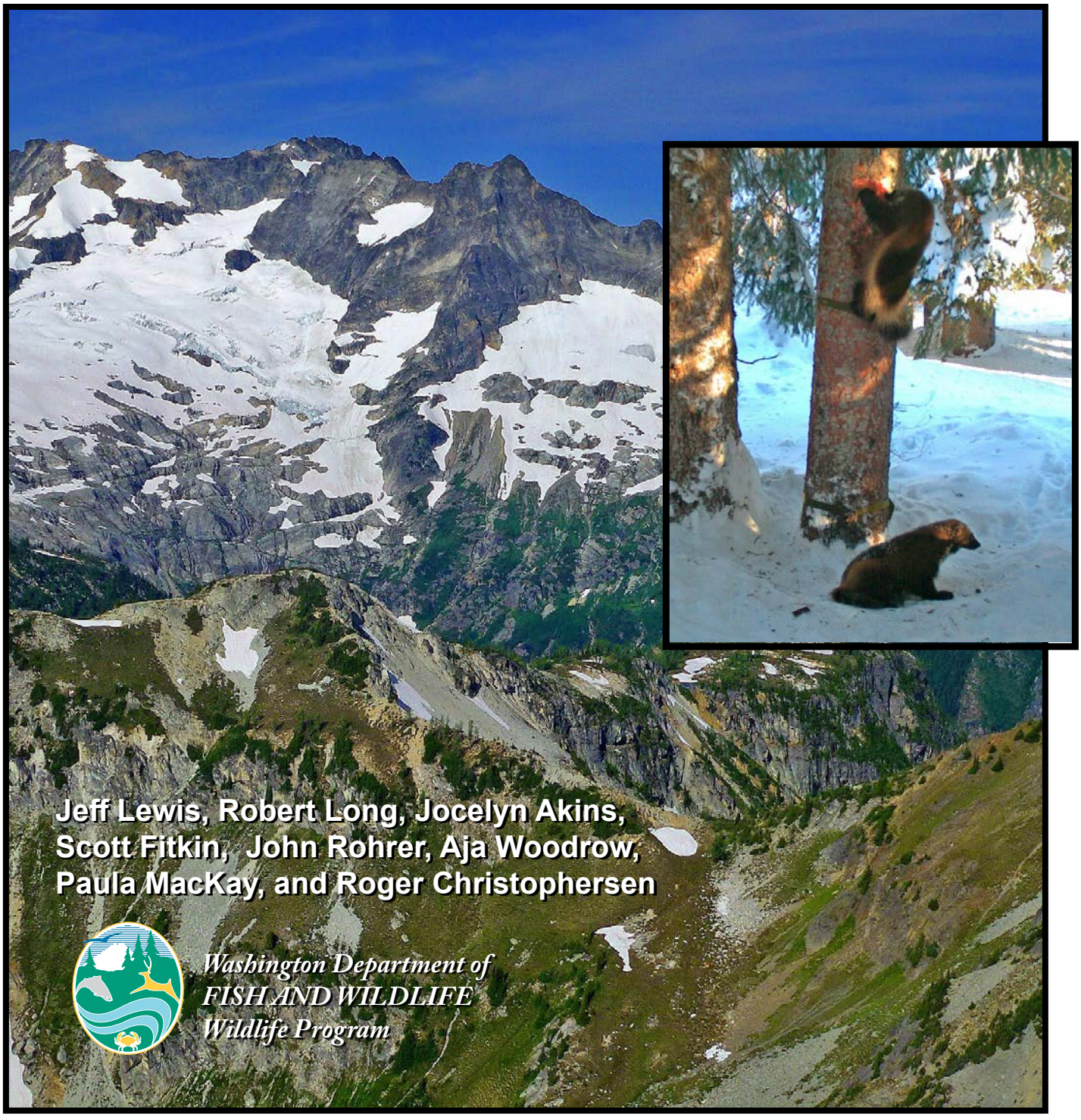
STATE OF WASHINGTON February 2020

Western States Wolverine Conservation Project: results of the Washington Wolverine Survey, Winter 2016-2017



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Washington Department of FISH AND WILDLIFE Wildlife Program

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On the cover: photos of F39 and M40; background of over the ridge from Xena's den by Scott Fitkin

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Western States Wolverine Conservation Project: Washington State Results for the Western States Wolverine Survey, Winter 2016-2017

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Acknowledgements

The Western States Wolverine Survey was conducted in the fall and winter of 2016-2017 by the Western States Wolverine Conservation Project (WSWCP). The survey was designed to provide the first formal assessment of wolverine distribution across the western states where resident populations of wolverines were known to exist: Idaho, Montana, Washington and Wyoming.

The design and sampling protocols for the survey were developed by the WSWCP, which is a team of wildlife biologists and managers including Diane Evans Mack and Rex Sallabanks (Idaho Department of Fish and Game), Bob Inman and Justin Gude (Montana Fish, Wildlife and Parks), Jake Ivan (Colorado Division of Wildlife), Bob Lanka and Zack Walker (Wyoming Game and Fish Department), Jeff Lewis (Washington Department of Fish and Wildlife), Robert Long (Woodland Park Zoo), Paul Lukacs (University of Montana), Scott Jackson and Mike Schwartz (US Forest Service), and Steve Torbit (U.S. Fish and Wildlife Service).

To conduct the wolverine survey in Washington, we were fortunate to work with a number of individuals who were skilled in surveying for carnivores in remote and rugged terrain, which makes up the bulk of wolverine habitat in Washington. This work required snowmobiling, hiking, skiing and snowshoeing to deploy and revisit survey stations, often over great distances, and with large amounts of survey equipment. Many individuals from several agencies and organizations helped to make this survey possible and successful. From the U.S. Forest Service, we thank Phyllis Reed, Jesse Plumage and Sonny Paz from Mount Baker-Snoqualmie National Forest; and Don Youkey, Tim Ross, Matt Marsh, and Monte Kuk from Okanogan-Wenatchee National Forest for their help. From Washington Department of Fish and Wildlife, we thank Paul Debryn, Jeff Heinlen, David Volsen, Nicolle Stephens, Hannah Anderson, and Penny Becker. From Conservation Northwest, we thank Drew Gaylord and Cathy Gaylord. From the National Park Service, we thank Kristine Rine and Jason Ransom from the North Cascades Park Service Complex, and Erin Burke from Mount Rainier National Park.

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Diane Evans Mack prepared a summary report for survey efforts in the Idaho (Evans Mack 2018), which served as a helpful template for this report. Hannah Anderson, Keith Aubry, Taylor Cotton, and Jason Ransom provided helpful comments on an earlier draft of this manuscript, and Derek Stinson created the report cover and provided helpful assistance with manuscript formatting.

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Introduction

The wolverine (*Gulo gulo*) is a mid-sized carnivore and member of the weasel family (Mustelidae). This species has a circumpolar distribution (Copeland and Whitman 2003), and historically occupied most alpine and subalpine habitats in the western United States (Aubry et al. 2007), including the Cascade Range of Washington (Dalquest 1948, Ingles 1965). As with several other native carnivores, the wolverine appears to have been nearly or fully extirpated from the state, as well as most of the contiguous US, by the mid-1900s (Aubry et al. 2007, Schwartz et al. 2007). While the causes for this extirpation are unknown, direct persecution, incidental capture and mortality via predator control campaigns, unregulated trapping, and low densities combined with little or no immigration, likely contributed (see McIntyre 1995, Aubry et al. 2007).

Although wolverines were extirpated from the state, they had recolonized the Cascade Range north of Interstate 90 (I-90) in Washington by the 1990s. Reasons for the wolverine's reestablishment in Washington are poorly understood, but may relate to (1) the cessation of predator control programs by the 1970s, (2) a reduced level of persecution as a result of formal protection from commercial trapping and a 2000 Citizen's Initiative in Washington State that banned the use of body gripping traps by the general public (Initiative 713), and (3) better education about the ecological role of carnivores overall, which may have enhanced acceptance of predators. Little was known about the wolverine population in Washington prior to the initiation of the North Cascades Wolverine Study (Aubry et al. 2016), which provided the first information on the movements, use areas, habitat associations, and baseline demographic characteristics of wolverines in the Pacific Northwest. This study also demonstrated that there is a single population of wolverines that occupies the Cascade Range in Washington and southern British Columbia. Further, limited verifiable detections (e.g., photographs and genetic identifications) of wolverines over the last ~15 years indicate at least an intermittent presence of this species in the southern Cascades (i.e., south of I-90) since the mid-2000s, and a consistent presence since 2010.

Because wolverines occur at low densities and occupy remote mountainous habitats, their presence can be difficult to detect. Hence, changes in wolverine distribution are difficult to monitor without substantial efforts. The proposed listing of the wolverine in the western U.S. under the Endangered Species Act (ESA; USFWS 2010) prompted concern about the impacts of climate change on the persistence and stability of wolverine populations, which are closely associated with persistent spring snow cover (Aubry et al 2007, Copeland et al. 2010, Inman et al. 2013). The proposed listing also prompted the establishment of the Western States Wolverine Conservation Project, the aim of which is to develop measures to conserve this species. One of the Project's first actions was to conduct a regional survey of wolverines in Idaho, Montana, Washington and Wyoming—the only states where resident populations of wolverines were known to occur in the contiguous U.S.

The objectives of the western states wolverine survey were to (1) evaluate the current distribution of wolverines, (2) identify gaps in the distribution, (3) establish a baseline for assessing future changes in distribution, (4) identify factors that affect wolverine occupancy in the western U.S., and 5) generate new insights about the wolverine's status and conservation needs/opportunities at a regional scale. In this report, we describe the survey effort and summarize the results that were obtained for the state of Washington toward meeting objectives 1-3. We also report detections made of other carnivores, and discuss how our results for wolverines and other carnivores can help carnivore biologists design future survey efforts for these species in Washington.

Methods

To identify a sampling area for the survey (Figure 1), we combined a habitat model based on persistent spring snow cover (Copeland et al. 2010) with a model of predicted primary habitat (Inman et al. 2013) to create a single habitat layer (hereafter, "modeled habitat"). We established a sampling grid of 15 km x 15 km cells (225 km^2, which is the mean size of a home range for female wolverines in the Greater Yellowstone Ecosystem; Inman et al. 2012) that encompasses the modeled habitat layer and is limited to cells composed of ≥ 50% modeled habitat (total *n* for all 4 states = 633; *n* for Washington = 93). From the resulting set of cells we used a Generalized Random Tessellation Stratified (GRTS) sampling procedure (Stevens and Olsen 2004) to select a spatially balanced subset of cells (~29%; Figure 1) to survey for wolverines (total *n* = 185; *n* for Washington = 26). Of the 26 cells selected for sampling in Washington, 25 were in the Cascade Range (Figure 1) and these are the focus of this report. The one remaining cell was located in the northeastern corner of the state and was sampled by our project colleagues in Idaho because of its proximity to a number of cells they were sampling in that region (Figure 1). Although the modeled habitat layer indicated the presence of suitable habitat on the Olympic Peninsula, wolverines did not occupy that area historically (Aubry et al. 2007). Consequently, suitable habitat on the Olympic Peninsula was excluded from the sampling frame.

We deployed survey stations within sampling cells based on three rules/factors: (1) each station must be placed within modeled wolverine habitat and, due to the nature of the station design, in an area with trees; (2) where possible, the station should be placed near the center of the survey cell; and, (3) where possible, stations should be placed outside of USFS designated wilderness areas to avoid impacting wilderness. At each sampling station, we deployed a single remote camera (Reconyx PC800 Hyperfire), a bait and/or lure, and hair-snare devices (.30 caliber gun brushes) to collect DNA for genetic analyses. We established two sampling protocols: one for stations deemed accessible by snowmobiles, snowshoes, or skis during the winter survey period (i.e., *accessible stations*), and a second protocol for areas deemed too difficult or impossible to access repeatedly during winter (i.e., *inaccessible stations*).

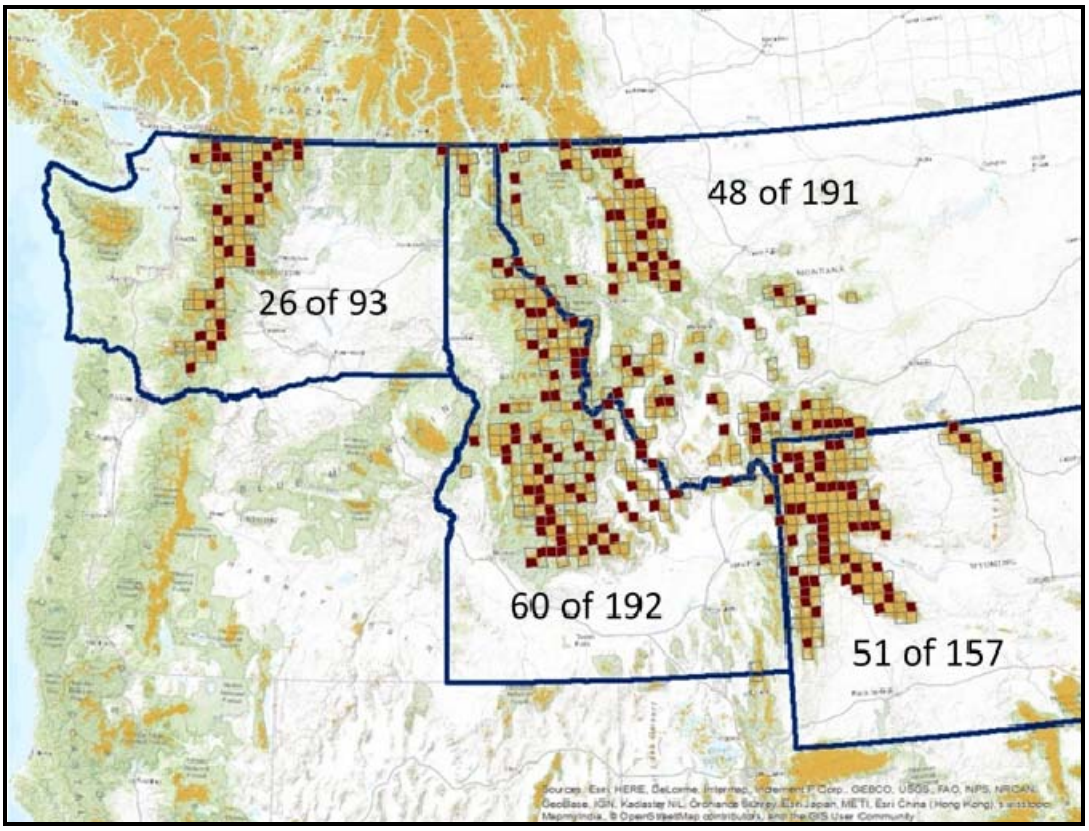

Figure 1. The sampling universe of 633 grid cells that included ≥ 50% modeled wolverine habitat (orange and red cells) and the 185 cells selected for sampling (red cells) across Washington, Idaho, Montana, and Wyoming. In Washington, 25 of the 26 sampling cells were located in the Cascade Range; the remaining cell was located in the northeastern corner of the state.

Accessible survey stations were deployed prior to 1 December 2016 and revisited in each of the next 4 months (on approximately 1 January, 1 February, 1 March, and 1 April of 2017; the station was removed during the April visit). These stations included a single camera, a large meat bait (e.g., deer hind quarter or beaver carcass), wolverine hair snares, lynx hair snares, wolverine lure, and lynx lure (Figure 2). At each accessible station, we attached the camera to a tree located 4-6 m from the bait tree, and aimed the camera to obtain photos of animals that visited the base of the tree or climbed up to the bait. We moved the camera and other survey station components up the bole of the bait tree during each revisit (as necessary) to prevent them from being covered or blocked by snow. During monthly revisits, biologists also replaced the bait and the camera's memory card and batteries, collected gun brushes that contained hair samples, replenished lure, and replaced damaged or missing gear.

The protocol for inaccessible stations differed from that used at accessible stations in four ways: 1) no bait was used; 2) an automated scent dispenser (R. Long, unpublished data) and a cow femur were included; the dispenser was set to drip lure on the femur every other day; 3) survey equipment was installed 2.5-3.7 m above the ground so that it would be above the anticipated snow level at its greatest depth during winter (i.e., so that the camera is not covered/blocked by snow), and 4) the camera was rotated 90° to include the entire target area

from the ground to the dispenser (Figure 2). The dispenser/bone protocol was developed specifically for surveys of wolverines and other species in difficult-to-access regions with deep snow (R. Long, unpublished data). Inaccessible stations were deployed prior to 1 December 2016 (as early as September 2016), but were not revisited until the late-spring or summer of the following year, depending on accessibility.

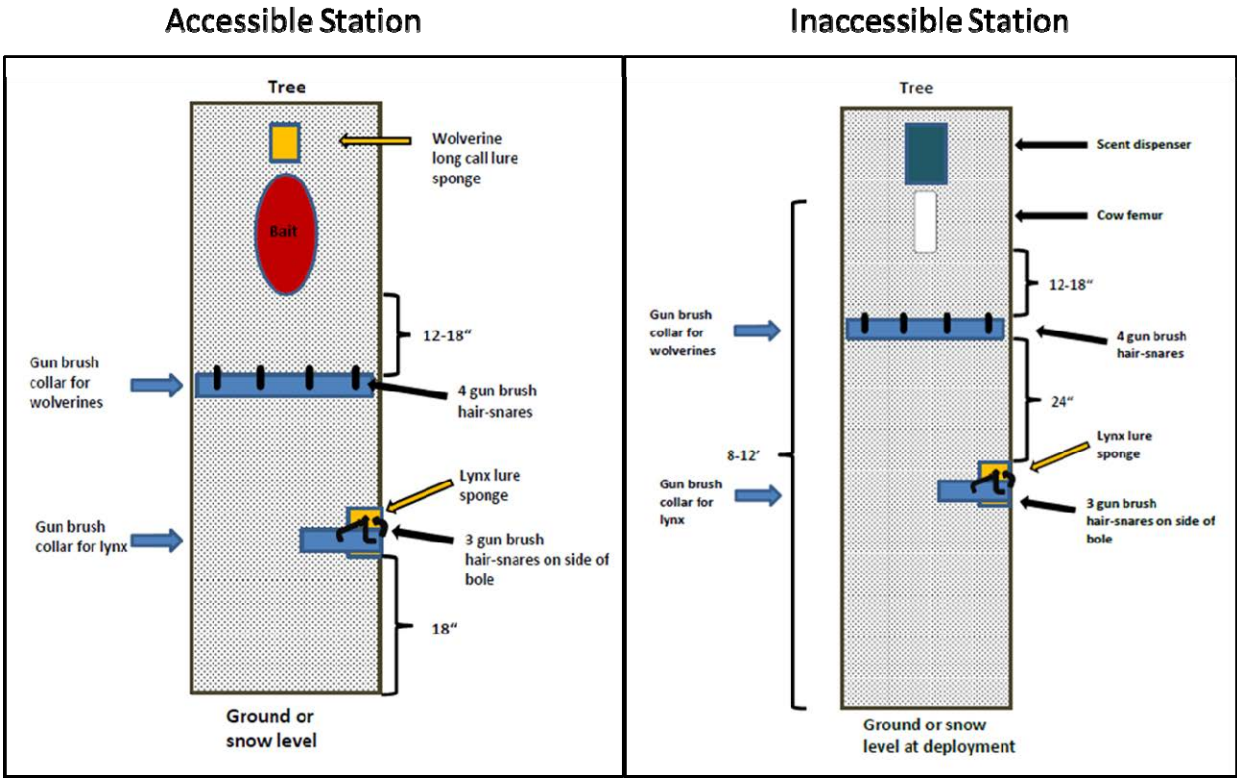

Figure 2. Bait-tree configurations used for attracting and detecting wolverines and lynx at accessible (left) and inaccessible (right) survey stations. The camera at each station is place on a tree approximately 4-6 m away from the bait tree; these graphics illustrate the view from that camera.

Images recorded at each station were numbered, inventoried, and attributed to include information about the species detected, with the latter based on species identification determined by two trained observers. Photo detection data were included in a project-wide occupancy analysis to estimate the probability of occupancy across the 633 grid cells within the Western States survey area, and also within each state (Figure 1). We submitted hair samples from carnivores obtained at survey stations to the National Genomic Center for Wildlife and Fish Conservation (US Forest Service, Missoula, MT) for DNA extraction and analysis. Suspected wolverine samples were analyzed to confirm species, and then to determine the individual's sex, mitochondrial haplotype, and microsatellite genotype, if the DNA was of sufficient quality.

We used detection data collected at survey stations to estimate wolverine occupancy across the Western States survey area and in Washington, specifically. Occupancy modeling allows for

statistical estimates of detectability to adjust raw observation rates of species, resulting in an estimate that can be interpreted as the probability that a given site (or camera station) was used by at least one wolverine during the course of the survey. Based on the parameter estimates, one can also derive the predicted proportion of sites that were used by wolverines during the survey.

Results and Discussion

Wolverine Detections

Survey data were available from 183 of the 185 stations deployed across the 4-states project areas, and wolverines were detected at 59 of the 183 stations (32%); data were unavailable from 1 camera that was stolen in Idaho, and from another camera that burned in a wildfire in Montana. In Washington, data were obtained from all 25 stations deployed in the Cascade Range, resulting in 56,182 digital images and 147 hair and scat samples. Wolverines were detected at 9 of the 25 stations (36%) in Washington (Table 1; Figures 3 and 4); with photographic images obtained at 9 stations and genetic samples collected at 8 of those 9 nine stations (Table 1). Seven of the 9 photographic detections occurred at stations located north of I-90 (*n* = 19) and the remaining 2 were from stations south of I-90 (*n* = 6; Figure 4, Table 1). Wolverines were not detected at the survey station located in the northeast corner of Washington (Figure 1).

Table 1. Detection and survey-station data for wolverines in Washington as part of the Western States Wolverine Survey, winter 2016-2017.

					Genetic Identification				
Sample Cell ID	Site name	National Forest[a]	Photo detection?	Latency to 1st detection	Species	Haplotype	Sex	Individual (genotype)	Minimum # Identified
Accessible Stations									
526	Twisp River	OWNF	Yes	50 days	Yes	Wilson-C	F, M	F39, M40	2
419	Placer	OWNF	Yes	64 days	Yes	Wilson-C	F	F37	1
457	Beverly	OWNF	Yes	95 days	Yes				1
533	Bridge Creek	OWNF	Yes[b]	46 days	Yes	Wilson-C	F, M	F39, M40	2
381	Alder Creek	GPNF	Yes	11 days	Yes	Wilson-C	M	M38	1
502	Perry Creek	MBSNF	Yes	39 days	Yes				1
494	Chiwawa	OWNF	Yes	92 days	No				1
Inaccessible Stations									
515	Company Creek	OWNF	Yes	112 days	Yes	Wilson-C			1
558	Mt. Shuksan South	MBSNF	Yes	81 days	Yes				1

[a]GPNF = Gifford Pinchot National Forest, OWNF = Okanogan-Wenatchee National Forest, and MBSNF = Mt. Baker-Snoqualmie National Forest.

[b]Two wolverines were detected/photographed at the station at the same time.

Figure 3. Examples of wolverine photo detections from the accessible station in cell 419 (left), the inaccessible station in cell 515 (center), and the accessible station in cell 533 (right; where 2 individuals were detected together over a period of 9 hours).

Our results indicate that wolverines use much of the northern portion of Washington's Cascade Range, and that the species is present in the central and southern portions of the Washington Cascades. These results are consistent with recent wolverine research findings from the North Cascades (Aubry et al. 2016; R. Long, unpublished data) and with recent verifiable detections of wolverines in the central (i.e., the region lying between State Route 2 and I-90) and southern portions of the Washington Cascades (i.e., the region south of I-90; A. Woodrow, US Forest Service, unpublished data; J. Akins, Cascades Carnivore Project, unpublished data; D. Werntz, Conservation Northwest, unpublished data).

Occupancy Estimation

Estimated mean occupancy in the 4-state area was 0.42 (95% CI = 0.29–0.55; Table 2; Lukacs et al., in press), which indicates that wolverines were predicted to have used approximately 42% of the cells sampled during the survey period, and by extension, approximately 42% of the project area in the four states during the survey period. In Washington, occupancy was estimated to be 0.43 (95% CI = 0.23–0.67). Based on this finding, we can estimate that 43% of the sampled cells (i.e., 0.43*25 = 10.75 cells) and the 91 available survey cells (i.e., 0.43*91= 39.13 cells) in the Washington Cascades were used during the sampling period (Figure 1). In comparison, occupancy probability was highest in Montana (0.60; 95% CI = 0.44–0.68), similar to Washington's estimate in Idaho (0.46; 95% CI = 0.34–0.59), and lowest in Wyoming (0.15; 95% CI = 0.07–0.26) (Table 2; Lukacs et al. in press).

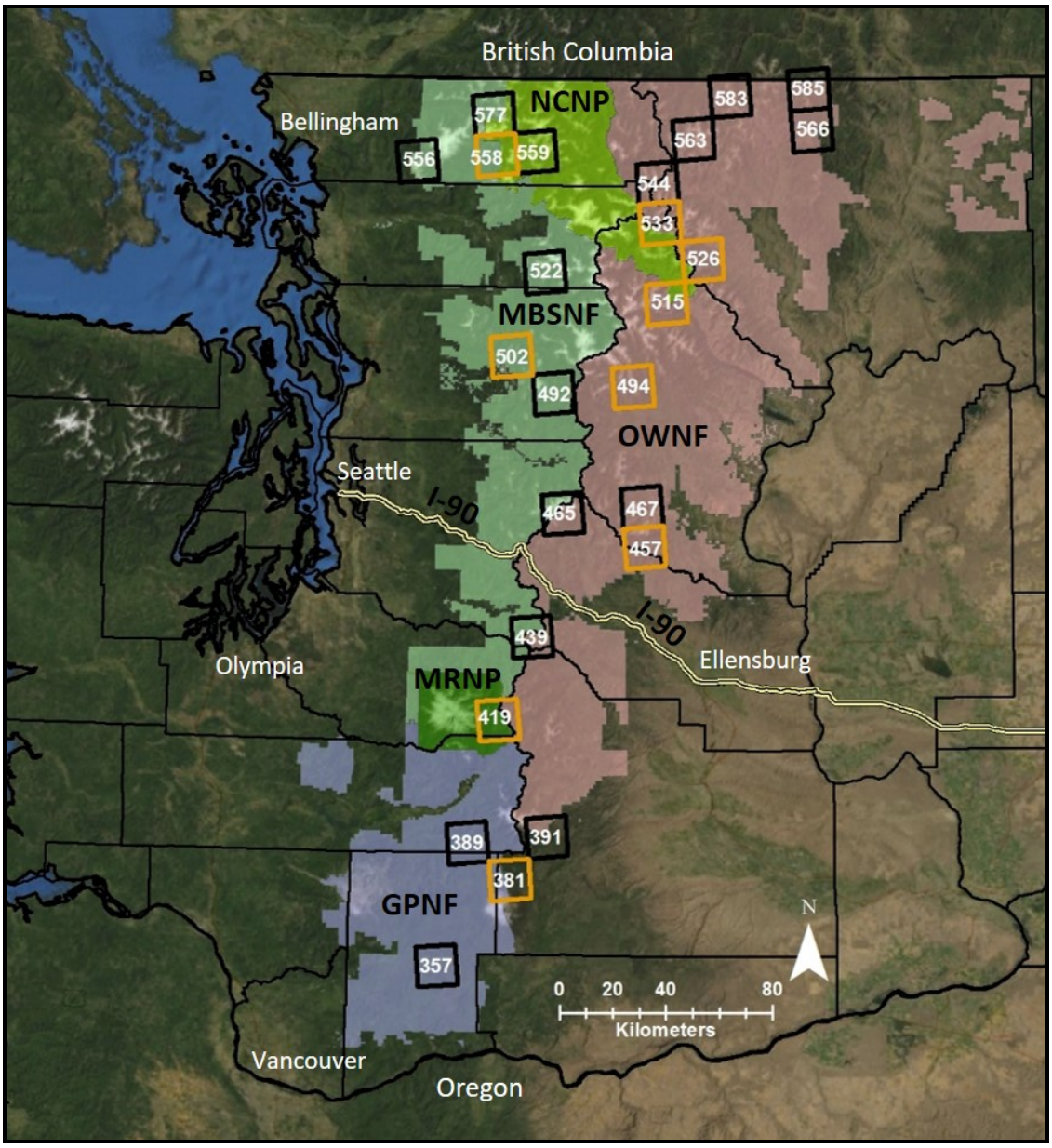

Figure 4. The 25 grid cells that were sampled in the Cascade Range of Washington, winter 2016-2017. Wolverines were detected in each of the grid cells with orange outlines; the numbers in those cells correspond to the detections listed in Table 1. NCNP = North Cascades National Park, MBSNF = Mount Baker-Snoqualmie National Forest, OWNF = Okanogan-Wenatchee National Forest, MRNP = Mount Rainier National Park, GPNF = Gifford Pinchot National Forest, and I-90 = Interstate Highway 90.

Genetic Detections of Wolverines in Washington

The use of hair snares at survey stations, in addition to cameras, enabled us to use DNA to detect a wolverine(s) in the event that a camera malfunctioned or was stolen. In addition, the collection of sufficient, high-quality DNA with hair snares can result in the detection of individual wolverines (via genotyping). With genetic data to identify individuals, we can gain a

better understanding of the genetic characteristics and size of the wolverine population in Washington.

Table 2. Wolverine occupancy model estimates by state.

		Occupied Cells			Occupancy Probability		
State	Cells	Estimate	LCL	UCL	Estimate	LCL	UCL
Idaho	189	87	65	112	0.46	0.34	0.59
Montana	194	117	85	132	0.60	0.44	0.68
Washington	93	40	21	62	0.43	0.23	0.67
Wyoming	157	24	11	41	0.15	0.07	0.26
Total	633	268	182	347	0.42	0.29	0.55

Of the 147 hair (*n* = 145) and scat (*n* = 2) samples collected in Washington during the survey, 127 (84%) were identified to species, including 29 from wolverines. Sex and genotype could be attributed to 10 (34.5%) of the 29 wolverine samples, which resulted in the identification of 4 individual wolverines: a female (F39; cells 526 and 533) and a male (M40; cells 526 and 533) in the North Cascades, and a female (F37; cell 419) and a male (M38; cell 381) in the South Cascades (Table 1, Figure 4). A haplotype could be attributed to 17 of the 29 Washington wolverine samples (58.6%), which were obtained from 5 survey cells and all 17 were identified as haplotype Wilson-C (the only haplotype in modern samples from Washington; McKelvey et al. 2014) (Table 1).

Wolverine Detection Rates in Washington

In Washington, detection rates at accessible stations (7/17 stations; 41%) and inaccessible stations (2/8 stations; 25%) did not differ statistically ($z = 0.78$, $P > 0.11$). Wolverines were detected as soon as 11 days after a survey station was deployed (at accessible cell 381) and as long as 112 days after deployment (at inaccessible cell 515) (Table 1). Mean latency to first detection was 65 ± 32 [SD] days for the 9 stations where wolverines were detected, and was shorter for the 7 accessible stations (57 ± 30 [SD] days) than for the 2 inaccessible stations (97 ± 22 [SD] days) (t = -1.72, p = 0.064) (Table 1). For the 7 accessible stations (where bait and lure were replenished each month), wolverines were first detected between the set-up date (prior to 1 December 2016) and the first visit at 3 stations (in cells 381, 502, and 533); between the first and second visits at 2 stations (cells 419 and 526); and between the second and third visit at 2 stations (cells 457 and 494). No wolverines were detected for the first time after the biologist's third visit to a station (i.e., between the 3rd visit and the 4th [last] visit).

Wolverines were detected genetically at 8 of the 9 stations (89%) where they were detected photographically, and they were detected both genetically and photographically at 2 inaccessible stations. While wolverines were genetically identified to species in 8 of the 9 cells where they were detected, only 4 individuals could be identified to sex and individual (Table 1).

Wolverines were more readily identified to individual at accessible stations (4/7) than at inaccessible stations (0/2) *(z* = 3.54, *P* < 0.001). The relatively low number of individuals identified genetically may be the result of DNA degradation over time from the generally wet conditions in the Washington survey area. Indeed, such degradation was likely worse at inaccessible stations, where there was a longer delay between hair deposition and collection. In the drier climates of Idaho and Montana, a greater number of individual wolverines (12 in ID, 23 in MT) were identified genetically.

Other Carnivore Detections in Washington

We detected a total of 11 carnivore species at 25 survey stations, including the wolverine, Canada lynx (*Lynx canadensis*), Cascade red fox (*Vulpes vulpes cascadensis*), fisher (*Pekania pennanti*), Pacific marten (*Martes caurina*), coyote (*Canis latrans*), gray wolf (*Canis lupus*), bobcat (*Lynx rufus*), mountain lion (*Puma concolor*), black bear (*Ursus americanus*) and badger (*Taxidea taxus*) (Table 3; Appendix 1). Pacific martens were the most commonly detected carnivore (at 76% of stations), followed by coyotes (56%), wolverines and bobcats (36%), black bears (32%) and Cascade red foxes (20%). Lynx were detected at only two stations (8%), and fishers, badgers and gray wolves were each detected at only a single station (4%) (Table 2). The mean number of carnivore species detected was 3.25 ± 0.45 (range: 1-5) for inaccessible stations and 2.82 ± 0.23 (range: 1-5) for accessible stations; these means were not statistically different (*t* = -0.94, *P* = 0.36) (Table 3). These findings indicate that the survey protocols used at both accessible and inaccessible cells were effective at detecting multiple carnivore species.

Accessible stations produced more genetic detections of wolverines, and a greater ratio of genetic to photographic detections (28 genetic to 48 photographic; 58.3%) than inaccessible stations (5 genetic to 26 photographic; 19.2%) (*z* = 3.23; *P* < 0.001) (Table 3). One explanation for this may be that individuals spent more time feeding on a meat bait at accessible stations, which increases the likelihood of hair deposition on snagging devices and higher likelihood of obtaining high-quality DNA for species or individual identification. The lower proportion of genetic detections for martens, bobcats, and black bears at inaccessible stations is likely an indicator of this effect (Table 2). Alternatively, hair samples may remain wet, or be subject to freeze-thaw cycles, for many months at inaccessible stations prior to collection, resulting in the degradation of some or all of the DNA present, and potentially preventing genetic identification of species or individuals. Likelihood of collecting usable DNA is an important consideration for biologists as they evaluate protocols for effectively and efficiently detecting species (where DNA is generally not required) and/or individuals (where DNA is often required).

Table 3. Survey cells where wolverines and other carnivores were detected photographically (as indicated by a "P") and/or genetically ("G") in Washington during the Western States Wolverine Survey, winter 2016-2017. Note: no genetic detection of a species occurred in the absence of a photo detection.

Sample Cell ID	Site name	wolverine	lynx	red fox	fisher	marten	coyote	gray wolf	bobcat	mt. lion	black bear	badger	Species detected
Accessible Stations (n = 17)													
526	Twisp River	**P, G**				**P, G**			**P, G**				3
357	Indian Heaven			**P**	**P, G**	**P, G**							3
577	Goat Mtn					**P, G**			**P, G**		**P, G**		3
389	Elk Peak			**P**		**P, G**	**P**						3
419	Placer	**P, G**		**P**		**P, G**	**P**						4
457	Beverly	**P, G**				**P, G**			**P, G**				3
566	Corral Butte						**P**				**P, G**		2
533	Bridge Creek	**P, G**				**P, G**							2
381	Alder Creek	**P, G**		**P**		**P, G**							3
467	Mountaineer Creek					**P, G**							1
439	Blowout					**P, G**	**P**						2
465	Pete					**P, G**			**P, G**	**P**			3
556	Twin Sisters						**P**		**P**		**P**		3
544	Hart's Pass					**P, G**	**P**						2
502	Perry Creek	**P, G**				**P**	**P**		**P**		**P**		5
391	Tieton			**P, G**		**P, G**							2
494	Chiwawa	**P**				**P, G**	**P**		**P**				4
	total	7/17 (41%)	0/17 (0%)	5/17 (29%)	1/17 (6%)	13/17 (76%)	8/17 (47%)	0/17 (0%)	7/17 (41%)	1/17 (6%)	4/17 (24%)	0/17 (0%)	$\bar{x}$ = 2.82
Inaccessible Stations (n = 8)													
522	Tenas Creek					**P, G**	**P**						2
563	Middle Fork Pasayten		**P**				**P, G**			**P**	**P**		4
492	Jack's Pass					**P, G**	**P**		**P**		**P**		4
559	Trapper Peak					**P**							1
585	Windy Peak		**P**				**P**			**P**	**P**		4
515	Company Creek	**P, G**				**P**		**P**	**P**		**P**		5
558	Mt Shuksan South	**P, G**				**P**	**P**						3
583	Ashnola Mtn					**P**	**P**					**P**	3
	total	2/8 (25%)	2/8 (25%)	0/8 (0%)	0/8 (0%)	6/8 (75%)	6/8 (75%)	1/8 (13%)	2/8 (25%)	2/8 (25%)	4/8 (50%)	1/8 (13%)	$\bar{x}$ = 3.25
	Species grand mean												$\bar{x}$ = 2.96
	Genetic grand total	**8/25 (32%)**	**0/25 (0%)**	**1/25 (4%)**	**1/25 (4%)**	**14/25 (56%)**	**1/25 (4%)**	**0/25 (0%)**	**4/25 (16%)**	**0/25 (0%)**	**2/25 (8%)**	**0/25 (0%)**	
	Photo grand total	**9/25 (36%)**	**2/25 (8%)**	**5/25 (20%)**	**1/25 (4%)**	**19/25 (76%)**	**14/25 (56%)**	**1/25 (4%)**	**9/25 (36%)**	**3/25 (12%)**	**8/25 (32%)**	**1/25 (4%)**	

Several noteworthy observations were obtained during the course of our survey. We detected coyotes at 56% of our survey stations, which we expected to be good habitat for wolverines, but suboptimal habitat for coyotes. Given the recent translocation of fishers to the southern Cascades of Washington, and the subsequent telemetry-based monitoring of released individuals (Lewis et al. 2018), fishers were likely also present in the five southernmost survey cells. Like the coyote, however, our survey area probably represents suboptimal habitat for the fisher, which was only detected in the southernmost survey cell (cell 357). In contrast, we predicted that good habitat for wolverines would also represent good habitat for montane red foxes (McKelvey et al. 2014). As expected, our surveys detected Cascade red foxes, but only in the five southernmost survey cells. This suggests that Cascade foxes are much less common, or possibly absent, in large portions of their historical range in the North Cascades (Aubry 1983, 1984; Akins 2017; Akins et al. 2018).

In Washington, the current distribution of the Canada lynx overlaps with wolverines in the subalpine forest habitats in the northern/northeastern portion of the sampling area. Because the Canada lynx is a species of conservation concern in Washington, and because it currently occupies a small portion of its historical range in the state (Lewis 2016), we made specific modifications to survey stations to attract and detect lynx across the northern portion of the Cascades. Our objective was to use new lynx detection data to inform ongoing conservation efforts for lynx in this area. Our inclusion of a lynx-lure sponge at each station was intended to attract lynx, but despite numerous station visits by bobcats, and several by lynx and mountain lions, these lure sponges (and associated hair-snares) did not elicit rubbing responses from these felids. Lynx-lure sponges were, however, of considerable interest to visiting wolverines, which extensively rolled-on and played with these sponges. Given the apparent attraction of wolverines to the lynx-lure sponge and the finding that at least one wolverine was genetically detected from hair left on a lynx hair snare (at station 419), it appears that this lure provides added incentive for wolverines to loiter at survey stations, making them more detectable by this type of hair snaring device.

Although gray wolves and mountain lions occurred in many of the areas where our survey was conducted (WDFW, unpubl. data), only a single gray wolf was detected in 1 cell (cell 515), and mountain lions were detected in only 3 cells (Table 3). These findings suggest that the survey protocols we used during this survey may be suboptimal for detecting gray wolves and mountain lions.

Despite the relatively short period of survey time available for black bears to visit most accessible stations following their emergence from dens, black bears were readily detected at survey stations.

The detection of a badger in cell 583 confirms the species does occur in the transboundary (Canada/United States) portion of the northern Cascade Range. If more badgers do occur in this

region, Washington could provide demographic support to the endangered badger population in southern British Columbia.

Conclusions from Washington

The survey provided a current assessment of wolverine distribution in Washington, which is valuable as a baseline for future assessments of distribution and occupancy, especially during a period when climate change is expected to significantly alter environmental conditions in Washington.

Our results demonstrate that the survey methods we employed were effective at detecting wolverines (and 10 other carnivore species) when deployed over 4-9 months, during 2-3 seasons, and in many types of weather. Wolverines were detected both photographically and genetically at both accessible and inaccessible stations, and wolverine detection rates were comparable between these two station types. Genotyping of individual wolverines was only possible for wolverines that visited accessible stations, suggesting that the survey methods and protocols for inaccessible stations did not provide sufficient amounts of high-quality DNA for individual identifications.

Wolverines were detected throughout much of the length of the Cascade Range, from the British Columbia border south to Mount Adams. A greater number of wolverine detections occurred north of the I-90 corridor than south of it (Figure 4); however, larger amounts of suitable wolverine habitat exists north of this corridor (Copeland et al. 2010). Our detections of at least 2 wolverines and other recent detections south of the I-90 corridor (J. Akins, unpublished data), indicate that wolverines appear to have an ongoing presence in this area despite (1) the relatively small amount and linear (N-S) distribution of suitable habitat, and (2) the potential lack of habitat connectivity between the North and South Cascades resulting from the restriction of wolverine movements by the I-90 corridor.

The occupancy estimate of 43% for the survey area in Washington indicates that nearly half of the suitable habitat available in Washington was used by wolverines during the survey. Given the substantial amount of suitable habitat in the Washington Cascades, this finding suggests that the wolverine population is sufficiently large and widely distributed to be unlikely to suffer extirpation in the immediate future. Give the limitations of our data, we cannot provide reliable projections for population persistence over longer time periods.

Along with wolverines, our surveys detected 10 other carnivore species, including a number of state and federally listed and candidate species (i.e., Canada lynx, fisher, gray wolf, Cascade red fox). The survey was particularly effective at detecting the Pacific marten, coyote, black bear, bobcat, and Cascade red fox. Detection data for these species are valuable for other assessments or conservation actions. Unlike our findings for wolverines, Pacific martens,

bobcats, and black bears were detected genetically at accessible stations much more frequently than at inaccessible stations. This finding suggests that the lack of bait at inaccessible stations does not facilitate sufficient hair deposition by these species with the methods we employed, and/or that the delay in recovering deposited hair at inaccessible stations results in DNA degradation.

The use of the scent dispenser protocol at inaccessible stations appeared to provide a valuable alternative to a station baited with meat, enabling successful camera-based detections despite carnivores spending less time investigating a station with no bait. The dispenser protocol provides continual attraction to inaccessible stations throughout the duration of the survey, making them an effective alternative to accessible stations, which were much more labor-intensive and, therefore, more costly to deploy. Given the relatively small number of wolverines that were identified to individual via DNA methods in Washington during the survey (n = 4), the trade-off of using only inaccessible stations for future surveys is relatively small. However, a hair-snare device that better preserves the DNA of hair deposited at inaccessible stations could significantly reduce this current trade-off.

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Appendix 1. Ten additional carnivore species detected during the wolverine survey in Washington, winter 2016-2017.


Mountain Lion
Fisher
Badger
Gray Wolf