

Wolverine Distribution and Ecology in the North Cascades Ecosystem 2013 Annual Report (December 6, 2013)

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Frontispiece. Adult male wolverine at a run-pole camera station (left); subadult male being released from a livetrap (right).

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). On 4 February 2013, the U.S. Fish and Wildlife Service proposed that wolverine populations in the contiguous U.S. be listed as “Threatened” under the Endangered Species Act (U.S. Fish and Wildlife Service 2013); their final decision will be published in February 2014. In addition, the wolverine 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 into the unroaded wilderness areas where they occur during all periods of the year. 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, give birth to young during winter in subnivean dens, and may be 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 affect wolverines or their use of preferred habitat.

Snowtracking and remote-camera surveys conducted from 1995 to 2005, 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 to evaluate the feasibility of trapping wolverines during winter in the northern Cascade Range. The first year of the study (2005/06) 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 obtained prior to 2005 were 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 we thought. 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 4 (winter 2008/09), we expanded the geographic scope of our study by establishing a collaborative relationship with forest carnivore biologists at the B.C. Ministry of Environment (Eric Lofroth and Rich Weir) and at the B.C. Ministry of Forests, Lands and Natural Resource Operations (Cliff Nietvelt). Ours is a truly collaborative effort; field crews in British Columbia follow our study protocols, and all data are 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 first 8 years of research (winters of 2005/06 thru 2012/13) 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 encompasses portions of the Pasayten and Lake Chelan-Sawtooth wildernesses, and extends approximately 80 km 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.

We have constructed 12 wolverine livetraps in Washington (Figure 2 and Table 1) and 15 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. Although we operated or monitored several trap sites in the eastern portion of our study area in Washington for multiple years, we did not detect any wolverine activity there. Thus, our trapping efforts during the past 2 winters (2011/12 and 2012/13) were focused on areas immediately adjacent to the Cascade Crest (Figure 2). In British Columbia, livetraps were operated for 4 winters (2008/09 thru 2011/12; Figure 2); however, 5 livetraps in the Skagit Valley north of Ross Lake were not operated during the winters of 2010/11 or 2011/12, due to limited access. Our collaborators in British Columbia were not able to acquire funding for live-trapping efforts in 2012/13.

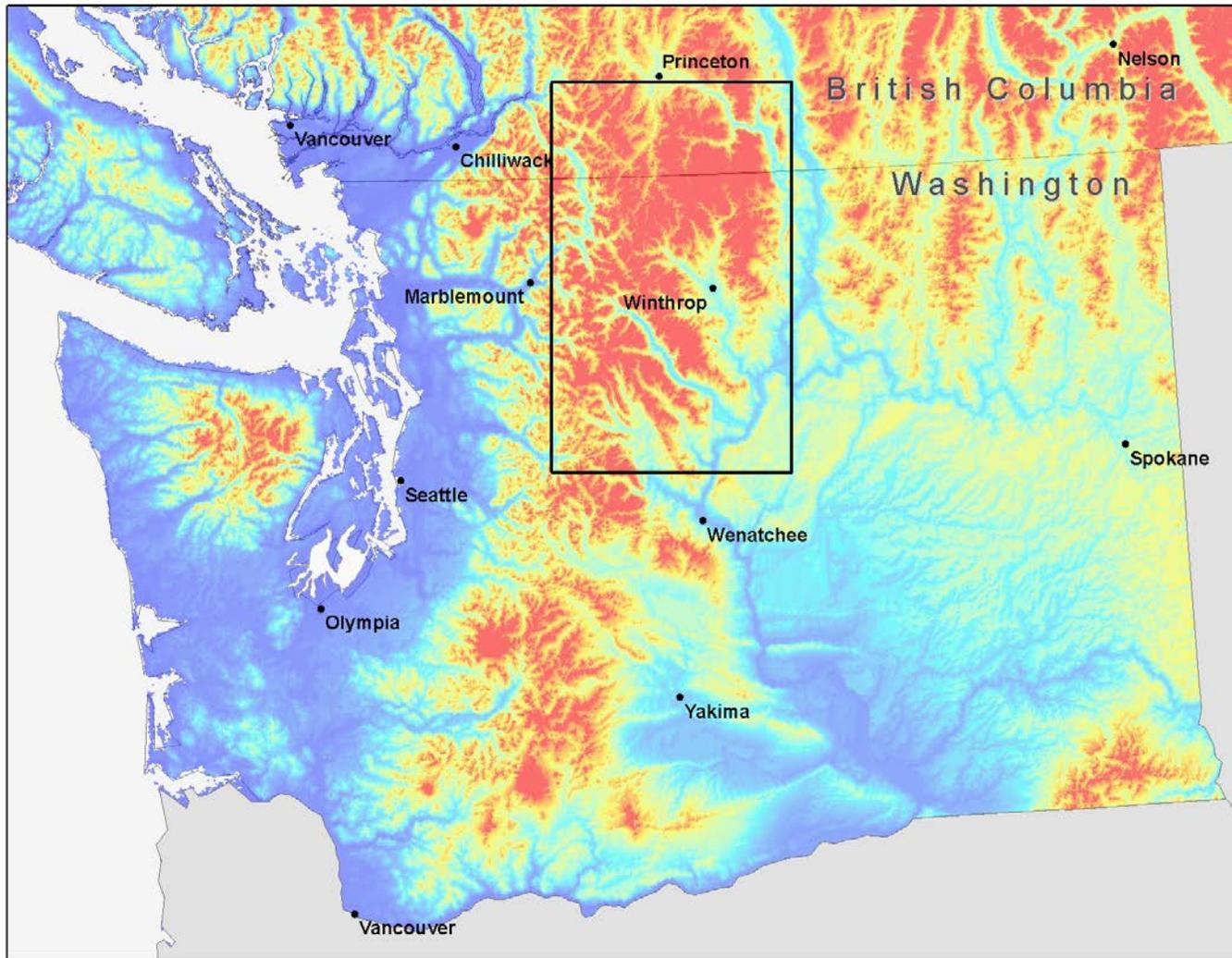


Figure 1. Primary area of research activities for the North Cascades Wolverine Study. Colors show the topographic gradient based on a digital elevation model; “cool” colors are lower in elevation than “warm” colors.

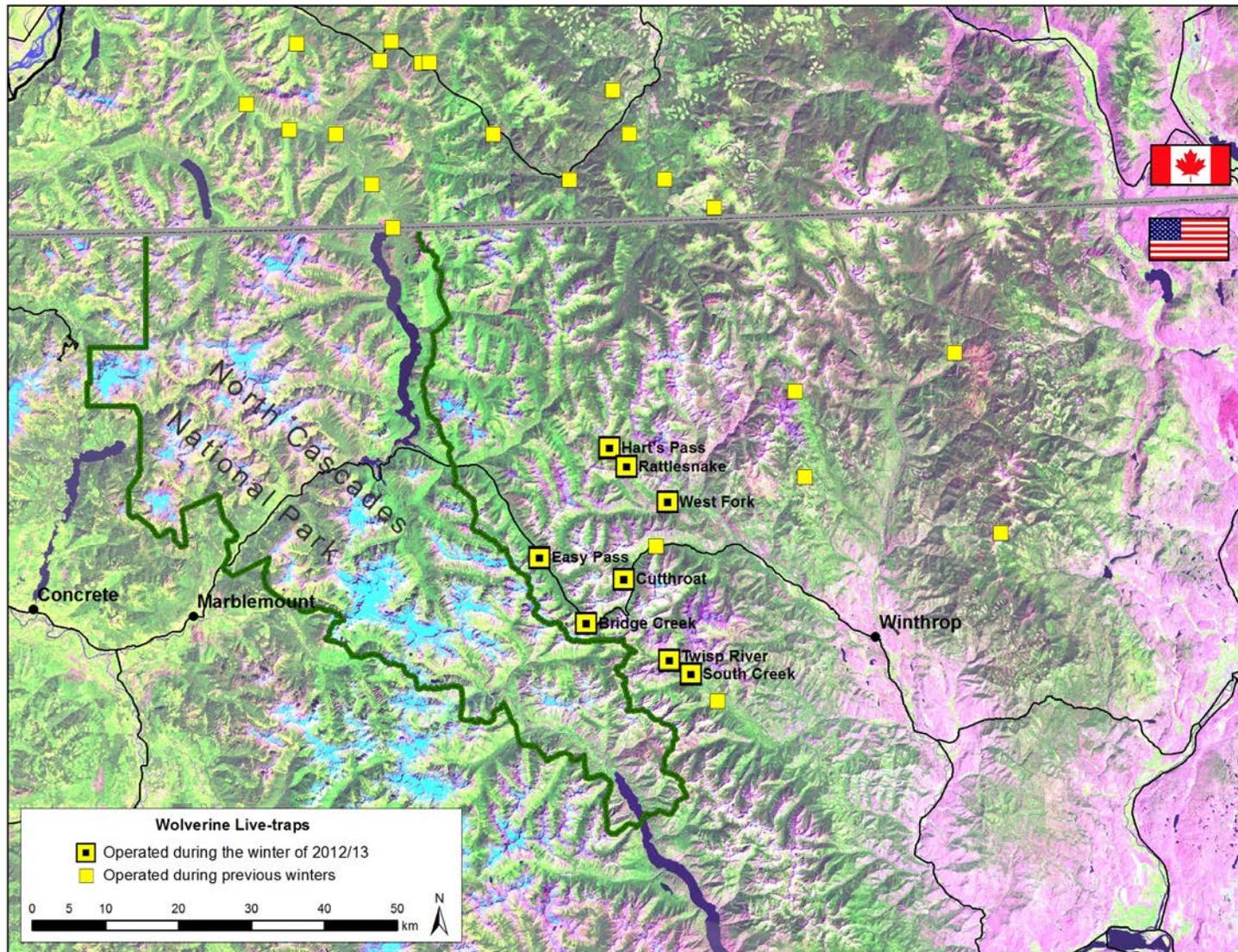


Figure 2. Locations of wolverine livetraps operated during the winter of 2012/13 by field crews in the North Cascades Ecosystem in Washington. No live-trapping efforts occurred in British Columbia during the winter of 2012/13.

Table 1. General site characteristics at wolverine livetraps 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	Winter built	Winters operated	Elevation (m)	Vegetation type
Cutthroat	2005/06	2005/06 thru 2010/11; 2012/13	1,341	Subalpine mixed-conifer
Hart's Pass	2005/06	2005/06 thru 2012/13	1,890	Subalpine mixed-conifer
Twisp River	2005/06	2006/07 thru 2012/13	1,097	Montane mixed-conifer
Baldy Pass ^a	2006/07	2006/07; 2007/08; 2008/09; 2010/11	1,951	Subalpine mixed-conifer
Billygoat	2007/08	2007/08 thru 2010/11	1,463	Subalpine mixed-conifer
Thirtymile ^b	2007/08	Monitored 2007/08 thru 2009/10	1,036	Montane mixed-conifer
Reynolds	2008/09	2008/09 thru 2011/12	884	Montane mixed conifer
South Creek	2008/09	2008/09 thru 2012/13	975	Montane mixed conifer
Rattlesnake	2008/09	2008/09 thru 2012/13	1,646	Subalpine mixed-conifer
West Fork	2008/09	2008/09 thru 2012/13	823	Montane mixed conifer
Silverstar Creek	2008/09	2008/09 thru 2011/12	1,036	Montane mixed conifer
Sweetgrass Butte	2008/09	2008/09 thru 2011/12	1,829	Subalpine mixed-conifer
Easy Pass	2010/11	2010/11 ^c and 2012/13	1,128	Montane mixed conifer
Bridge Creek	2011/12	2011/12 and 2012/13	1,372	Subalpine mixed-conifer

^aThe Baldy trap was removed after the winter of 2010/11 and moved to Bridge Creek.

^bThe Thirtymile trap was removed after the winter of 2009/10 and moved to Easy Pass.

^cThe Easy Pass trap was only open for a few days during the winter of 2010/11.

In Washington, we built traps *in situ* in areas where wolverine occurrences had been documented recently, and located them within ~150 m of roads that were regularly used by snowmobilers. We constructed traps using logs cut from trees at the site based on 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).

In British Columbia, our collaborators constructed 10 livetraps during the winter of 2008/09, 2 additional traps during the winter of 2009/10, and 3 during the winter of 2010/11; all were located in Interior Douglas-fir, Coastal Western Hemlock, and Montane Spruce biogeoclimatic zones. In British Columbia, field crews 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, 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, 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 the animal dies during the lifespan of the satellite transmitter. In year 3 (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 4 (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 first year of our 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 2 and 3 (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 years 2 and 3 of the study. However, analyses of our satellite location data for those 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 4 (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 and was the standard duty cycle we use for all wolverines collared from 2008/09 thru 2012/13.

Unlike satellite collars, GPS collars that have been used successfully on wolverines by other researchers 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 2 (1 female captured twice, and 1 male captured 3 times), we experimented with 1 GPS collar in year 3 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. Unfortunately, we were not able to recapture the male before he slipped his 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 determined that satellite collars are the best option for collecting wolverine movement data in our study area, and we do not plan to use store-on-board GPS collars during the remainder of our study.

In year 5 (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. (2011, 2008) to obtain clear photographs of the light-colored throat and chest blazes of wolverines, which can be used for individual identification. During each winter since 2009/10, we have continued to operate run-pole remote-camera stations (Figure 3) altering the number and locations of stations to meet

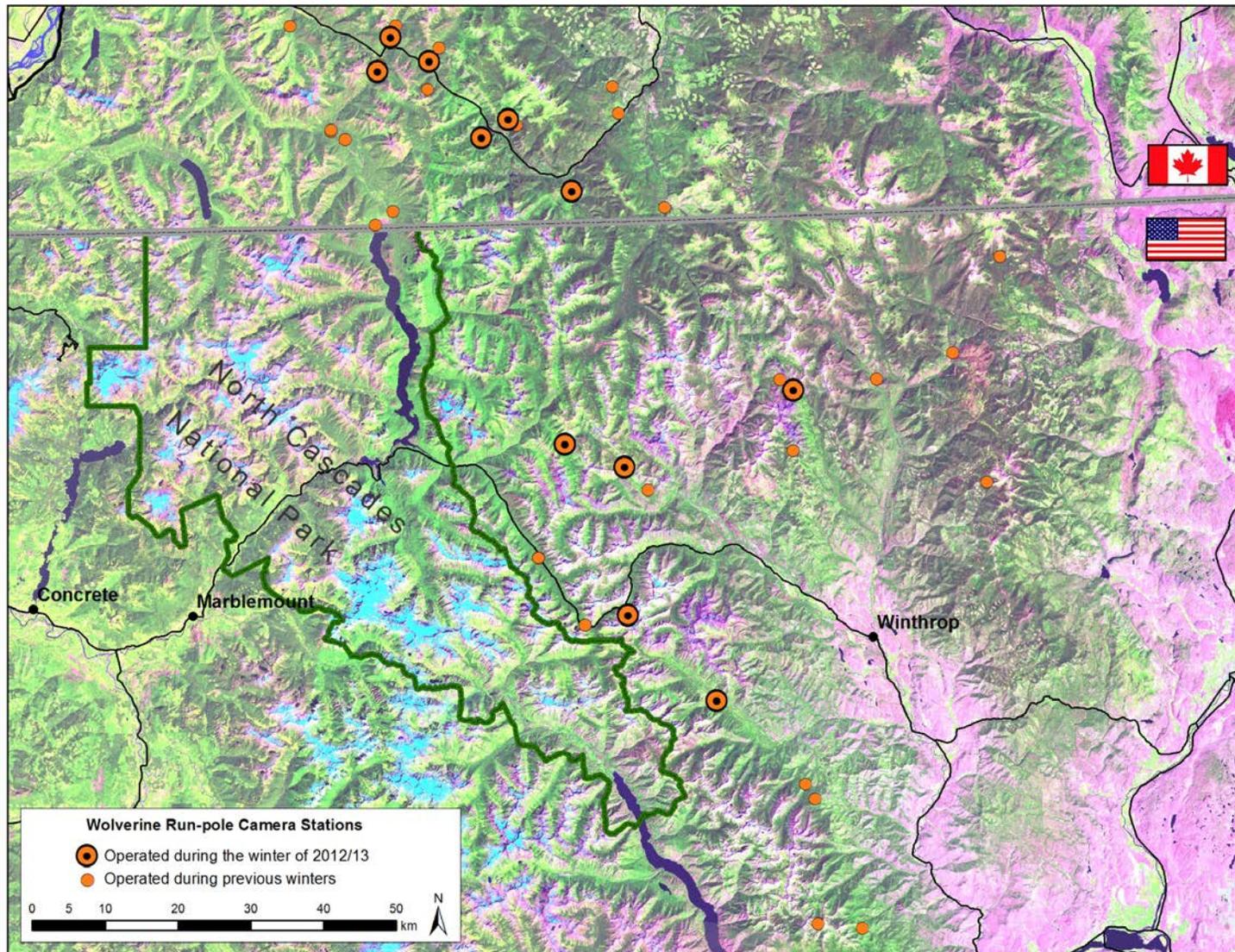


Figure 3. Locations of run-pole remote-camera stations operated during the winter of 2012/13 by field crews in the North Cascades Ecosystem of Washington and British Columbia.

project objectives including monitoring our existing study population and surveying new locations within the study area where wolverines have not yet been detected.

III. Results

Trapping—In Washington, we operated 2 traps during year 1 (winter 2005/06), 4 traps during year 2 (winter 2006/07), 5 traps during year 3 (winter 2007/08), 11 traps during year 4 (winter 2008/09), 10 traps during year 5 (winter 2009/10), 12 traps during year 6 (winter 2010/11), 7 traps during year 7 (winter 2011/12), and 8 traps during year 8 (winter 2012/13) for a total of 3,811 trap nights (Table 2). In most years, the trapping season began in January and continued into late-March or early April; however, during the past 2 winters (2011/12 and 2012/13), we began trapping in early December. Some trap sites take longer to open at the beginning of the season than others (i.e., it takes longer to establish a safe snowmobile route), and there are occasions when we need to close some of the traps due to high avalanche danger. Thus, in any given winter, the number of trap nights can be much lower for some traps than others (Table 2). To date in Washington, we have live-trapped 13 different wolverines on 27 occasions during 8 winter field seasons (Table 2). Non-target species captured included Canada lynx, marten, and bobcat; all were released unharmed.

Our collaborators in British Columbia operated most of their 10 livetraps for 17-20 days during the winter of 2008/09 (year 4), but did not capture any wolverines. During the winter of 2009/10 (year 5), they operated 12 livetraps from 7 January to March 22 for a total of 472 trapnights and captured 2 adult wolverines. During the winter of 2010/11 (year 6), they operated livetraps for varying number of days from 12 January to 5 April, but did not capture any wolverines. During the winter of 2011/12 (year 7), they operated 9 livetraps for a total of 538 trap-nights and captured 1 new female on 2 occasions. No livetraps were

Table 2. Capture results for wolverine livetraps in the northern Cascade Range in Washington.

Trap site	Trap nights	Wolverine captures	Non-target captures
Year 1 (2005/06)			
Cutthroat	49	0	0
Hart's Pass	70	2	0
Year 2 (2006/07)			
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 3 (2007/08)			
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 4 (2008/09)			
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
Year 5 (2009/10)			
Cutthroat	57	0	3 marten

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Trap site	Trap nights	Wolverine captures	Non-target captures
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
Year 6 (2010/11)			
Cutthroat	73	0	0
Hart's Pass	31	1	0
Twisp River	87	1	0
Baldy Pass	60	0	0
Billygoat	30	0	3 marten
Reynolds	79	0	1 marten
South Creek	79	0	0
Rattlesnake	32	1	0
West Fork	57	0	0
Silverstar	64	0	0
Sweetgrass	63	0	0
Easy Pass	4	0	1 marten
Year 7 (2011/12)			
Hart's Pass	52	0	0
Twisp River	129	1	0
Reynolds	125	0	0
South Creek	129	1	0
Rattlesnake	86	0	0
Easy Pass	55	2	4 marten

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Trap site	Trap nights	Wolverine captures	Non-target captures
Bridge Creek	58	1	1 marten
Year 8 (2012/13)			
Cutthroat	91	0	3 marten
Hart's Pass	27	0	0
Twisp River	91	2	4 marten
South Creek	98	1	0
Rattlesnake	41	1	0
West Fork	34	1	0
Easy Pass	53	2	0
Bridge Creek	48	1	0
Totals	3,811	27	56

operated in British Columbia this past winter (2012/13). Thus, to date in British Columbia, we have captured 3 individual wolverines: 2 that were previously captured in Washington (Rocky and Melanie) and 1 that was new to the study (Kendyl). Incidental captures during the past 4 winters included marten, Canada lynx, and cougar.

Capture Histories, Spatial Use, and Movements of Wolverines—Detailed capture information for each study animal is presented in Table 3. Four of our study animals have been captured and monitored using satellite/VHF collars during multiple years. Although the remaining wolverines have only been monitored during a single year, periodic detections at remote-camera stations have provided valuable information on the welfare and general location of those wolverines. To delineate wolverine activity areas (Table 4, Figure 4), we calculated 100% minimum convex polygons using all location data in Argos accuracy-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.

Table 3. Data for 13 wolverines live-trapped in the North Cascades Ecosystem in Washington and British Columbia from 2006 thru 2013. We fitted wolverines with satellite/VHF collars and programmed the satellite transmitter as follows: “on” for 5 hr each day during year 1 (2005/06); “on” for 48 hr and “off” for 24 hr during years 2 and 3 (2006/07, 2007/08); and since year 4 (2008/09), “on” for 14 hr between 0500 and 1900 hours followed by 34 hr “off”.

Wolverine name and sex	Capture date	Trap site	Estimated age	Weight (kg)
#1 – Melanie (F)	February 10, 2006	Hart’s Pass, WA	1-2	8.6
	February 14, 2007	Hart’s Pass, WA	2-3	9.6
	March 7, 2010	Memaloose, BC	5-6	10.1
#2 – Rocky (M) ^a	April 11, 2006	Hart’s Pass, WA	2-3	14.7
	January 25, 2008	Hart’s Pass, WA	3-4	14.2
	March 24, 2008	Hart’s Pass, WA	3-4	13.8
	February 26, 2010	Memaloose, BC	5-6	15.0
	February 8, 2011	Twisp River, WA	6-7	13.2
	February 20, 2012	Easy Pass, WA	7-8	14.7
	March 14, 2012	South Creek, WA	7-8	13.4
#3 – Chewbacca (M)	January 24, 2007	Twisp River, WA	2-4	13.6
	March 17, 2007	Twisp River, WA	2-4	14.6
#4 – Xena (F)	February 11, 2007	Twisp River, WA	1-2	8.0
	March 26, 2007	Twisp River, WA	1-2	8.0
	February 18, 2012	Twisp River, WA	6-7	9.5
	February 20, 2013	Twisp River, WA	7-8	9.0
#5 – Sasha (F)	February 23, 2009	Twisp River, WA	1-2	8.1
#6 – Eowyn (F)	February 1, 2010	South Creek, WA	1-2	9.2

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Wolverine name and sex	Capture date	Trap site	Estimated age	Weight (kg)
#7 – Mattie (F) ^b	January 29, 2011	Hart’s Pass, WA	≥2	7.7
#8 – Mallory (F)	March 24, 2011	Rattlesnake, WA	≥3	8.3
	February 6, 2012	Easy Pass, WA	≥4	9.5
#9 – Special K (M) ^c	February 5, 2012	Bridge Creek, WA	unknown	unknown
#10 – Kendyl (F)	February 29, 2012	Memaloose, BC	1-2	9.9
#11 – Dasher (M)	December 24, 2012	South Creek, WA	1	11.6
	February 5, 2013	Twisp River, WA	1	11.6
#12 – Logan (M)	January 24, 2013	Easy Pass, WA	1-2	11.5
	January 26, 2013	Bridge Creek, WA		
	February 12, 2013	Rattlesnake, WA		
	February 16, 2013	Easy Pass, WA		
#13 – Chance (M)	March 14, 2013	West Fork, WA	2-3	12.3

^aOriginally, this male was named ‘Thor’ but was renamed ‘Rocky’ in 2008.

^bSatellite transmitter programmed to operate continuously.

^cWe were not able to sedate this wolverine enough to handle him or fit him with a satellite/VHF collar.

Table 4. Activity areas calculated for wolverines monitored in the North Cascades Ecosystem in Washington and British Columbia from 2006 thru 2013. Activity areas are 100% minimum convex polygons delineated using Argos satellite location data in accuracy-classes 3 (<250 m), 2 (250–500 m), and 1 (500–1,500 m). These are preliminary results for information only.

Wolverine	Year	Tracking period (months)	# of satellite locations	Activity area (km ²)
#1 – Melanie (F)	2006	Not enough locations to calculate an activity area		
	2007	5	130	1,447
	2010	6	183	1,225
#2 – Rocky ^a (M)	2006	Not enough locations to calculate an activity area		
	2008	2	99	1,162
	2010	9	317	2,992
	2011	5.5	114	1,149
	2012	6.5	96	1,429
#3 – Chewbacca (M)	2007	5	80	1,893
#4 – Xena (F)	2007	5.5	118	1,969
	2012	6	174	643 ^a
	2013	7	235	1,296
#5 – Sasha (F)	2009	6	143	1,495
#6 – Eowyn (F)	2010	Made extreme long-distance movements; could not calculate an activity area		
#7 – Mattie (F)	2011	2.5	174	965
#8 – Mallory (F)	2011	5	162	535
	2012	5	69	293 ^a
#9 – Special K (M)	2012	Not collared		
#10 – Kendyl (F)	2012	3	121	571
#11 – Dasher (M)	2012-2013	1.5	42	199
#12 – Logan (M)	2013	5	159	2,088
#13 – Chance (M)	2013	Made extreme long-distance movements; could not calculate an activity area		

^aAdult female was denning for the first 2 months of the tracking period (i.e., her movements were very restricted) and then was travelling with young during the remainder of the tracking period.

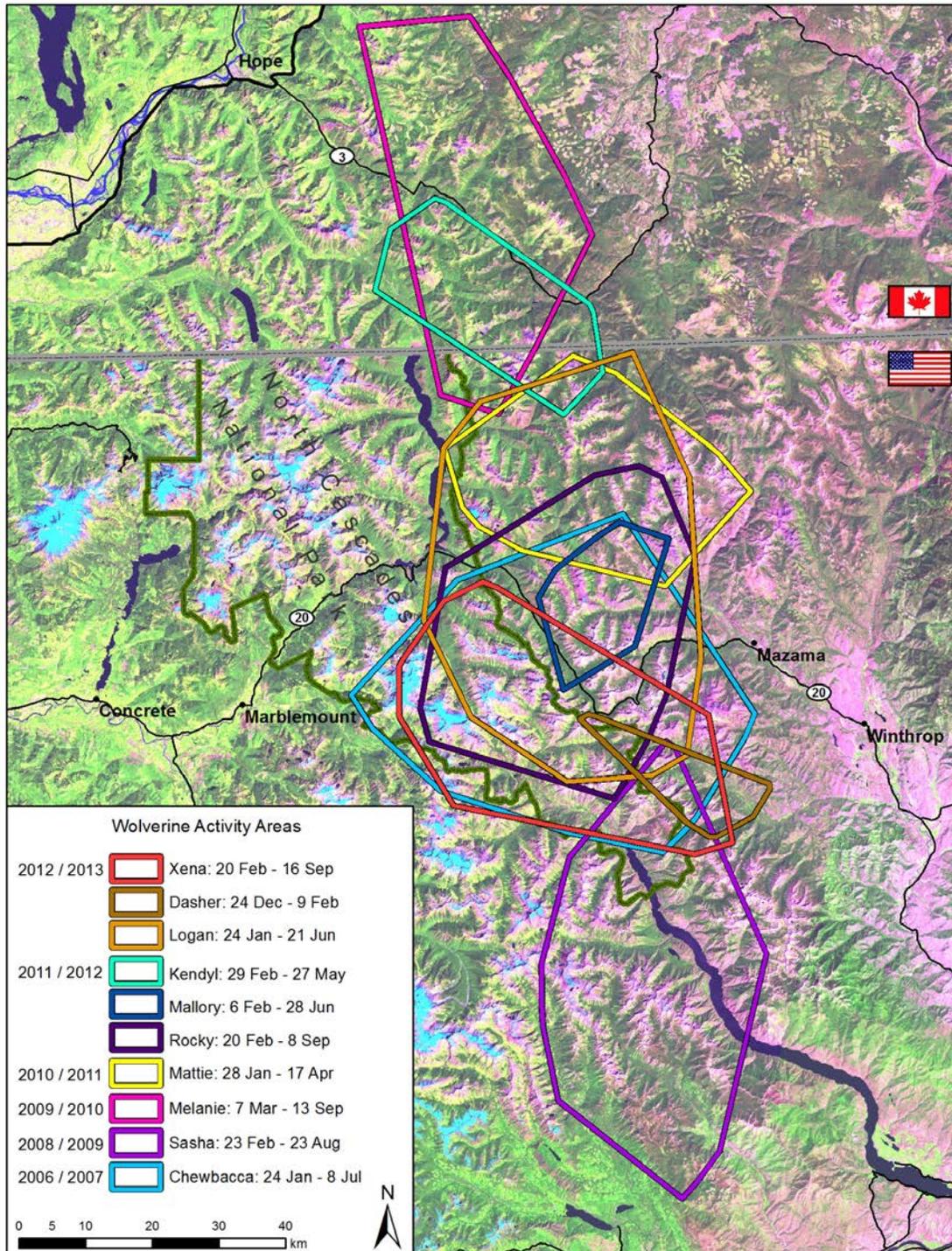


Figure 4. The most recent activity areas for 10 individual wolverines tracked with satellite radio-collars in the North Cascades Ecosystem since the beginning of the study in 2005/2006. Activity areas are 100% minimum convex polygons delineated using Argos satellite location data in accuracy-classes 3 (<250 m), 2 (250–500 m), and 1 (500–1,500 m) for the dates indicated.

Wolverine #1 – Melanie: Melanie was initially captured in 2006 at the Hart’s Pass trap (Table 3; Appendix, Photo 2). Approximately 1 week after her capture, the activity sensor data from her collar indicated that it was no longer moving. Upon retrieving the collar, we determined that the metal band used to attach the collar strap to the transmitter package had broken. The manufacturer corrected this design flaw on all remaining satellite collars before we deployed any additional collars on other wolverines. We recaptured Melanie in the Hart’s Pass trap in 2007 and fitted her with a new satellite/VHF collar. We obtained 130 high-quality locations for her during a 5-month period in 2007, resulting in an activity area of approximately 1,447 km² (Table 4). 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. 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 (11 km 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. Copeland, U.S. Forest Service, personal communication). Consequently, the outcome of Melanie’s reproductive effort in 2007 remains unknown. We did not recapture Melanie again until the

winter of 2009/10 when she was live-trapped at the Memaloose trap in British Columbia (Table 3). We fitted Melanie with a satellite/VHF collar and collected 183 high-quality locations over a 6-month period (Table 4). We determined that she was not reproductive in 2010, and her activity area had shifted from being primarily in Washington during 2007 to almost exclusively in southern British Columbia in 2010 (Figure 4). Although we have not recaptured Melanie since 2010, we detected her at the Memaloose run-pole camera station in British Columbia in April and May of 2012, indicating that she was still a resident adult female in the northern portion of our study area.

Wolverine #2 – Rocky: Rocky (also known as ‘Thor’) was originally captured as a young male in the Hart’s Pass trap in 2006 (Table 3; Appendix, Photo 3). To-date, we have captured and monitored Rocky’s movements during 5 different years (2006, 2008, 2010, 2011, 2012), he is 8-9 years old, and he appears to be one of the primary resident adult males in our study population. In each of these years, we have monitored Rocky’s movements from 2–9 months, and the size of his activity area has varied from 1,149 to almost 3,000 km² (Table 4). Rocky’s movements appear to be influenced, in part, by the number and perhaps the reproductive status of available females. The largest activity area we have documented for him to date was in 2010, when he extensively overlapped Melanie’s 2010 activity area in British Columbia (Figure 4) and ranged well south of Rainy Pass along Highway 20 in Washington. We speculated that the areas he was using in Washington coincided with those of at least 1 adult female (we had detected Xena and another wolverine at a run-pole camera station near the passes along Highway 20). In 2011, his activity area was restricted to Washington where he extensively overlapped 2 collared females (Mattie and Mallory). In 2012, Rocky’s movements were also restricted to Washington and completely encompassed those of 2 reproductive adult females (Mallory and

Xena), suggesting that he was the father of the kits produced by these 2 females in 2012.

Although we did not capture Rocky in 2013, we detected him on video at the Twisp River trap site on January 29, 2013. Rocky was travelling with a subadult male (Dasher) that we had live-captured a month previously – this association, in conjunction with genetic data from both males, indicate that Rocky is likely Dasher’s father. It also indicates a degree of social tolerance in wolverines between a father and his male offspring that has not been described previously.

Wolverine #3 – Chewbacca: In 2007, we captured a young male wolverine (Chewbacca) in the Twisp River trap (Table 3; Appendix, Photo 4). We fitted Chewbacca with a satellite/VHF collar and obtained 80 high-quality locations, resulting in an activity area of approximately 1,893 km² (Table 4). 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). We did not recapture Chewbacca in the winter of 2007/08; however, we obtained photographs of him in February and May of 2008 at a remote-camera station we installed near the Twisp River trap.

Wolverine #4 – Xena: In 2007, we captured a young nulliparous female wolverine (Xena) in the Twisp River trap (Table 3; Appendix, Photo 5). We fitted Xena with a satellite/VHF collar and obtained 118 high-quality satellite locations, resulting in an activity area that was approximately 1,969 km² (Table 4). We detected Xena multiple times during the winter of 2009/10 at the Easy Pass camera station in Washington but did not recapture her until February 2012. During 2012, Xena used areas similar to those that she used in 2007, but the size of her activity area was considerably smaller (Table 4). Xena was reproductive in 2012, and we located her reproductive den in North Cascades National Park in late April (Appendix, Photo 6). Thus, her smaller activity area was likely related to more localized and restricted movements

during the denning period (late February thru April) and during the spring and summer once she was travelling with young.

By placing remote cameras near the entrance to her den, we were able to document that Xena had 1 kit. She removed her kit from the den in late April and, based on the size of the kit and the approximate date when we believe Xena began to den, we estimated the kit's age to be at least 9 weeks. Reproductive females typically move their kits to a new den site once the kits get older and close to weaning (at 9-10 weeks of age). After the snow had melted, we returned to Xena's den site in August and determined that she and her kit had been using the space under a large rock structure (Appendix, Photo 6). Although we collected hair and scats at the site, genetic analyses did not provide us with any new information on Xena's kit.

We live-captured Xena again this past year (2013) and monitored her movements for 7 months (Table 4, Figure 4). Xena was not reproductive in 2013 and her activity area was substantially larger than it was in 2012 when she had young. Xena is 7-8 years old now.

Wolverine #5 – Sasha: In 2009, we captured a young nulliparous female (Sasha) at the Twisp River trap and fitted her with a satellite/VHF collar (Table 3, Appendix, Photo 7). During the first month we monitored her, Sasha traveled approximately 56 km (straight-line distance) southwest to the Entiat and Chiwawa River watersheds. Her movements continued to be centered in this area for the remainder of the summer (Figure 4). We obtained 143 high-quality satellite locations during a 6-month period for Sasha; her activity area was 1,495 km² and was located further south in the northern Cascades than any of the other wolverines monitored so far in this study (Figure 4, Table 4). Although we have not recaptured Sasha since 2009, we detected her at a run-pole camera station located in the Entiat River drainage in March and April of 2012 (Appendix, Photo 7). The photos of Sasha at the camera station revealed that she is in

good condition, and her continued presence in this area indicates that she is a resident adult female (4-5 years of age) in the southern portion of our study area.

Wolverine #6 – Eowyn: In 2010, we captured a young nulliparous female (Eowyn) at the South Creek trap in Washington and fitted her with a satellite/VHF collar (Table 3; Appendix, Photo 8). During the first 2 months that we monitored her, Eowyn traveled over 483 kilometers north across the Pasayten wilderness and into British Columbia (Figure 5). We obtained 165 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.

Wolverine #7 – Mattie: In 2011, we captured a young female (Mattie) at the Hart's Pass trap and fitted her with a satellite/VHF collar (Table 3; Appendix, Photo 9). The capture crew suspected that Mattie might be pregnant and thus fitted her with a satellite transmitter programmed to be on 24 hours per day, 7 days per week. However, her subsequent satellite locations did not indicate that she was denning (i.e., her movements were not concentrated in a single area, nor did she repeatedly return to any given area over an extended period of time). We obtained 174 high-quality satellite locations during a 2.5-month period before her satellite transmitter expired in mid-April 2011. Mattie's activity area was 965 km² (Table 4, Figure 4) and overlapped part of Rocky's 2011 activity area. Mattie's activity area was also coincident with part of the area that had been occupied by Melanie in 2007.

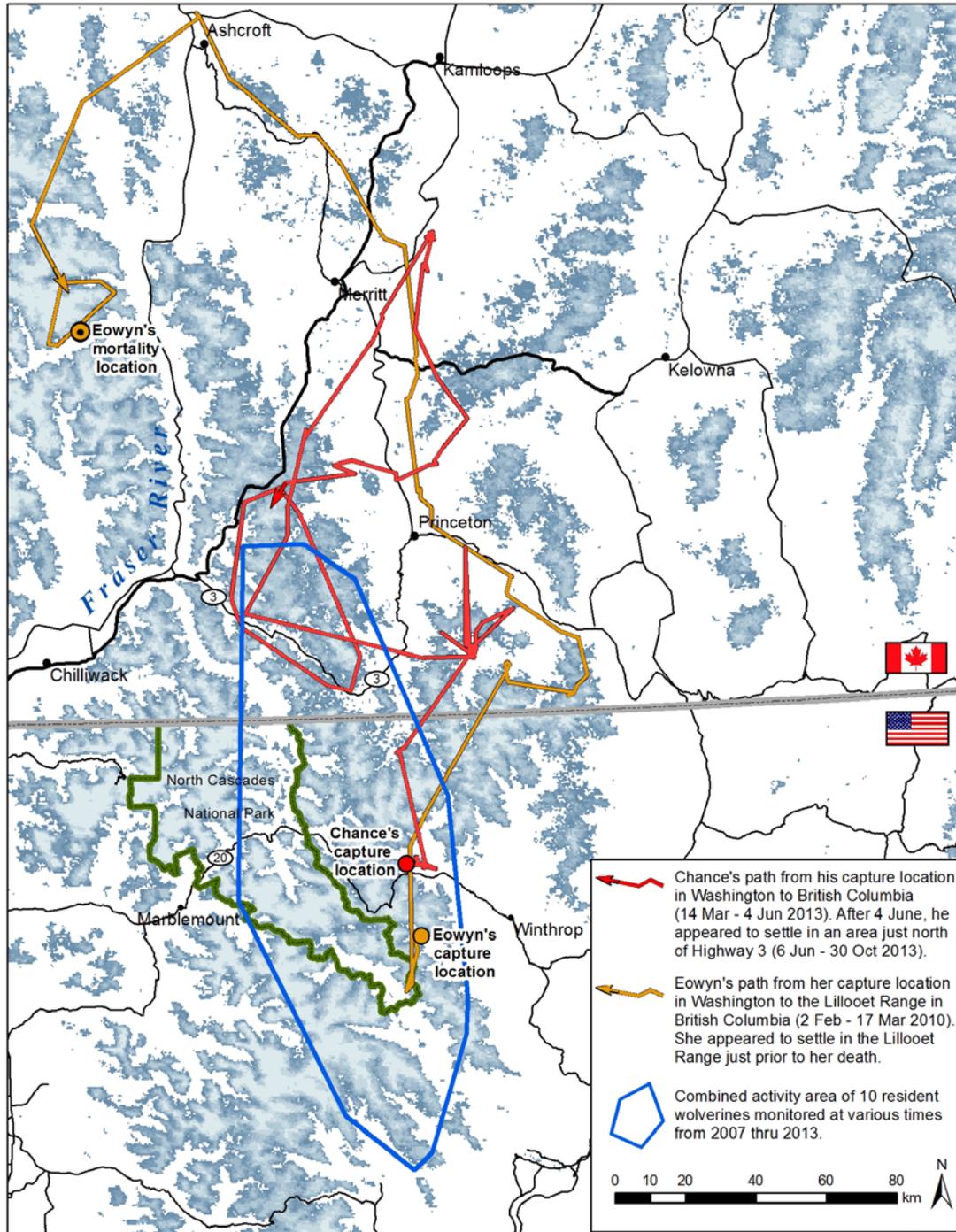


Figure 5. Long-distance movements made by a subadult male (Chance) during 2013 and a young nulliparous female wolverine (Eowyn) during 2010. Movement paths were determined using satellite location accuracy classes 3 (<250 m) and 2 (250-500 m). Polygons depicting areas of more localized movements, as well as the combined activity area for resident wolverines, were determined using satellite location accuracy classes 3, 2, and 1 (500-1500 m).

Wolverine #8 – Mallory: In 2011, we captured an adult female (Mallory) at the Rattlesnake trap and fitted her with a satellite/VHF collar (Table 3; Appendix, Photo 10). Mallory's chest and throat blazes were identical to those of a wolverine detected at our Easy Pass run-pole remote-camera site in March 2010 (see Table 5). We obtained 162 high-quality satellite locations during a 5-month period for Mallory and her activity area was 535 km² (Table 4). We recaptured Mallory in 2012 at the Easy Pass trap site (Table 3) and fitted her with a new satellite collar. Mallory used the same general area in 2012 (Figure 4) that she used in 2011, however, the overall size of her 2012 activity area was smaller (Table 4). Mallory was reproductive in 2012; consequently, her movements were probably more localized than they would be if she was not denning or travelling with young.

We located Mallory's reproductive den on the Okanogan-Wenatchee National Forest in late April (Appendix, Photo 11). Unfortunately, by the time we could land a helicopter near Mallory's den to install a remote camera (in early May), she had already abandoned the site; i.e., Mallory's kit(s) were at or near the age of weaning by early May and she moved them to a new den site. After the snow melted, we returned to Mallory's reproductive den site and determined that she had been using a large log jam that had been created at the bottom of an avalanche chute several years ago (Appendix, Photo 11). Although we collected multiple scats at the den site, genetic results from those samples did not provide us with any information on the identity or potential number of kits that Mallory may have produced.

Wolverine #9 – Special K: In February of 2012, we captured a new male wolverine at the Bridge Creek trap site (Table 3; Appendix, Photo 12). Unfortunately, we could not sedate him enough to safely handle him and fit him with a satellite/VHF collar. Thus we collected a hair sample and released him without a collar. The hair sample provided adequate DNA and

subsequent analyses of microsatellite data verified that Special K was a previously unknown male. Because the drug combination we were using (ketamine and medetomidine) did not appear to be very effective on this animal, we are now prepared to use Telazol should we recapture him. However, this male may have moved out of our primary study area. On 30 July 2012, he was detected at a remote run-pole camera station located west of the Cascade Crest near Sauk Mountain on the Mount Baker-Snoqualmie National Forest (identification determined from genetic analysis of hair collected at the camera station; station operated by Roger Christophersen, North Cascades National Park).

Wolverine #10 – Kendyl: In February of 2012, our collaborators in British Columbia captured a new female in the Memaloose trap (Table 3; Appendix, Photo 13). Kendyl was fitted with a satellite/VHF collar and we collected 121 high-quality satellite locations on her over a 3-month period before she slipped her collar (Table 4). Her activity area was primarily in southern British Columbia (Figure 4); she ventured south into Washington on apparently only 1 occasion. Although we did not recapture Kendyl in 2013, she was detected at the Memaloose run-pole camera station in British Columbia on multiple occasions between March 22 and May 5.

Wolverine #11 – Dasher: In December of 2012, we captured a new subadult male in the South Creek trap (Table 3; Appendix, Photo 14). We fitted Dasher with a satellite/VHF collar but the collar failed at the end of January 2013. We recaptured Dasher in early February in the Twisp River trap and replaced his satellite/VHF collar with a new one. Unfortunately, Dasher slipped his new collar a week later. However, during the 1.5 months we were able to monitor his movements, we obtained 42 high-quality satellite locations and his activity area was 199 km² (Table 4, Figure 4). Most of his movements were within Xena's activity area (Figure 4) and genetic results indicate that Xena is likely his mother.

We sent Dasher's failed collar back to the manufacturer where they determined that the transmitter package had been damaged, allowing moisture to penetrate and corrode the transmitter components. Further examination revealed that the damage may have been inflicted by another wolverine chewing on the transmitter package. Given that Dasher was probably <1 year of age at the time of his capture, he was likely still interacting at times with his parents. Genetic data indicate that Dasher is most likely the offspring of Xena and Rocky. His telemetry location data revealed he was moving within Xena's activity area, and remote video footage taken at the Twisp River trap site revealed Dasher and Rocky travelling together.

Wolverine #12 – Logan: In January 2013, we captured a new subadult male in the Easy Pass trap (Table 3; Appendix, Photo 15) and fitted him with a satellite/VHF collar. We collected 159 high-quality satellite locations for him over a 5-month period and his activity area was 2,088 km² (Table 4, Figure 4). Genetic results from tissue samples collected during his capture indicate that he could be the offspring of Rocky and Melanie.

Wolverine #13 – Chance: In March 2013, we captured a new subadult male in the West Fork trap (Table 3; Appendix, Photo 16) and fitted him with a satellite/VHF collar. Within several weeks of his capture, it was evident that Chance was making exploratory movements and did not have an established activity area. During a 12-week period, Chance travelled over 564 km (Figure 5) north into British Columbia. In early June, after several forays and going well beyond the activity areas of other wolverines we have monitored thus far, he returned to the most northern portion of our study area just north of Highway 3 in British Columbia (Figure 5). Chance continued to move within this area for the next 4.5 months until his transmitter quit at the end of October. Genetic results indicate that Chance is not the offspring of any of our other study animals. Thus it is unclear where he originated from, and we may have captured him after

he had already started to make exploratory movements.

Camera Stations—The run-pole remote-camera stations continue to be an effective method for detecting and identifying individual wolverines in our study area. Detailed results for run-pole camera stations operated in the Washington portion of our study area are presented in Table 5.

In British Columbia, our collaborators operated 9 run-pole camera stations during year 5 (2009/10) and detected Melanie on multiple days in February, March, and April 2010 at both the Memaloose and Cambie camera stations. Rocky was detected on multiple days in February and April at these same 2 camera stations. No wolverines were detected at 8 run-pole camera stations operated in British Columbia during year 6 (2010/11). In year 7 (2011/12), 7 stations were operated in British Columbia and at least 4 different wolverines were detected. Two different, un-collared, wolverines were detected at the Sumallo Grove station: 1 in December 2011 (Appendix, Photo 17) and 1 in February and April of 2012 (Appendix, Photo 18). At the Memaloose camera station, Kendyl was detected on multiple days in February and April of 2012 (before and after she was live-captured; see Appendix, Photo 13); Melanie was detected on multiple days in April and May (Appendix, Photo 2); and an un-collared wolverine was detected on multiple days in April and May (Appendix, Photo 19). Because we did not obtain clear photos of the throat and chest blazes, we cannot determine if the un-collared wolverine detected at Memaloose (Appendix, Photo 19) is a different individual than the one detected at Sumallo Grove in February and April (Appendix, Photo 18). During this past winter (2012/13), Kendyl was detected on multiple occasions at the Memaloose camera station between March 22 and May 5. Camera detections of non-target species included marten, ermine, grizzly bear, black bear, cougar, bobcat, Canada lynx, and spotted skunk.

Table 5. Eight run-pole camera stations were operated in the northern Cascade Range in Washington for a total of 758 days during the winter of 2009/10, 10 stations were operated for 468 days during 2010/11, 6 stations were operated for 799 days during 2011/12, and 5 stations were operated for 446 days during 2012/13.

Station	Winter	Days operated	No. of wolverine photos	No. of photos of other carnivore species
Billygoat	2011/12	106	0	118 marten
	2012/13	68	0	36 marten 2 coyote
Bridge Creek	2009/10	148	355 (Rocky)	1088 marten 2 black bear
	2010/11	78	3 (Rocky) 1 (Mattie)	982 marten
Bryan Butte	2009/10	21	0	92 marten
	2010/11	26	0	0
Buttermilk	2010/11	43	0	831 marten 14 coyote
				120 marten
Cache Creek	2010/11	42	0	120 marten
Easy Pass	2009/10	244	68 (Xena)	290 marten
			34 (new wolverine) ^a	
	2010/11	47	0	739 marten
Eightmile	2009/10	33	0	15 Canada lynx 13 marten
				0
Freezeout	2010/11	63	0	600 marten
				0
Hairpin	2011/12	175	0	281 marten
	2012/13	127	0	771 marten
Lake Creek	2010/11	33	0	1,361 marten
Libby	2009/10	32	0	7 marten
	2010/11	62	0	141 marten

Continued next page

Station	Winter	Days operated	No. of wolverine photos	No. of photos of other carnivore species
Pick Peak	2009/10	187	0	466 marten
Rattlesnake	2011/12	121	8 (Rocky)	6 black bear 2 Canada lynx 1 marten
	2012/13	100	81 (Logan)	0
Slate Creek	2009/10	83	313 (Rocky)	0
	2011/12	175	43 (Rocky) 24 (Mallory)	1 black bear 1 Canada lynx 27 marten
	2012/13	58	0	0
Reynolds	2012/13	93	0	177 marten
South Fork Gold	2011/12	123	0	0
Sweetgrass	2009/10	19	0	0
	2010/11	69	0	147 marten
Thirtymile	2011/12	99	0	15 marten

^aThe chest markings of this wolverine match those of an adult female subsequently captured in 2011 (Mallory).

Backcountry Snow-tracking Routes—In year 5 (winter 2009/10), we established 2 backcountry snowtracking routes in Washington to backtrack wolverines to obtain DNA samples (scat or hair; Ulizio et al. 2006) in areas that were too remote for trapping. 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, but the quality of the DNA from these samples was too poor to determine species. We completed a second trip into the Spanish Camp area from February 18-22, during which we followed 1 putative wolverine track for a short distance, but collected no samples. Finally, 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. No back-country snow-tracking routes have been sampled since the winter of 2009/10.

IV. Discussion and Management Implications

Due to the substantial logistical challenges involved in conducting a radio-telemetry study of wolverines in the northern Cascade Range, our primary objectives during the first 3 years of the study (winters 2005/06, 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.

In year 1, by placing traps in strategic locations, we were able to capture and radio-collar 2 wolverines, including a juvenile female and a subadult 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 locations. 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. These 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 2 and 3. During that time, we captured 2 new wolverines, recaptured the juvenile female and subadult male from year 1, collected 80–130 high-quality locations for each study animal during a 2–6 month period, and documented that reproduction was occurring in Washington (i.e., Melanie was pregnant in 2007). During years 4 thru 8 (winters 2008/09 thru 2012/13), we have continued to capture new wolverines and recapture many of the study animals we monitored in previous years. To date, we have captured 13 different wolverines in Washington and British Columbia, 4 of which we monitored in multiple years. During 2011/12, we obtained valuable information on the reproductive ecology of wolverines in Washington and located the first reproductive dens ever documented in this region. Overlap in adult male and female activity areas likely indicates reproductive pairs. For example, Rocky’s movements during 2012 completely overlapped those of the 2 reproductive females (Mallory and Xena), indicating that he is likely the father of their kits. High-quality satellite location data also indicated that Rocky periodically visited each of the female’s den sites. This past winter (2012/13), we captured a young male (Dasher), and genetic analyses revealed that he is likely the offspring of Rocky and Xena. Thus, using both field and genetic data, we can elucidate familial relations among our study animals.

During the course of this study, we have been able to delineate activity areas for 10 wolverines using satellite location data (Figure 4, Table 4) and document long-distance movements by 2 subadults (1 female 1 male; Figure 5). Furthermore, the activity areas for 8 of 10 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.

Satellite location data that we collected on wolverines during 2006/07 and 2007/08 were used as part of a larger dataset (telemetry data from wolverine studies conducted in North America and Fennoscandia) to develop a spatially explicit model of wolverine habitat based on the wolverine's bioclimatic envelope and their association with persistent spring snow cover (i.e., snow cover thru the wolverine reproductive denning period; Copeland, et al. 2010). Since this model was developed, we have collected an additional 1,994 high-quality satellite locations on 9 wolverines in Washington and British Columbia. The vast majority of these telemetry locations fall within areas having snow cover that persists into late spring (Figure 6) indicating that the bioclimate envelope model is effective for delineating potential wolverine habitat in the North Cascade Ecosystem, and would be useful for both management and conservation purposes.

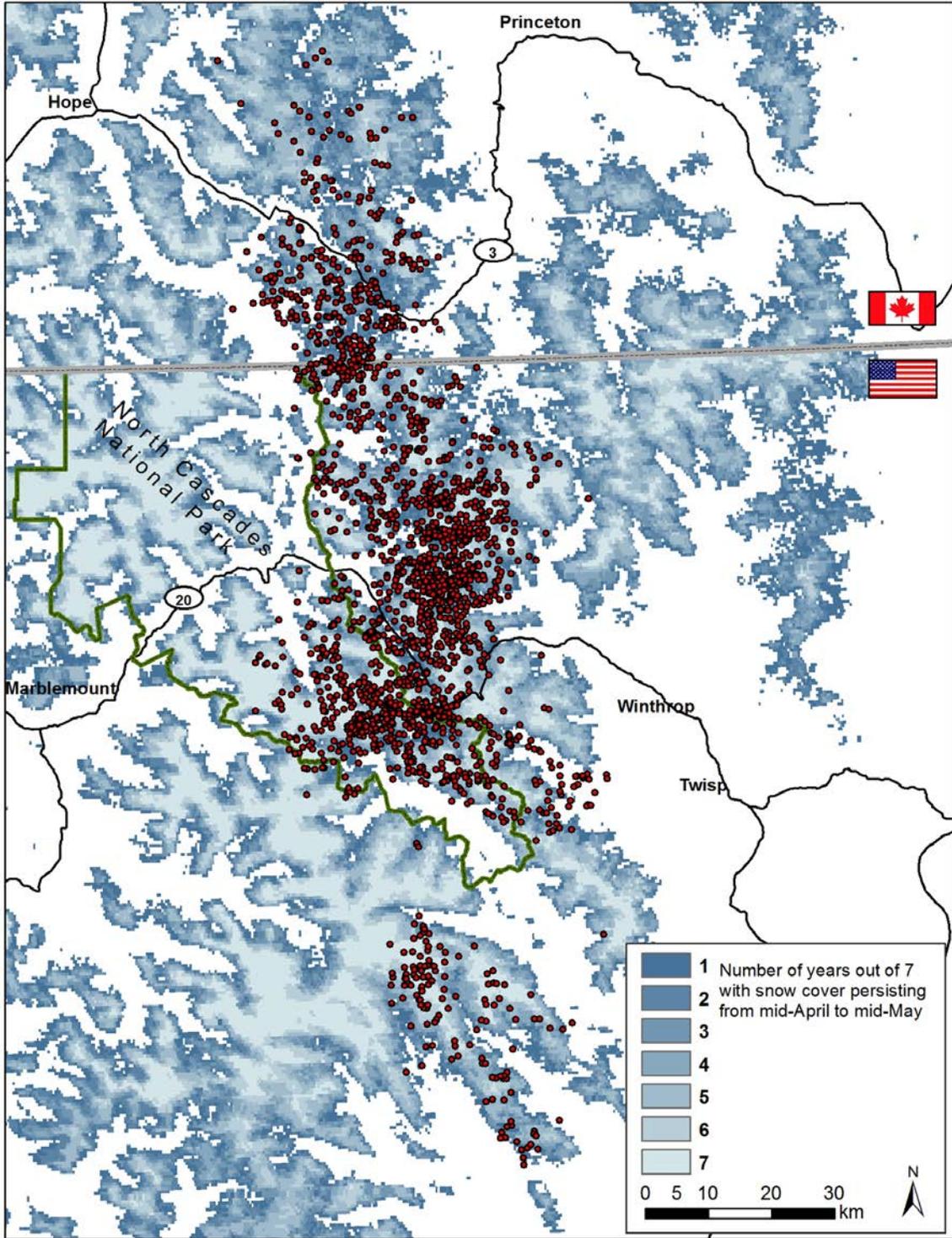


Figure 6. More than 1,900 high-quality satellite locations (red dots) obtained on 9 wolverines monitored from 2008/09 thru 2012/13 overlaid on a map of persistent spring snow cover developed by Copeland et al. (2010) and representing potential wolverine habitat in the Northern Cascades Ecosystem.

V. Future Research

In year 9 (2013/14), we will continue to collaborate with researchers in British Columbia, who will operate run-pole camera stations. In Washington, we will focus trapping efforts on our most productive trap sites, including Hart's Pass, Rattlesnake, Easy Pass, Bridge Creek, and Twisp River. In year 9, we will be deploying a new model of satellite/VHF collar from Sirtrack (KiwiSat 303) on any of the wolverines we capture. The new model incorporates improvements in battery technology that extend the life of the satellite transmitter from about 8 months to 15 months (450 days). This will allow us to track wolverines year-round, and may provide additional opportunities for us to locate the natal dens of reproductive females. Additionally, the new collar model is about 50 grams lighter than the previous model (approximately 160 vs. 210 grams). We plan to operate at least 7 run-pole remote-camera stations next year, and at all of the stations, we will install hair-snagging devices for collecting DNA samples from wolverines that visit the sites.

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 continue to locate natal and maternal dens, and document reproductive attainment. When we captured Mallory and Xena in early February of 2012, we could not determine if they were pregnant (i.e., teats were not noticeably enlarged and we could not detect any fetuses when we palpated their abdomens). Nevertheless, by carefully analyzing their satellite location data, we were able to determine that

they were denning by early March, and to delineate relatively small areas to search from a helicopter to locate each of their den sites. Working with our various partners, we were also able to land a helicopter at the den sites during the denning period and install remote cameras, as well as return to the den sites later in the summer to collect genetic samples and habitat data. These methods worked well; we verified reproduction and the genetic samples we collected may eventually provide detailed information on the number and identity of kits.

VI. Partnerships

This research could 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, Eric Lofroth and Rich Weir of the British Columbia Ministry of Environment, and Cliff Nietvelt of the British Columbia Ministry of Forests, Lands and Natural Resource Operations, all of whom have contributed funding or in-kind contributions to the study. Additional funding and 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 U.S. Fish and Wildlife Service; the Wolverine Foundation; the Seattle Foundation/Tom and Sonya Champion Fund; and the USFS 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, David Bowden, Kat Dees, Andre Dulac, Mila Dunbar-Irwin, Justin Ewer, Mike

Harmon, Dan Harrington, Morgan Hartsock, Jeff Heinlen, John Jakubowski, Adam Kehoe, Gary Koehler, Michael Liu, Alexis Monetta, Andrew Myhra, Bob Naney, Joyce Neilson, Kim Romain-Bondi, Dan Russell, Brandon Sheeley, Bryan Smith, Gabe Spence, Ann Sprague, Blake Stokes, Chris Vennum, and Lindsay Welfelt; in British Columbia, Travis Desy, Dan Guertin, Brent Gurd, Matt Rochetta, Heidi Schindler, and Dylan Taylor. 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 (CNW) in Bellingham, WA to conduct remote-camera surveys for wolverines and other forest carnivores in the Cascade Range in Washington. During the past 2 years (2012 and 2013), CNW detected 4 different wolverines in the Chiwaukum Creek drainage south of Highway 2. Genetic analysis of hair collected at the site after each of these detections revealed that 2 of the wolverines were females (subsequently named Peg and Lacy) and 2 were males (Bootjack Mountain and Clark). The Bootjack Mountain male was detected at another CNW remote-camera station about 10 miles south of the Chiwaukum site. Most recently, CNW volunteers installed a run-pole camera station near Ice Lakes on the Entiat Ranger District of the Okanogan-Wenatchee National Forest and detected a wolverine at that site in September of 2013. We hope these efforts will continue to 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

Upon completion of this study, our findings will be published in one or more scientific outlets. However, data collected during this study have already been used in 2 important publications on the wolverine's bioclimatic niche and its potential vulnerability to global

warming. Telemetry data that we collected on Washington wolverines from 2005/06 thru 2006/07 contributed to a journal article published in the *Canadian Journal of Zoology* (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. Results from this study also contributed to a journal article published in *Ecological Applications* (McKelvey et al. 2011; Aubry is a co-author) that predicts the potential effects of global warming on the geographic extent and connectivity of wolverine habitat in the western contiguous U.S.

We have given numerous 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.

Aubry, K.B., 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.

Aubry, K.B. 2010. Biology and conservation of the wolverine in California. Peninsula Round Table, Burlingame, California.

Rohrer, J. 2010. Wolverines in the North Cascades. Sun Mountain Lodge, Winthrop, WA.

Aubry K.B., C.M. Raley, J.J. Rohrer, E.C. Lofroth, and S.H. Fitkin. 2011. Preliminary results from the North Cascades wolverine study. Joint Annual Meeting of the Society for Northwestern Vertebrate Biology and the Washington Chapter of the Wildlife Society, Gig Harbor, Washington.

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Appendix, Photo 1. Wolverine live trap 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 has been live-captured at Hart's Pass in Washington (2006, 2007) and at the Memaloose trap site in British Columbia (2010). Most recently, we detected her in May 2012 at the Memaloose run-pole camera station (above).



Appendix, Photo 4. Chewbacca was live-captured at Twisp River in Washington (2007) and was detected in February and May 2008 at a remote camera station near the Twisp River trap (above).



Appendix, Photo 3. Rocky was live-captured during 2006, 2008, 2010, 2011, and 2012 at 3 trap sites in Washington (Hart's Pass, Twisp River, and Easy Pass) and at the Memaloose trap site in British Columbia. Also, we have frequently detected him at run-pole camera stations (above).



Appendix, Photo 5. Xena was live-captured at Twisp River in Washington in 2007, detected at the Easy Pass run-pole camera station in 2010, and then recaptured at the Twisp River trap site in 2012 and 2013. Xena was reproductive in 2012 (above: Xena captured on remote camera emerging from her den) but was not reproductive in 2013.



Den entrance we located in April; note mound of snow uphill of the den entrance.

Large rock structure that was buried under ~3 meters of snow when Xena was using it as a reproductive den site.

General area that the snow hole and tunnel accessed.



Appendix, Photo 6. Xena's reproductive den site in 2012 located in North Cascades National Park, Washington.



Appendix, Photo 7. Sasha was live-captured at the Twisp River trap in Washington in 2009. Most recently, she was detected at a run-pole camera station in April 2012 (above: station operated by the Entiat Ranger District, Okanogan-Wenatchee National Forest).



Appendix, Photo 9. Mattie was live-captured at the Hart's Pass trap site in Washington in 2011.



Appendix, Photo 8. Eowyn was live-captured at the South Creek trap site in Washington in 2010. This wolverine is now deceased (apparently killed by a cougar).



Appendix, Photo 10. Mallory was live-captured at the Rattlesnake trap site in 2011 and Easy Pass in 2012 (both in Washington). We've also detected Mallory at several run-pole camera stations (above). Mallory was reproductive in 2012.



Mallory accessed her den via an opening and tunnel that she dug in the snow that started at the bottom of this tree well.

Space under downed trees used by Mallory and her kit(s).



Appendix, Photo 11. Mallory’s reproductive den site in 2012 located on the Okanogan-Wenatchee National Forest, Washington. This area was under about 2.4 meters of snow when used by Mallory.



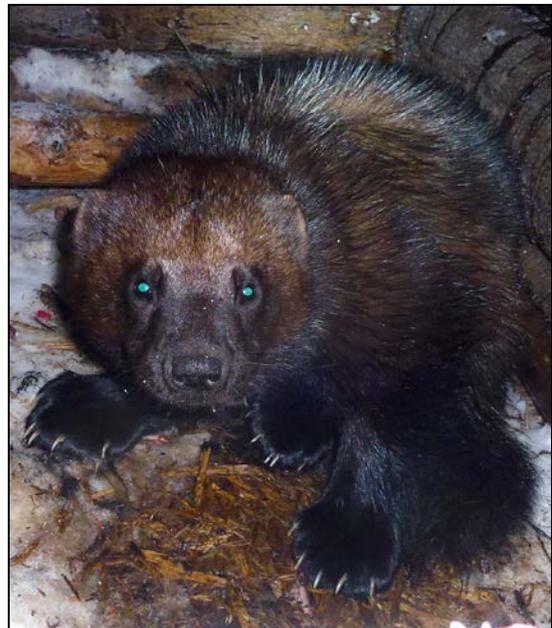
Appendix, Photo 12. Special K was live-captured at the Bridge Creek trap site in Washington in 2012. He was released without a satellite collar.



Appendix, Photo 14. Dasher was live-captured at the South Creek trap site in Washington in December of 2012 and again at the Twisp River trap site in February of 2013.



Appendix, Photo 13. Kendyl was live-captured at the Memaloose trap site in British Columbia in 2012. She was also detected on multiple days at the Memaloose run-pole camera station in April of 2012 (above) and again in March, April, and May of 2013.



Appendix, Photo 15. Logan was live-captured at the Easy Pass trap site in Washington in January of 2013.



Appendix, Photo 16. Chance was live-captured at the South Fork trap site in Washington in March of 2013.



Appendix, Photo 18. Un-collared wolverine detected at Sumallo Grove camera station in British Columbia in February and April of 2012.



Appendix, Photo 17. Un-collared wolverine detected at the Memaloose camera station in British Columbia in April and May of 2012.



Appendix, Photo 19. Un-collared wolverine detected at Memaloose camera station in British Columbia in April and May of 2012.