Wolverine Distribution and Ecology in the North Cascades Ecosystem
2010 Annual Report

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Frontispiece. Northern Cascade Range in Washington.

I. Introduction

The wolverine (*Gulo gulo*) is one of the rarest mammals in North America and the least known of the large carnivores (Banci 1994). It is considered a sensitive species in the Pacific Northwest Region by the U.S. Forest Service, and a candidate species for listing as threatened or endangered by the state of Washington. The northern Cascade Range in Washington represents the southernmost extent of current wolverine range along the Pacific coast of North America (Aubry et al. 2007). Prior to our research, wolverines had never been studied in the field in this region, due partly to their low densities and extremely limited access during all periods of the year into the unroaded wilderness areas where they occur. Recent radiotelemetry studies of wolverines in the Rocky Mountains of British Columbia (Krebs et al. 2007) and the United States (Copeland 1996, Copeland et al. 2007, Squires et al. 2007) indicate that wolverines are wide-ranging, inhabit remote areas near timberline, and are sensitive to human disturbance at natal and maternal den sites. Winter recreation activities are widespread in the northern Cascade Range and often occur in suitable wolverine denning habitat. Such activities may adversely affect wolverine populations or their preferred habitat.

Snowtracking and remote-camera surveys conducted during the last 10-15 years, coupled with a review of historical occurrence records in Forest Service files, resulted in a number of highly credible wolverine observations (many verifiable) from areas near the Cascade Crest on the Methow Valley Ranger District of the Okanogan-Wenatchee National Forest. Consequently, we chose this area for a pilot study we conducted during the winter of 2005/06 to evaluate the feasibility of trapping wolverines during winter in the northern Cascade Range. The pilot study was successful, so we have continued to use this area as the center of a greatly expanded study area that we are currently using to monitor wolverine movements with satellite telemetry, estimate home ranges, and investigate patterns of habitat use.

Although all verifiable records of wolverine occurrence in Washington during the past 10 years had been from areas near the Cascade Crest, DNA analysis confirmed that a sample of hair collected in 2005 in the Kettle Range near Danville in Ferry Co. was from a wolverine (C. Loggers, U.S. Forest Service, personal communication). This record suggested that wolverines may be more broadly distributed in Washington than previously believed. Thus, an additional objective of our study was to expand our trapping area and establish trap sites as far east of the Cascade Crest as feasible, in hopes of capturing individuals or family groups that occur outside the Pasayten Wilderness. Also, findings from our research to date indicate that wolverines in the northern Cascades of Washington appear to be part of a larger population that includes portions of British Columbia and, possibly, Alberta.

As in Washington, however, relatively little is known about the population status or ecology of wolverines in southwestern Canada. Consequently, in year 3 (winter 2008/09), we expanded the geographic scope of our study by establishing a collaborative relationship with Eric Lofroth, Mesocarnivore Specialist for the B.C. Ministry of Environment. Eric has conducted field research on wolverines in B.C., and brings a wealth of knowledge and experience to the project. This is a truly collaborative effort; field crews in British Columbia follow all of our protocols, and resulting data will be sent to the Pacific Northwest Research Station to be integrated with data collected in Washington.

This progress report is cumulative, and includes results from the pilot study, as well as the first 4 years of research (winters of 2006/07 thru 2009/10) on wolverine distribution and ecology in the North Cascades Ecosystem.

II. Methods

Our study area is located in the northern Cascade Range, primarily on the Methow Valley Ranger District of the Okanogan-Wenatchee National Forest in Washington (Figure 1). The Methow Valley Ranger District is bounded on the north by British Columbia, Canada, on the west by North Cascades National Park, and extends south to near the Columbia River and east to the divide between the Methow and Okanogan River watersheds. It encompasses portions of the Pasayten and Lake Chelan-Sawtooth wildernesses, and extends approximately 50 mi along the Cascade Crest. Vegetation cover types include bitterbrush/bluebunch wheatgrass at lower elevations, mixed-conifer forests at mid- to high elevations, and alpine meadows, rocky ridges, peaks, and small glaciers at the highest elevations. In 2008/09, we expanded the study area northward into the Silver Skagit, Skagit, and Similkameen watersheds of British Columbia. This area encompasses multiple land ownerships including portions of Skagit Valley and Manning Provincial Parks.

To date, we have constructed 12 wolverine livetraps in Washington and 12 in British Columbia (Figure 2). In Washington, we located all traps near the Cascade Crest or adjacent to the Pasayten and Lake Chelan/Sawtooth Wildernesses. We constructed 3 wolverine livetraps for the pilot study (winter 2005/06) and built 9 additional traps during subsequent years: 1 in year 1 (winter 2006/07), 2 in year 2 (winter 2007/08), and 6 in year 3 (winter 2008/09; Table 1).

In Washington, we built traps *in situ* in areas where wolverine occurrences had been documented recently, and located them within ~500 ft of roads that were regularly used by snowmobilers. We constructed traps from logs cut from trees at the site using the design recommended by Copeland et al. (1995), which is being used for wolverine studies in the northern Rocky Mountains and elsewhere in North America (Appendix, Photo 1).

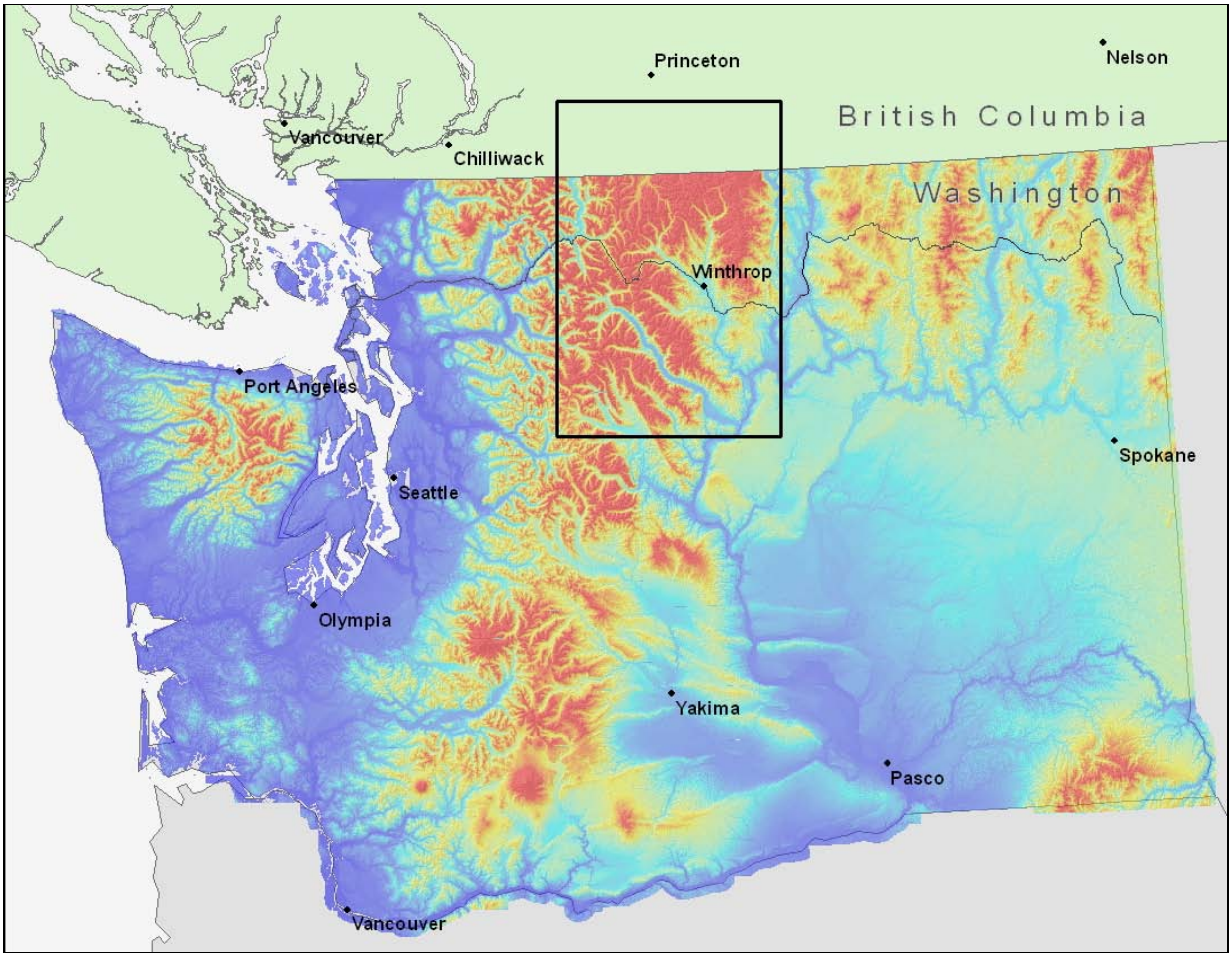

Figure 1. Primary area of research activities during the pilot study (winter 2005/06) and years 1 thru 4 (winters 2006/07, 2007/08, 2008/09, and 2009/10) of a long-term study of wolverines in the North Cascades Ecosystem. In Washington, colors show the topographic gradient based on a digital elevation model; "cool" colors are lower in elevation than "warm" colors.

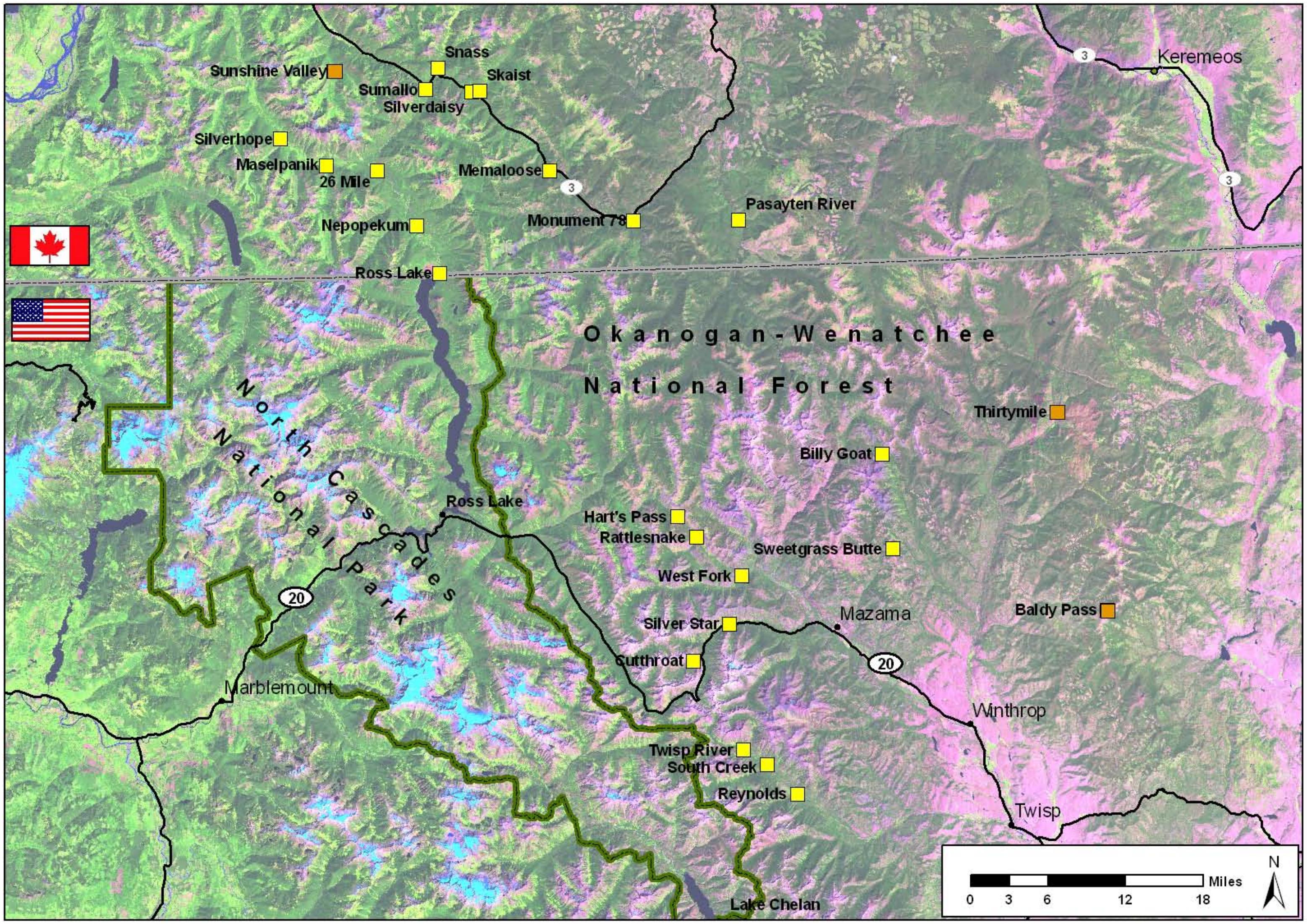

Figure 2. Locations of wolverine livetraps operated or monitored during the winter of 2009/10 in the North Cascades Ecosystem by field crews in Washington and British Columbia (yellow squares); traps indicated with orange squares were not operated this year.

Table 1. General site characteristics at 12 wolverine livetraps deployed in the northern Cascade Range of Washington. For traps that were built but not operated immediately (i.e., traps were not set to live-capture wolverines), we baited and monitored the site for wolverine activity.

Trap site	Year built	Year first operated	Elevation (ft)	Vegetation type
Cutthroat	2005/06	2005/06	4,400	Subalpine mixed-conifer
Hart's Pass	2005/06	2005/06	6,200	Subalpine mixed-conifer
Twisp River	2005/06	2006/07	3,600	Montane mixed-conifer
Baldy Pass	2006/07	2006/07	6,400	Subalpine mixed-conifer
Billygoat	2007/08	2007/08	4,800	Subalpine mixed-conifer
Thirtymile	2007/08	monitored	3,400	Montane mixed-conifer
Reynolds	2008/09	2008/09	2,900	Montane mixed conifer
South Creek	2008/09	2008/09	3,200	Montane mixed conifer
Rattlesnake	2008/09	2008/09	5,400	Subalpine mixed-conifer
West Fork	2008/09	2008/09	2,700	Montane mixed conifer
Silverstar Creek	2008/09	2008/09	3,400	Montane mixed conifer
Sweetgrass Butte	2008/09	2008/09	6,000	Subalpine mixed-conifer

In British Columbia, we constructed 10 livetraps during the winter of 2008/09 and 2 additional traps during the winter of 2009/10 (Figure 2); all were located in Interior Douglas-fir, Coastal Western Hemlock, and Montane Spruce biogeoclimatic zones. In British Columbia, we prefabricated traps with milled lumber, and then transported them to the trap site for re-assembly and installation (Lofroth et al. 2008; Appendix, Photo 1).

We baited traps with parts of road-killed mule deer, beaver carcasses, and/or salmon carcasses, and monitored them daily via a trap-site transmitter that indicated whether the trap lid had closed. We visited all operating traps twice per week to ensure that they were functioning properly. We immobilized captured wolverines with a mixture of ketamine and medetomidine (Washington) or Telazol (British Columbia) administered via a jab stick. We took tissue samples from all captured wolverines for genetic profiling, and gathered data on the sex, age, and condition of captured animals. We attached a small, brightly colored plastic tag to each ear, and outfitted each study animal with Sirtrack radio-collars containing both Argos satellite transmitters and standard VHF transmitters. Satellite transmitters provide general location and movement data collected remotely via an internet-based connection to the Argos Data Collection System. When possible, the VHF transmitters enable us to obtain fine-scale occurrence data to facilitate locating natal and maternal dens of reproductive females, and to recover radio-collars that are removed prematurely by the study animal or if it dies during the lifespan of the satellite transmitter. In year 2 (2007/08), we began taking standardized photographs of throat and chest markings of all captured wolverines; such markings can be used to distinguish individuals. In year 3 (2008/09), we modified our capture/handling protocol to include a passive integrated transponder (PIT) tag injected subcutaneously on the back of captured wolverines to enable individual identification of previously captured animals if they are no longer wearing a collar or ear tags.

During the pilot study, we programmed satellite transmitters to be on for only 5 hr each day so that the transmitters would gather location data for >1 yr. However, this duty cycle resulted in very few satellite locations from radio-collared wolverines, indicating that a longer duty cycle was needed to obtain a sufficient number of high-quality locations to investigate broad-scale habitat use by wolverines. To correct these problems, during years 1 and 2 (winters 2006/07 and 2007/08), we programmed satellite transmitters to be "on" for 48 hr and "off" for 24 hr and to transmit a signal every 60 sec while on. We programmed the VHF transmitters to be on continuously. Using these duty cycles, the satellite and VHF transmitters had a battery life of 4 and 12 months, respectively. These duty cycles proved successful and we were able to collect >80 high-quality satellite locations on each collared wolverine during the initial 2 years of the study. However, analyses of our satellite location data for these 2 years revealed that most of the high-quality locations were acquired between the hours of 0600 and 1800. This pattern may result from both limitations of satellite coverage in our study area as well as wolverine behavior patterns (e.g., wolverines may be less active during the night and in a position that obstructs the ability of the satellite to pick up transmission signals). Consequently, in year 3 (2008/09), we reprogrammed all of the satellite transmitters to be "on" for 14 hr between 0500 and 1900 hrs PST and then "off" for 34 hr. This new duty cycle extended the life of our satellite transmitters from 4 to about 8 months.

Unlike satellite collars, GPS collars that have been used successfully on wolverines are store-on-board systems that require recapturing animals to retrieve location data. GPS collars typically provide more accurate location data (calculated using triangulation methods) than satellite collars (calculated using the Doppler shift). Based on our recapture rate in year 1 (1 female captured twice, and 1 male captured 3 times), we experimented with 1 GPS collar in year 2 to determine if we could successfully augment our current research program with this technology. In March 2008, after one of the satellite collars on a male wolverine had been collecting location data for 2 months, we recaptured the male and replaced his collar with a Lotek store-on-board GPS/VHF radio-collar. We programmed the GPS locator to "fix" a location once per hour, giving it a projected battery life of 45 days.

To obtain additional information on wolverine activity at trap-sites in Washington, we installed remotely triggered cameras (Trailmaster 500, Trail Watcher S600, or Trail Watcher 2035 systems) near some of the traps with bait or lure for attractants. To identify additional areas for live-trapping wolverines in British Columbia, we installed 9 remote-camera stations (using Reconyx camera systems) with hair-snagging devices during the winter of 2008/09 in various locations both north and south of Highway 3.

In year 4 (2009/10), we installed 8 run-pole remote-camera stations in Washington and 9 in British Columbia using the design recommended by Magoun et al. (2008) to obtain clear photographs of the light-colored throat and chest blazes of wolverines, which can be used for individual identification (Figure 3). We also established 2 backcountry snowtracking routes in Washington to backtrack wolverines to obtain DNA samples (scat or hair; Ulizio et al. 2006) in areas that are too remote for trapping.

III. Results

Trapping—In Washington, we operated 2 traps during the pilot study (winter 2005/06), 4 traps during year 1 (winter 2006/07), 5 traps during year 2 (winter 2007/08), 11 traps during year 3 (winter 2008/09), and 10 traps during year 4 (winter 2009/10) for a total

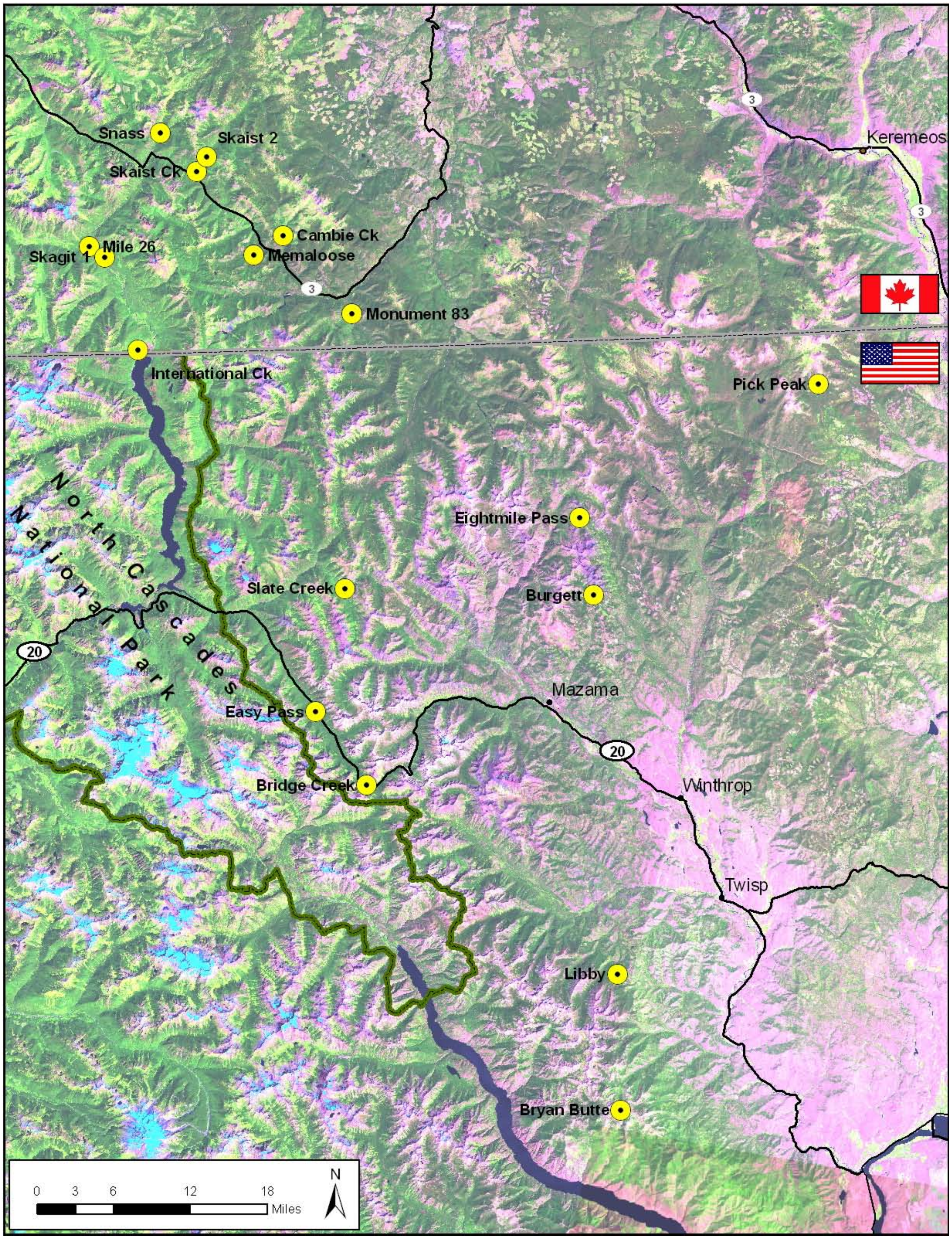

Figure 3. Locations of run-pole remote camera stations established during the winter of 2009/10 in the northern Cascade Range of Washington and British Columbia.

of 2,035 trap nights. To date in Washington, we have captured and radio-collared 6 different wolverines on 11 occasions during 5 winter field seasons (Table 2). Non-target species captured included Canada lynx, marten, and bobcat.

In British Columbia during the winter of 2008/09 (year 3), we operated 10 livetraps for varying lengths of time between 13 January and 26 March. We operated most traps for 17-20 nights, for a total of 268 trapnights. The only exception was the Sunshine Valley trap, which we closed after 4 nights due to high levels of human activity in the vicinity (we moved this trap to a better location in year 4). We did not capture any wolverines in British Columbia during year 3; incidental captures included marten and cougar. In British Columbia during the winter of 2009/10 (year 4), we operated 12 livetraps (Figure 2) from 7 January to March 22 for a total of 472 trapnights. We captured 2 different wolverines: Rocky on February 26 and an adult female, which we believe is Melanie, on March 22. Non-target species captured included 2 Canada lynx and 23 marten.

Capture Histories, Spatial Use, and Movements of Radio-collared Wolverines— Melanie was a young female first captured on February 10, 2006 at the Hart's Pass trap (Table 3). The first reliable location that the satellite collected from her radio-collar was approximately 1 week later and the activity data displayed on the Argos website indicated that the collar was no longer moving. The metal band used to attach the collar strap to the transmitter package had broken. The collar malfunction was a design problem identified by the manufacturer soon after we radio-collared Melanie. The manufacturer corrected this design flaw on all remaining satellite collars before they were deployed on other wolverines. On April 11, 2006, 5 photographs were taken of Melanie at a baited camera station near the Hart's Pass trap site. In each photograph, her yellow ear tags were visible, providing positive

Table 2. Capture results for wolverine livetraps operated in the northern Cascade Range in Washington during 5 winter field seasons (2005/06 to 2009/10).

Trap site	Trap nights	Wolverine captures	Non-target captures
Pilot study			
Cutthroat	49	0	0
Hart's Pass	70	2	0
Year 1			
Cutthroat	62	1 (escaped)	1 marten
Hart's Pass	20	1	0
Twisp River	52	4	4 bobcat
Baldy Pass	46	0	2 marten
Year 2			
Cutthroat	64	0	0
Hart's Pass	56	2	2 marten
Twisp River	85	0	0
Baldy Pass	62	0	1 marten
Billygoat	65	0	0
Year 3			
Cutthroat	70	0	0
Hart's Pass	81	0	2 Canada lynx
Twisp River	80	1	6 marten
Baldy Pass	69	0	0
Billygoat	70	0	0
Reynolds	80	0	1 marten
South Creek	87	0	0
Rattlesnake	67	0	2 marten
West Fork	77	0	0
Silverstar	91	0	3 marten
Sweetgrass	77	0	0

Trap site	Trap nights	Wolverine captures	Non-target captures
Year 4			
Cutthroat	57	0	3 marten
Hart's Pass	54	0	0
Twisp River	64	0	0
Billygoat	40	0	0
Reynolds	64	0	2 marten, 1 bobcat
South Creek	64	1	5 marten
Rattlesnake	57	0	0
West Fork	57	0	0
Silverstar	58	0	3 marten
Sweetgrass	40	0	1 marten
Totals	2035	11	39

Table 3. Capture data and measurements for 6 wolverines radio-collared in the northern Cascade Range, Washington during 5 winter field seasons (2005/06 to 2009/10).

Animal name and sex	Capture date	Trap site	Estimated age	Weight (kg)	Ear-tag color
Melanie – F	February 10, 2006	Hart's Pass	1-2	8.6	
	February 14, 2007	Hart's Pass	2-3	9.6	
	March 7, 2010[a]	Memaloose	5-6	10.1	all orange
Rocky – M[b]	April 11, 2006	Hart's Pass	3-4	14.7	
	January 25, 2008	Hart's Pass	3-4	14.2	
	March 24, 2008	Hart's Pass	3-4	13.8	
	February 26, 2010	Memaloose	5-6	15.0	LF: yellow
					LB: green
Chewbacca – M	January 24, 2007	Twisp River	2-4	13.6	all blue
	March 17, 2007	Twisp River	2-4	14.6	
Xena – F	February 11, 2007	Twisp River	1-2	8.0	all red
	March 26, 2007	Twisp River	1-2	8.0	
Sasha – F	February 23, 2009	Twisp River	1-2	8.1	LF: blue
					LB: yellow
					RF: yellow
					RB: blue
Eowyn – F	February 1, 2010	South Creek		9.2	LF: white
					LB: orange
					RF: orange
					RB: white

[a] We believe that this adult female is Melanie, but collected an ear-tissue sample for DNA analysis to verify her identity (results have not been received yet).

[b] We captured a male wolverine at Hart's Pass on April 11, 2006 and named him 'Thor'. In 2008, we captured what we believed was a new male wolverine (no collar and no ear-tags) at the same trap and named him 'Rocky'; however, subsequent DNA analysis of ear-tissue samples determined that 'Rocky' and 'Thor' were the same individual. We now identify this wolverine as 'Rocky'.

identification. We recaptured Melanie in the Hart's Pass trap the following year on February 14, 2007. We fitted her with a new-design collar and obtained 130 high-quality locations for her from February 14 to July 31, 2007, resulting in an activity area of approximately 560 mi^2 (Figure 4). To delineate activity areas, we calculated 100% minimum convex polygons using all data in Argos location-classes 1−3. Note that an activity area does not represent a home-range estimate; the estimation of home ranges requires careful data screening and more rigorous analytical procedures. Data on the areal extent of wolverine activity areas are presented here solely to provide a general idea of spatial use by our study animals. Melanie's activity area was centered in the western half of the Pasayten Wilderness on the Okanogan-Wenatchee National Forest, and included portions of the North Cascades Scenic Highway Corridor and Manning Provincial Park in British Columbia, Canada. Melanie had grown in length by 11 cm and increased in weight by 1 kg between February 11, 2006 and February 14, 2007 (Table 3). Our physical examination of her on February 14, 2007 also revealed that she was pregnant (distended nipples and at least 1 fetus felt during palpation). Over a 17-day period in late February and early March, we obtained 5 high-quality locations for Melanie in a localized area near Center Mountain (7 mi NW of Hart's Pass), indicating that she may have established a natal den. However, soon after that time, she stopped frequenting that site and did not return. We conducted several helicopter flights during the spring of 2007 to determine whether Melanie had successfully given birth to kits by tracking the VHF signal for her collar and attempting to see her on the ground accompanied by kits; however, these flights were unsuccessful. Although our location data suggest that Melanie may have lost her kits, such data can be misleading (J.P. Copeland, U.S. Forest Service, personal communication). Consequently, the outcome of Melanie's reproductive effort in 2007

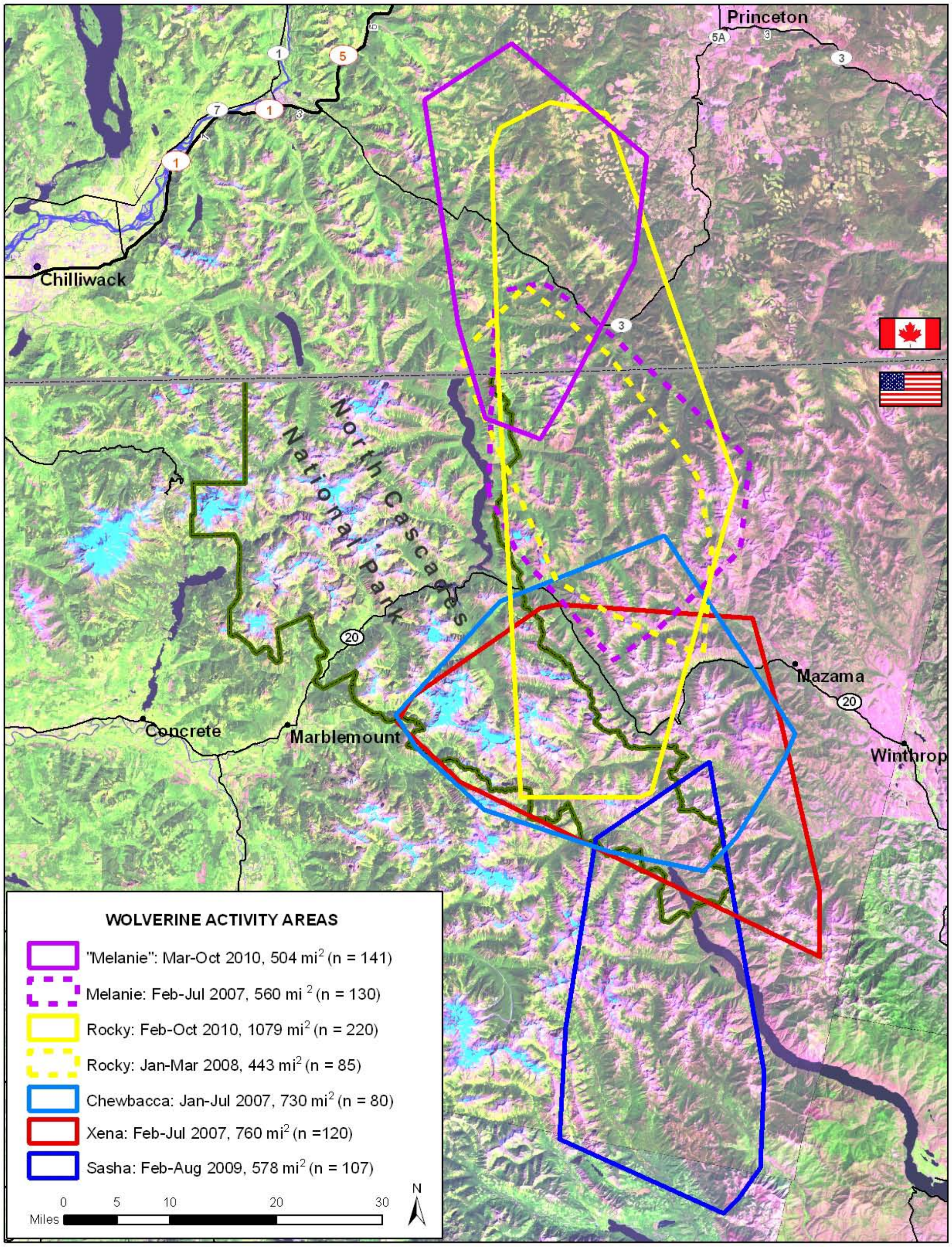

Figure 4. Activity areas for 6 wolverines tracked with satellite radio-collars in the North Cascades Ecosystem. Activity areas are 100% minimum convex polygons delineated using Argos satellite data in location-classes 3 (<250 m), 2 (250−500 m), and 1 (500−1,500 m) for the dates indicated. The background image is Landsat TM Bands 543. These are preliminary results for information only, and should not be cited or used for other purposes.

remains unknown. We did not recapture Melanie during the winter of 2007/08, but did obtain photographs of her at a remote-camera station near the Hart's Pass trap on April 7, 19, 24, 26, and May 7, 2008. These photographs revealed that she still had 1 yellow ear tag but no satellite collar (Appendix, Photo 2). Although we operated several traps in the vicinity of Hart's Pass during the winter of 2008/09, we did not recapture Melanie. On March 7, 2010, we captured an adult female at the Memaloose trap in British Columbia and, based on ventral blazes on the chest and throat, we believe that the female is Melanie. Nevertheless, we collected an ear-tissue sample and are waiting for the results of DNA analyses to confirm her identity. We fitted "Melanie" with a satellite/VHF collar and collected 141 high-quality locations over a 7-month period (Figure 4; satellite transmitter was programmed with a duty cycle of 14 hr "on" between 0500 and 1900 hours followed by 34 hr "off"). Although "Melanie" is an adult, she was not reproductive in 2010.

We captured a young male in the Hart's Pass trap on April 11, 2006 and named him 'Thor'. We obtained 15 reliable satellite locations on him between April 12 and June 21 before his collar failed. Although we did not recapture 'Thor' the following winter (2006/07), we obtained photographs of him on April 13, 2007 at a remote camera station near the Hart's Pass trap. Green ear tags were visible in the photographs providing positive identification (Appendix, Photo 3). On January 25, 2008 we captured what we thought was a new male wolverine in the Hart's Pass trap (no ear tags or other identifying marks) and named him 'Rocky' (Table 3). However, DNA analysis of ear-tissue samples revealed that 'Rocky' and 'Thor' were the same individual (Table 3; we now refer to this male as 'Rocky'). We obtained 85 high-quality satellite locations over a 2-month period, resulting in an activity area of about 443 mi^2. Rocky's activity area included the western half of the Pasayten wilderness on the Okanogan-Wenatchee National Forest, and parts of the North Cascades Scenic Highway Corridor and Manning Provincial Park in British Columbia, Canada. His activity area almost completely overlapped Melanie's during 2007 (Figure 4). We recaptured Rocky in the same trap on March 24, 2008 and replaced his satellite collar with a Lotek GPS/VHF collar. We obtained photographs of Rocky on April 25 and May 23, 2008 at the Hart's Pass camera station. In the photographs he still had both white ear tags and the GPS collar. We were not able to recapture Rocky to retrieve the GPS collar with stored location data, nor were we able to locate the collar's VHF signal during an extensive search from a fixed-wing aircraft. Therefore, we do not plan to use store-on-board GPS collars during the remainder of our study. We did not recapture Rocky in year 3 (2008/09), but we recaptured him this past winter on February 2, 2010 in the Memaloose trap in British Columbia. We were able to make a positive identification because he still had 1 ear tag. We fitted Rocky with a satellite/VHF collar and, to date, have collected >200 high-quality locations (Figure 4; satellite transmitter was programmed with a duty cycle of 14 hr "on" between 0500 and 1900 hours followed by 34 hr "off").

On January 23, 2007, we captured a young male wolverine (Chewbacca) in the Twisp River trap and recaptured him in the same trap on March 17 (Table 3). We fitted him with a satellite/VHF collar at first capture, and replaced it at his second capture with a new-design satellite/VHF collar that was smaller and lighter. Between January 23 and July 13, 2007, we obtained 80 high-quality locations for Chewbacca, resulting in an activity area of approximately 730 mi^2. This area included the southeast portion of North Cascades National Park and the adjacent Lake Chelan-Sawtooth Wilderness and North Cascades Scenic Highway Corridor of the Okanogan-Wenatchee National Forest (Figure 4). During the 55 day-interval between successive captures, Chewbacca gained 1 kg in weight (Table 3). We did not recapture Chewbacca in the winter of 2007/08; however, we obtained photographs of him on February 27 and May 2, 2008 at a remote-camera station we installed near the Twisp River trap. The photographs verified that he still had both blue ear tags and was still wearing his now-defunct satellite collar (Appendix, Photo 4). We did not recapture Chewbacca during the winters of 2008/09 or 2009/10, nor did we detect him at any remote camera stations.

On February 11, 2007, we captured a young nulliparous female wolverine (Xena) in the Twisp River trap, and recaptured her in the same trap on March 26 (Table 3). We fitted her with a satellite/VHF collar at her first capture and replaced it with a new satellite collar when we recaptured her in March. From February 11 to July 31, 2007 we obtained 120 high-quality satellite locations for Xena, resulting in an activity area that was approximately 760 mi^2 (Figure 4). About 90% of her activity area overlapped that of Chewbacca's (Figure 4), suggesting that they may be a mated pair. Although we did not recapture Xena in year 2, we obtained photographs of her on February 27 and April 30, 2008 at the Twisp River camera station. The photographs revealed that she still had both red ear tags and was wearing her now-defunct satellite collar (Appendix, Photo 5). We have not recaptured Xena since 2007, but we detected her multiple times this past winter (2009/10) at the Easy Pass camera station in Washington (Appendix, Photo 5).

On February 23, 2009, we captured a young nulliparous female (Sasha) at the Twisp River trap and fitted her with a satellite/VHF collar (Appendix, Photo 6). Her satellite transmitter was programmed with our new duty cycle: 14 hr "on" between 0500 and 1900 hours followed by 34 hr "off". During the first month we monitored her, Sasha traveled approximately 35 air miles southwest to the Entiat and Chiwawa River watersheds. Her movements continued to be centered in this area for the remainder of the summer. We obtained 107 high-quality satellite locations during a 6-month period for Sasha before her satellite transmitter failed in early September 2009. Sasha's activity area was 578 mi^2 and was located further south in the northern Cascades than any of the other wolverines monitored so far in this study (Figure 4). We did not recapture Sasha during this past winter (2009/10).

On February 1, 2010, we captured a young nulliparous female (Eowyn) at the South Creek trap in Washington and fitted her with a satellite/VHF collar (Appendix, Photo 7). Her satellite transmitter was programmed with our new duty cycle: 14 hr "on" between 0500 and 1900 hours followed by 34 hr "off". During the first 2 months that we monitored her, Eowyn traveled over 303 air miles north across the Pasayten wilderness and into British Columbia (Figure 5). We obtained 125 high-quality satellite locations during a 2-month period for Eowyn before satellite data indicated that her collar stopped moving on March 31. On 12 May 2010, the B.C. crew retrieved Eowyn's collar and skull from a steep slope above the Nahatlatch River in the Lillooet Range, which is at the southern end of the Coast Range in British Columbia (Figure 5). Evidence at the site indicated that Eowyn was killed by a cougar.

One of the behavioral traits we observed in our study animals was a tendency to travel along more or less circular or "figure-eight" routes within a large portion of their activity areas over relatively short periods of time (generally <2 weeks), often returning close to their starting point (Figure 6). As other researchers have speculated, such routes may reflect the most efficient way to mark territories and/or locate ungulate carcasses during the winter, or they may have some other function. In 2007, Melanie moved at least 65 mi in 10 days, including a movement of 8 mi during a 4-hr period; Xena moved at least 86 mi in 9 days, including a movement of 20 mi during a 14-hr period; and Chewbacca moved at least 94 mi in 12 days, including a movement of 16 mi during a 13-hr period. In 2008, Rocky moved at least 78 miles in 6 days, including a movement of at least 7 miles during a 5-hr period (Figure 6).

To identify elevation zones that may be preferred by our study animals, we used ArcGIS software to place a circular buffer 1.2 mi^2 in size (1-km radius) around all wolverine locations in Argos classes 1−3, and calculated the percent occurrence of the following elevation bands within

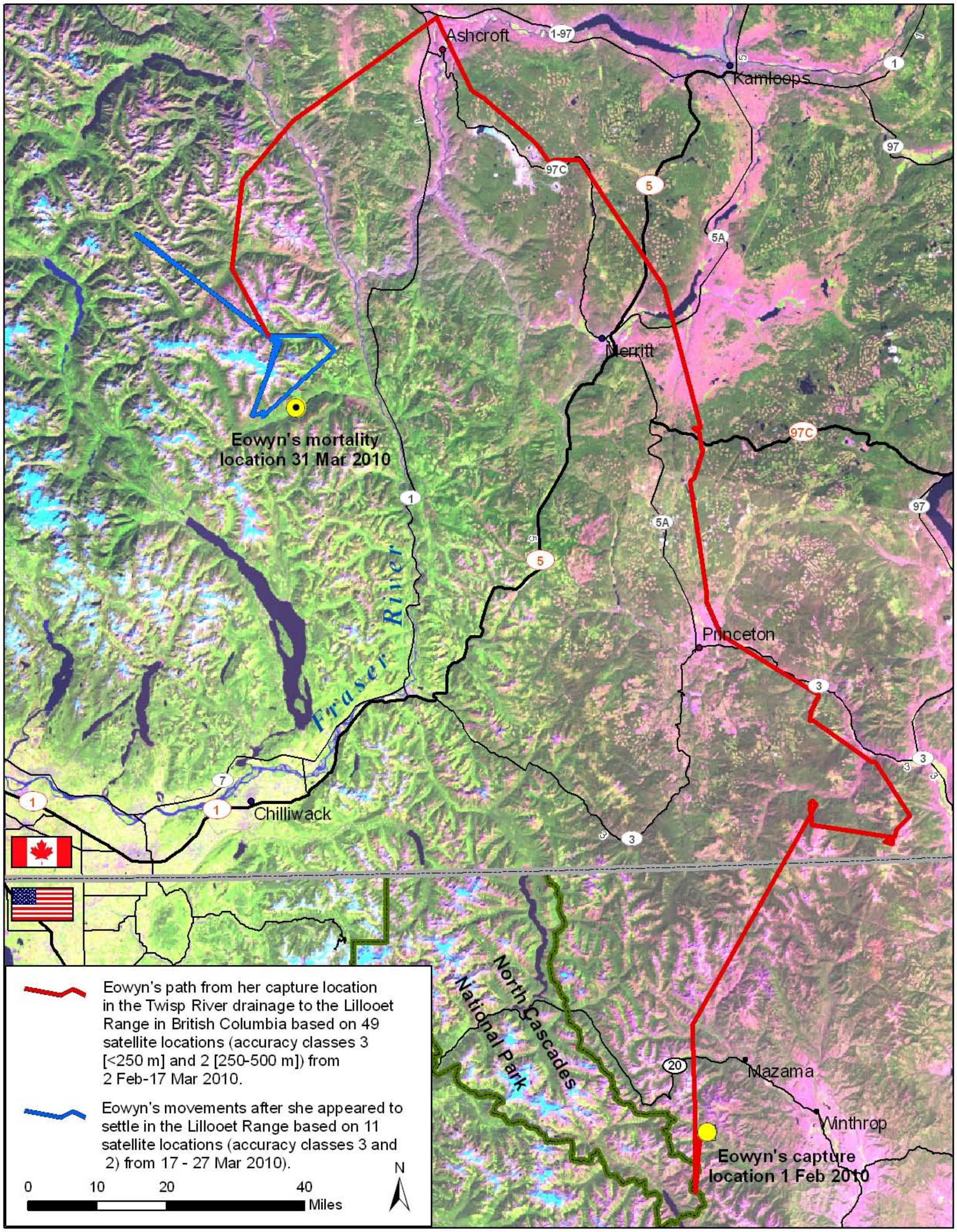

Figure 5. Movement path taken by a young nulliparous female wolverine (Eowyn) during February and March 2010 that she initiated soon after being captured and radio-collared in the Twisp River drainage in Washington.

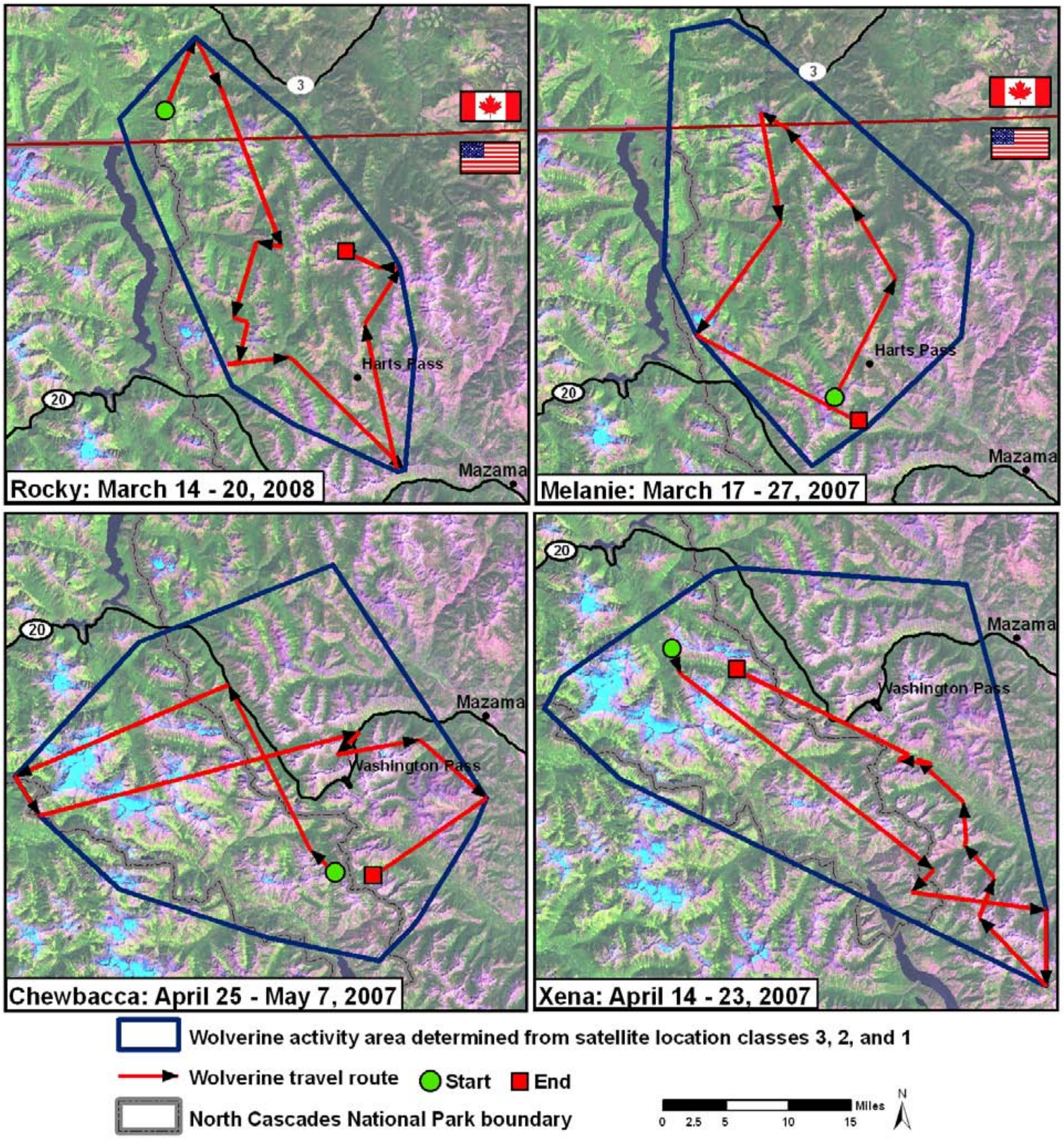

Figure 6. Short-term circular or "figure-eight" travel routes for 4 radio-collared wolverines in the North Cascades Ecosystem. Routes traveled by study animals were delineated using Argos satellite data in location-classes 3 (<250 m), 2 (250−500 m), and 1 (500−1,500 m) for the dates indicated. These are preliminary results for information only, and should not be cited or used for any other purposes.

the buffers: ≤4,430 ft, 4,431–5,910 ft, 5,911–7,380 ft, and >7,380 ft. We then compared those results with the percent occurrence of these elevation bands in each wolverine activity area. We selected these elevation bands based on our field observations and professional judgments' solely to provide a preliminary assessment of habitat use by wolverines along an elevation gradient; selection of elevation zones and associated habitat conditions by wolverines will be analyzed in more detail in subsequent reports and publications. For all wolverines analyzed, the low-elevation band (≤4,430 ft) was used at levels below availability, the moderate-elevation band (4,431–5,910 ft) was used at levels comparable to or exceeding availability, the high-elevation band (5,911–7,380 ft) was used at levels exceeding availability, and the highest elevation band (>7,380 ft) was used at levels comparable to availability (Table 4). In our study area, treeline generally occurs at elevations ranging from 6,000 to 7,000 ft. suggesting that, in the North Cascades Ecosystem, wolverines may select relatively high-elevation habitats at or near treeline (Figure 7).

***Camera Stations*—**In Washington, we operated 8 run-pole remote-camera stations during year 4 (winter 2009/10; Figure 3). We obtained photographs of 3 individual wolverines on 9 occasions (Table 5). We obtained photographs of Rocky at the Bridge Creek station on February 21, 2010 and at the Slate Creek station on March 7 and 8, 2010. We obtained photographs of Xena at the Easy Pass station on February 15, March 18, 23, 24, and 31, and April 10, 2010 (Appendix, Photo 5). We obtained photographs of a wolverine new to this study at the Easy Pass station on March 23, 24, and 31. On March 23 there was a 29-minute separation between the photographs of the new wolverine and the photographs of Xena. On March 24 the separation between the 2 was 53 minutes and on March 31 it was about 185 minutes. It seems likely that these 2 wolverines were travelling together on those days. Non-target species photographed included marten, lynx, black bear, mule deer, red squirrel, and gray jays.

Table 4. Composition of wolverine activity areas (from north to south, see Figure 4) by elevation band compared to the composition of buffered satellite locations (location-classes 3−1). We used a 30-m DEM (digital elevation model) for all calculations; overlapping 1.2-mi^2 buffers were dissolved into a single polygon. Results are preliminary and for information only.

Elevation bands used by each study animal	Percent within activity area	Percent within buffered satellite locations
"Melanie" (7 Mar – 3 Oct 2010; *n* = 141)		
<4,430 ft	21	17
4,431 – 5,910 ft	64	62
5,911 – 7,380 ft	15	21
>7,380 ft	<1	<1
Rocky (2 Feb – 14 Oct 2010; *n* = 212)		
<4,430 ft	18	10
4,431 – 5,910 ft	53	52
5,911 – 7,380 ft	27	36
>7,380 ft	2	2
Melanie (15 Feb – 11 Jul 2007; *n* = 130)		
<4,430 ft	17	8
4,431 – 5,910 ft	50	46
5,911 – 7,380 ft	31	43
>7,380 ft	2	3
Chewbacca (27 Jan – 8 Jul 2007; *n* = 80)		
<4,430 ft	26	19
4,431 – 5,910 ft	38	38
5,911 – 7,380 ft	33	40
>7,380 ft	3	3
Xena (12 Feb – 28 Jul 2007; *n* = 119)		
<4,430 ft	25	17
4,431 – 5,910 ft	36	39
5,911 – 7,380 ft	35	40
>7,380 ft	4	4
Sasha (27 Feb – 23 Aug 2009; *n* = 107)		
<4,430 ft	35	17
4,431 – 5,910 ft	35	44
5,911 – 7,380 ft	27	34
>7,380 ft	3	5

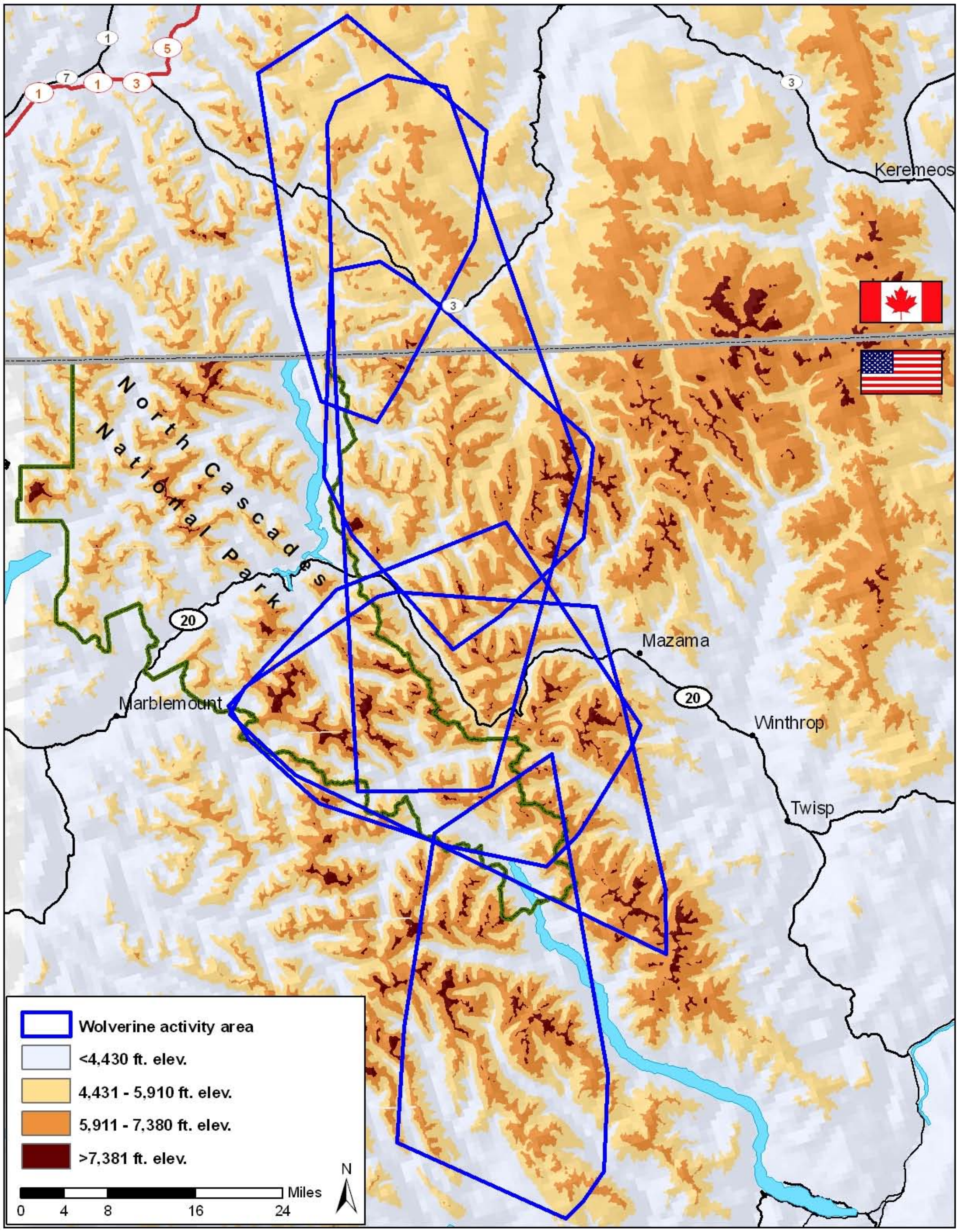

Figure 7. Activity areas for 5 wolverines during 2006/07, 2007/08, 2008/09, and 2009/10 overlain on 4 elevation bands (there are 2 activity areas for Melanie who used a different area in 2006/07 than in 2009/10). Wolverine activity areas were derived from Argos satellite location-classes 3, 2, and 1. These are preliminary results for information only, and should not be cited or used for any other purposes.

Table 5. During the winter of 2009/10, 8 run-pole remote-camera stations were operated for a total of 758 days in the northern Cascade Range, Washington.

Camera station	Days operated	No. of wolverine photos	No. of photos of other carnivore species
Bridge Creek	148	355 (Rocky)	1088 (marten) 2 (black bear)
Bryan Butte	21	0	92 (marten)
Easy Pass	244	68 (Xena) 34 (new wolverine)	290 (marten)
Eightmile Pass	33	0	15 (Canada lynx) 13 (marten)
Libby Trailhead	32	0	7 (marten)
Pick Peak	187	0	466 (marten)
Slate Creek	83	313 (Rocky)	0
Sweetgrass	19	0	0

In British Columbia, we operated 9 run-pole camera stations during year 4 (2009/10; Figure 3). We detected "Melanie" on multiple days in February, March, and April at both the Memaloose and Cambie camera stations. We also detected Rocky on multiple days in February and April at these same 2 camera stations (Appendix, Photo 3). We did not detect any new wolverines in British Columbia. Camera detections of non-target species included marten, ermine, grizzly bear, black bear, cougar, bobcat, and spotted skunk.

Backcountry Snow-tracking Routes**—**In Washington we completed 3 multi-day, backcountry snow-tracking routes. We made a 3-day scouting trip into the Spanish Camp area of the Pasayten Wilderness from February 10-12. During this trip we followed 1 putative wolverine track and collected 2 scat samples. DNA analysis of these samples has not yet been completed. We completed a 5-day trip into the Spanish Camp area from February 18-22. During this trip we followed 1 putative wolverine track for a short distance, but collected no samples. We completed a 4-day trip in the Sawtooth area from March 18-21, but we found no putative wolverine tracks and collected no samples.

IV. Discussion and Management Implications

Due to the substantial logistical challenges involved in conducting a radio-telemetry study of wolverines in the northern Cascades of Washington, the primary objectives of the pilot study (winter 2005/06) and years 1 and 2 (winters 2006/07 and 2007/08) were to determine if we could: (1) safely and effectively live-trap and radio-collar wolverines in the northern Cascades of Washington, and (2) use Argos satellite telemetry to investigate their distribution, movement patterns, habitat use, and reproductive ecology. The results from our pilot study were both encouraging and disappointing.

By placing the traps in strategic locations, we were able to capture and radio-collar 2 wolverines, including a juvenile female and a sub-adult male. One collar malfunctioned soon after being deployed, and dropped off before we could collect more than a few locations and, although the second collar operated for several months, it failed to provide a strong data set of satellite locaitons. Problems involved both the design of the collar and the duty cycle, which failed to provide us with an adequate number of high-quality satellite locations. The mechanical failure was the manufacturer's fault, and they subsequently redesigned their collars to correct that problem. However, we concluded that our failure to obtain a large number of high-quality satellite locations from the other collar was probably due to the high topographic relief of our study area, and resulting difficulties in obtaining high-quality satellite locations during only 5 hr each day.

Based on our experiences and recommendations from colleagues, we modified the duty cycle on our satellite collars to maximize acquisition of high-quality satellite locations (by setting the duty cycle to "on" between 0500 and 1900 hrs) and to lengthen our data-collection period from 4 to potentially 8 months (i.e., the collars run for 14 hrs every other day). Also, early on in the study, we reduced the width and thickness of the collar strap and eliminated the timed-release mechanism to reduce both the size and weight (from about 225 to 200 grams) of the radio-collars, and to minimize the possibility of mechanical failures. Our new-design radio-collars continue to work well and have remained on our wolverines throughout the data-collection period and longer (>12 months). With these modifications, we achieved both of our objectives during years 1 and 2. During the first 2 years of our study, we captured 2 new wolverines, recaptured the juvenile female and sub-adult male from the pilot study, collected 80–130 high-quality locations for each study animal during a 2–6 month period (Figure 4), and documented the first known reproductive event for wolverines in Washington. During years 3 and 4 (winters 2008/09 and 2009/10), we captured 2 new wolverines, recaptured 2 study animals monitored in previous years, extended the monitoring period up to 8 months, and collected 107 to >220 high-quality locations for each animal.

We have been able to delineate activity areas for 5 wolverines using satellite location data; overlap among males and females suggest that Chewbacca and Xena, and Rocky and Melanie, may represent reproductive pairs (Figure 4). Although we were not able to determine the fate of Melanie's offspring in year 1, we have documented that reproduction is occurring among Washington wolverines. Furthermore, during the past 5 winters, the activity areas for 5 of 6 study animals were located primarily in Washington, demonstrating that there is a resident population of wolverines in the state. Clearly, recent verifiable wolverine occurrence records in Washington do not represent Canadian wolverines that occasionally wander into Washington. Rather, our results provide support for the current range of wolverines described by Aubry et al. (2007). However, the extent and location of the activity areas we delineated suggest that a relatively small number of wolverines may be capable of establishing home ranges within the state. The conservation of wolverines in Washington will depend on reliable knowledge of their distribution, population status, and habitat relations. This knowledge can only be gained by long-term field research; thus, it is essential that we continue this research and find ways to expand the scope of our activities beyond the boundaries of our current study area.

In year 1, we captured wolverines 6 times in 180 trapnights for a capture rate of 1 wolverine per 30 trapnights, which is higher than the capture rate reported by Copeland (1996) in Idaho (1 wolverine per 47 trapnights). Although our capture rate was not as high in year 2 (2 captures in 332 trapnights) as in year 1, all 4 wolverines radio-collared prior to that season were detected on ≥1 occasion at remote cameras installed near some of the trap sites. Despite relatively low capture rates in both Washington and British Columbia, we continue to capture new wolverines each year (1 new female in year 3 and year 4) and recapture previously monitored study animals (2 recaptures in year 4).

V. Future Research

In year 5, we will continue to collaborate with researchers in British Columbia, who will operate the 12 livetraps they installed last winter and construct up to 5 new traps: 2 in the Silver Skagit drainage and 3 in Manning Provincial Park. In addition they will operate at least 9 run-pole remote-camera stations. In Washington, we will operate 11 of the 12 of traps we have built so far (Figure 2), but will move the Thirtymile trap to the vicinity of the Easy Pass camera station, to try and recapture Xena and the new wolverine that was photographed there last winter. We will not be operating the Baldy Pass trap, but plan to install a run-pole camera station in the vicinity to monitor potential wolverine activity. We will operate the 8 run-pole remote-camera stations established last year and install up to 5 additional stations. Pre-determined backcountry snowtracking routes will not be followed in future years, but we will backtrack wolverines opportunistically to collect DNA samples if we have the time and resources available.

There is growing evidence that wolverine distribution throughout their Holarctic range is determined primarily by the availability of suitable denning habitat. In montane regions, denning habitat appears to be related to a combination of relatively deep snow cover near treeline that persists into the spring for reproductive dens and, possibly, remoteness from human activities (Aubry et al. 2007; Magoun and Copeland 1998). Thus, one of the primary objectives of our future research on wolverines in Washington will be to locate natal and maternal dens, and document reproductive attainment. We have programmed 4 satellite/VHF radio-collars to collect location data continuously (24 hr/day for 78 days). This duty cycle will enable us to track the activities of reproductive females more closely and to identify frequently used sites where a potential natal or maternal den may be located. We will deploy these satellite/VHF collars on female wolverines that appear to be pregnant at the time of capture. If we can identify clusters of locations indicative of a potential den site, we will conduct aerial telemetry flights and/or set-up a remote camera near the site to verify reproduction.

VI. Partnerships

This research would not have been possible without the collaboration and direct involvement of John Rohrer of the Methow Valley Ranger District, Okanogan-Wenatchee National Forest, Scott Fitkin of the Washington Department of Fish and Wildlife, and Eric Lofroth of the British Columbia Ministry of Environment, who have all contributed both funds and in-kind contributions to the study. Funding and additional support for work conducted in Washington were provided by Seattle City Light; the USFS and BLM Interagency Special Status/Sensitive Species Program (ISSSSP); the USFS National Carnivore Program in Missoula, Montana; the Seattle Foundation/Tom and Sonya Campion Fund; and the Pacific Northwest Research Station. Funding and support for work conducted in British Columbia was provided by the Habitat Conservation Trust Fund, the Skagit Environmental Endowment Commission, the British Columbia Ministry of Environment, and the British Columbia Conservation Foundation. The following individuals ably assisted in trap construction, maintenance, and/or the handling and radio-collaring of captured wolverines: in Washington, Bruce Akker, Mo Kelly-Akker, Chase Bolyard, Kat Dees, Andre Dulac, Scott Fitkin, Mike Harmon, Dan Harrington, Morgan Hartsock, Jeff Heinlen, John Jakubowski, Adam Kehoe, Gary Koehler, Andrew Myhra, Bob Naney, Joyce Neilson, Kim Romain-Bondi, Dan Russell, Brandon Sheeley, Bryan Smith, Ann Sprague, and Blake Stokes; in British Columbia, Dan Guertin, Brent Gurd, Cliff Nietvelt, and

Heidi Schindler. Cathy Raley conducted GIS analyses of wolverine location data, and created the maps included in this report with assistance from Beth Galleher. Lastly, we are indebted to Jeff Copeland of the Rocky Mountain Research Station for his encouragement, enthusiasm, and invaluable assistance and advice during the initial 2 years of this research.

We are currently working with volunteers at Conservation Northwest in Bellingham, WA to conduct remote-camera surveys for wolverines and other forest carnivores in the northwestern portion of North Cascades National Park, west of Ross Lake. We hope these efforts will document the presence of wolverines in other areas of northern Washington, and enable us to expand our study area farther west of the Cascade Crest.

VII. Publications and Presentations

Telemetry data that we collected on Washington wolverines during the winter and spring of 2007 is part of a journal article that was published in the *Canadian Journal of Zoology* earlier this year (Copeland, et al. 2010; Aubry is a co-author) that defines the bioclimatic envelope of the wolverine based on the climatic conditions that result in persistent spring snow cover, This work presents a spatially explicit model of wolverine habitat for all components of the population during all seasons of the year that can be used for both management and conservation purposes; it can also be used to provide an empirical basis for predicting the potential effects of global warming on wolverine distribution worldwide. Upon completion of this study, research results will be published in one or more scientific outlets. We have given a number of public and scientific oral presentations that include results from this study, including:

Aubry, K.B. 2006. Ecology and conservation of forest carnivores in the Pacific Northwest. Oral presentation to Methow Conservancy, Winthrop, Washington.

Copeland, J.P., K.B. Aubry, K.S. McKelvey, and S.W. Running. 2006. The implications of global warming on a snow-dependent species—a case for the wolverine. Oral presentation at the Defenders of Wildlife’s Carnivores 2006 Symposium, St. Petersburg, FL.

Aubry, K.B., J.J. Rohrer, S.H Fitkin, and C.M. Raley. 2007. Distribution and ecology of the wolverine in northern Washington: preliminary results. Oral presentations at the Joint Annual Meeting of the Oregon and Washington Chapters of the Wildlife Society, Pendleton, Oregon: this talk was also given at a tech-transfer meeting of wolverine researchers and USFWS personnel involved in a 12-month status review for the potential listing of wolverines in the contiguous U.S., Missoula, Montana.

Aubry, K.B., J.J. Rohrer, S.H Fitkin, and C.M. Raley. 2007. Distribution and ecology of the wolverine in northern Washington: preliminary results. Oral presentation at tech-transfer meeting of wolverine researchers and USFWS personnel involved in the ongoing 12-month status review for the potential listing of wolverines in the contiguous U.S., Missoula, MT.

Aubry K.B., K.S. McKelvey, J.P. Copeland, and P. Gonzalez. 2007. Wolverine range and climatic requirements. Oral presentation to Natural Resources Staff at the Washington Office of the Forest Service, Washington, D.C.

McKelvey, K.S., K.B. Aubry, J.P. Copeland, and P. Gonzalez. 2007. The likely effects of climate change on wolverines. Oral presentation to Natural Resources Staff at the Washington Office of the Forest Service, Washington, D.C.

K.B. Aubry, J.J. Rohrer, S.H Fitkin, and C.M. Raley. 2007. North Cascades wolverine project. Oral presentation at Workshop entitled, “Washington's Cascades: I-90 and North”, Conservation Northwest, Ellensburg, WA.

Aubry, K.B. 2008. Wolverine secrets. Oral presentation to the Adopt-a-Stream Foundation, Northwest Stream Center, Everett, WA.

Aubry, K.B. 2008. Wolverines in Washington. Oral presentation to a troop of Royal Rangers and their parents, Sultan, WA.

McKelvey, K.S., J.P. Copeland, K.B. Aubry, M.K. Schwartz. 2009. The relationship between wolverines and climate: past, present, and future. Oral presentation, Weekly Seminar Series, National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, CA. February 2009.

Aubry, K.B., K.S. McKelvey, J.P. Copeland. 2009. Wolverine distribution and relations with snow cover: potential threats from global warming. Departmental Seminar, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.

Aubry, K.B. 2010. Wolverine research and conservation. Interagency seminar series (USFS, BLM, USGS, and USFWS), “Spotlight on Science: Sharing Research with Partners”, Portland, OR.

Aubry K.B. 2010. On the track of the elusive wolverine. Oral presentation to the Streamkeeper Academy, Northwest Stream Center, Everett, WA.

Aubry K.B. 2010. On the track of the elusive wolverine. Oral presentation to the Island County Beach Watchers, Washington State University Extension Program, Stanwood, WA.

VIII. Literature Cited

Aubry, K.B., K.S. McKelvey, and J.P. Copeland. 2007. Distribution and broadscale habitat relations of the wolverine in the contiguous United States. Journal of Wildlife Management 71:2147-2158.

Banci, V. 1994. Wolverine. Pages 99-127 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, L.J. Lyon, and W.J. Zielinski, tech. eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the western United States. USDA Forest Service. General Technical Report RM-254, Fort Collins, CO.

Copeland, J.P. 1996. Biology of the wolverine in central Idaho. Thesis, University of Idaho, Moscow.

Copeland, J.P., E. Cesar, J.M. Peek, C.E. Harris, C.D. Long, and D.L. Hunter. 1995. A live trap for wolverine and other forest carnivores. Wildlife Society Bulletin 23:535-538.

Copeland, J.P., K.S. McKelvey, K.B. Aubry, J.R. Squires, M.K. Schwartz, J. Krebs, E. Lofroth, A. Landa, J. Persson, R. Inman, J. Wilmot, H. Golden, A. Magoun, C.L. Copeland, R.L. Yates, I. Kojola, and R. May. 2010. The bioclimatic envelope of the wolverine (*Gulo gulo*): do climatic constraints limit its geographic distribution? Canadian Journal of Zoology 88:233-246.

Copeland, J.P., J.M. Peek, C.R. Groves, W.E. Melquist, K.S. McKelvey, G.W. McDaniel, C.D. Long, and C.E. Harris. 2007. Seasonal habitat associations of the wolverine in central Idaho. Journal of Wildlife Management 71:2201-2212.

Krebs, J., E.C. Lofroth, and I. Parfitt. 2007. Multi-scale habitat use by wolverines in British Columbia, Canada. Journal of Wildlife Management 71:2180-2192.

Lofroth, E.C., R. Klafki, J.A. Krebs, and D. Lewis. 2008. Evaluation of live-capture techniques for free-ranging wolverines. Journal of Wildlife Management 72:1253-1261.

Magoun, A.J., and J.P. Copeland. 1998. Characteristics of wolverine reproductive den sites. Journal of Wildlife Management 62:1313-1320.

Squires, J.R., J.P. Copeland, T.J. Ulizio, M.K. Schwartz, and L.F. Ruggiero. 2007. Sources and patterns of wolverine mortality in western Montana. Journal of Wildlife Management 71:2213-2220.

Ulizio, T.J., J.R. Squires, D.H. Pletscher, M.K. Schwartz, J.J. Claar, and L.F. Ruggiero. 2006. The efficacy of obtaining genetic-based identifications from putative wolverine snow tracks. Wildlife Society Bulletin 34:1326-1332.

Appendix, Photo 1. Wolverine livetrap constructed of natural logs at Hart's Pass in the northern Cascade Range in Washington (left), and the trigger mechanism located at the back of the trap (center). In British Columbia, wolverine traps were prefabricated using milled lumber (right) and then transported to the trap site for final assembly.

Appendix, Photo 2. Melanie, a female, was detected on 3 April 2008 at a remote camera station near Hart's Pass in the northern Cascade Range in Washington. She was recaptured at the Memaloose trapsite in British Columbia on March 7, 2010 (pending results from DNA analyses to confirm identification).

Appendix, Photo 3. Rocky, a male, has been detected multiple times at remote camera stations over the past 4 years including Hart's Pass, Washington in 2007 (left) and Memaloose, British Columbia in 2010 (right). Rocky was recaptured at the Memaloose trapsite on February 26, 2010.

Appendix, Photo 4. Chewbacca, a male, was detected in February and May 2008 at a remote camera station near the Twisp River trap in Washington.

Appendix, Photo 5. Xena, a female, was detected in February and April 2008 at a remote camera station near the Twisp River trap in Washington (left). Most recently, she was detected multiple times between February and April of 2010 at the Easy Pass camera station in Washington (right).

Appendix, Photo 6. Sasha, a female, was detected in February 2009 at a remote-camera station near the Twisp River trap in Washington.

Appendix, Photo 7. Eowyn, a female, was captured at the South Creek trapsite in Washington on February 1, 2010.