	TYPE	AUDITORY					# BIRDS SEEN	BEHAVIOR	INITIAL FLIGHT DIRECTION	BIRD HEIGHT SEEN	CLOSEST DIST. TO BIRDS SEEN	DEPART FLIGHT DIRECTION	FINAL DETECTION DIRECTION	NOTES
					VOCAL SERIES				OTHER				Canopy= 1.0	( ) units			Heard Only Dist. To Birds (L= Loud, M= Moderate, F= Faint)
					Start	End	#	OL	W / J								
	/	0431	—	—	—	—	—	—	—	—	—	—	.	—	—	—	begin survey
	/	0646	—	—	—	—	—	—	—	—	—	—	.	—	—	—	end survey
													.				
													.				* note
													.				-0510 brief glimpse
													.				of potential MAMU
													.				-first seen to NW
													.				flying south at
													.				0.8 canopies and
													.				lost sight to SW
													.				Flight somewhat slow
													.				and erratic. Confidence
													.				not sufficient to
													.				call MAMU.
													.				Closest distance to
													.				target ~ 35 m
													.				
													.				
													.				
													.				

TYPE: **H** = Heard Only (no visual), **S** = Seen Only (silent), **B** = Both Seen and Heard.
AUDITORY - Vocal Series (Vocalizations): **K** = KEER calls, **G** = Groan (alternate) calls, **O** = Whistle or Soft Que calls, **U** = Unknown, **---** = None or N/A. Indicate the vocal type heard at both the start and end if calls grade between different types during the detection. Indicate the number heard **1-5** or **M** = Multiple. **OL** = Overlapping Vocalizations (**Y** or **N**).
AUDITORY - Other (Non-Vocal Sounds): **W** = Wing Sound, **J** = Jet Sound, **---** = None or N/A. If both are heard write W / J.
BEHAVIOR: **F** = Flight Over Canopy, **C** = Circle Over Canopy, **T** = Fly-Through At or Below Canopy (≤ 1.0), **B** = Circle At or Below Canopy (≤ 1.0), **L** = Seen Landing in or Departing From a Tree, **S** = Stationary Calling (fixed-point multiple calls <100 m), **U** = Unknown. **(Check Reverse Side When Using 2-Sided Forms)**