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A Survey of Forest Carnivores in Mount Rainier National Park, Washington

National Park Service,
North Coast and Cascades Network

Natural Resource Technical Report NPS/NCCN/NRTR—2010/412

ON THE COVER

Cascade red fox and American marten photographed by remote camera, Mount Rainier National Park, Washington. Photograph courtesy of Mount Rainier National Park.

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Executive Summary

As part of the NPS Servicewide Vertebrate and Vascular Plant Inventory, we used remotely-triggered cameras to inventory forest carnivores in Mount Rainier National Park during the winters of 2000-2001 and 2001-2002. Using standardized protocols, we sampled 20 4-mi^2 blocks: 11 blocks in 2000-2001 and 9 blocks in 2001-2002. We obtained 1313 photographs of 13 mammal and 5 bird species. We identified 7 species of forest carnivores: American marten, spotted skunk, coyote, short-tailed weasel, bobcat, black bear, and red fox. We recorded two additional species (Virginia opossum and cougar) in preliminary test efforts that were not detected during protocol surveys. American marten were the most common species recorded, found in 70% of the sample blocks and representing 52.6% of the total animal photos collected. Neither lynx nor fisher was recorded.

Acknowledgments

This report is the culmination of the work of a series of wildlife ecologists at MORA. Jim Petterson (2000-2002) performed all the planning and data collection with the assistance of Eva Patton and Brad Buckley. Jim Schaberl (2002-2008) performed the data compilation and summaries, and Mason Reid (2008-present) prepared this report based on their efforts.

Introduction

In 2000, the National Park Service Natural Resource Challenge initiated a vertebrate and vascular plant inventory program to document at least 90% of the species expected to occur in parks with significant natural resources. In the North Coast and Cascades Network, Mount Rainier National Park (MORA), Olympic National Park, and North Cascades National Park Service Complex natural resource managers identified forest carnivores as a high priority taxa in need of basic information (NCCN 2001).

This taxonomic group was ranked a high priority for several reasons outlined in Happe *et al.* (2005) and Christofersen and Kuntz (2005). Firstly, little information on forest carnivores exists for parks in the network, primarily due to the difficulty of collecting information in rugged and remote wilderness areas. The recent development of new techniques has greatly improved the ability to effectively assess carnivores in remote areas (Aubry 1997, Zielinski and Kucera 1995). In addition, these methods can be used for more than one species at a time. These survey protocols have wide acceptance region wide, and have been employed by multiple land management agencies.

Furthermore, several forest carnivore species are listed on either federal or state endangered species lists (Federal: lynx (*Lynx canadensis*), wolf (*Canis lupus*), grizzly bear (*Ursus arctos*)). State: fisher (*Martes pennanti*); have recently been petitioned for listing (wolverine (*Gulo gulo*)); are soon to be proposed for listing (Federal: fisher, coastal marten (*Martes americana caurina*); or are of special management concern (cougar (*Felis concolor*)). Many species of forest carnivores experience numerous threats that have caused concern about their status (habitat loss, isolation of any remnant populations in protected areas such as national parks, long standing effects of historic harvest pressure, and loss of major food sources) (Ruggiero *et al.* 1994). Most recently, wildlife biologists from state and federal agencies in Oregon and Washington met and formed the *ad hoc* Pacific Northwest Forest Carnivore Group. The group's goal is to work together across jurisdictional boundaries to gather more information on these key taxa. Better quality data on forest carnivore presence and distribution within the parks in the region is a key piece in that effort.

Our primary objective was to gain information on species presence, specifically to document 90% of the species expected to occur within the park. For most of the three parks, some forest carnivore species have not been documented for over 40 years, and several are suspected to be extirpated (fisher in MORA, NOCA, and OLYM, wolverine in NOCA, MORA, wolf in OLYM, MORA, and Canada lynx in MORA). The secondary objective was to gain insight on species' distribution patterns across broad geographic, elevation and precipitation gradients. To obtain these objectives, each of the three parks surveyed for forest carnivores for two successive winters. MORA was the first park, and collected information during the winters of 2001 and 2002. This report summarizes those findings.

Study Area

Mount Rainier National Park is located in the Cascade Range of southcentral Washington, just over an hour's drive from the metropolitan areas of Tacoma and Seattle to the west (Figure 1).

MORA occupies 94,750 ha (235,625 ac) and encompasses a 3,900 m (12,600 ft) elevation gradient, culminating in Mt. Rainier at 4393m (14,411 feet), the second highest peak in the continental United States. The park consists of four main elevational forest zones (Franklin et al. 1988, Moir et al. 1977). The lowest zone (below 750 m (2461 ft)) is composed of Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterphylla*), western red cedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*; found only in the Carbon River drainage) and grand fir (*Abies grandis*). Mid-level forests occur between 750 and 1,450 m (2461 to 4757 ft), and are dominated by Pacific silver fir, Douglas-fir, western hemlock, western red cedar, and noble fir (*Abies procera*). From 1,600 m to approximately 1,450 m (4757 ft), forest stands are composed primarily of subalpine fir *(Abies lasiocarpa*), mountain hemlock (*Tsuga mertensiana*), Alaska-yellow cedar (*Chamaecyparis nootkatensis*), and Pacific silver fir (*Abies amabilis*). Subalpine parklands occur above 1,600 m (5250 ft) and are dominated by subalpine fir.

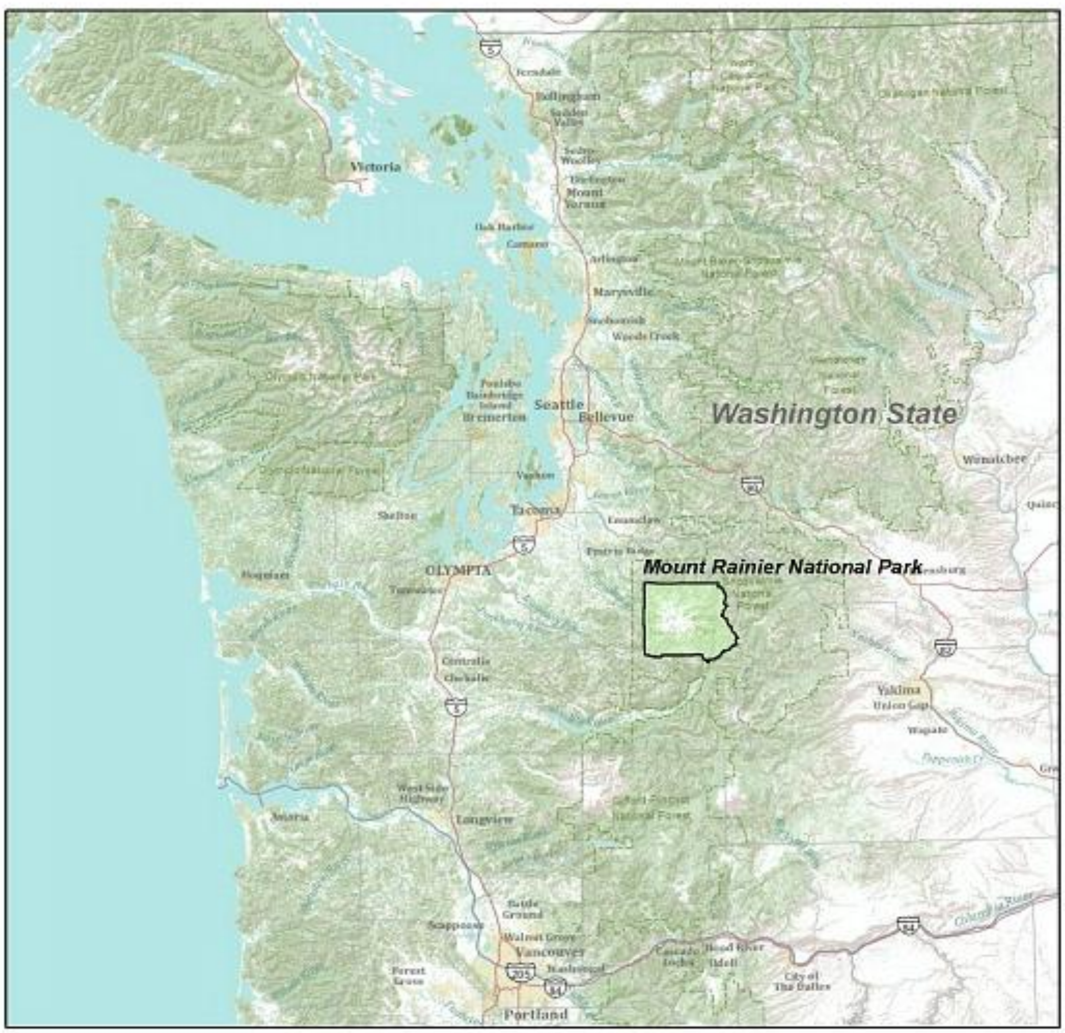

Figure 1. Mount Rainier National Park, Washington.

Study sites were located throughout the park, representing the five major river drainages: Nisqually, Cowlitz, White, Carbon and Mowich. Elevations for the sites ranged from 606 m (2000 ft) near the Carbon River to 1755 m (5790 ft) near Glacier Basin on the White River (Appendix A).

Methods

Methodology followed procedures outlined in Aubrey (1997) and Zielinski and Kucera (1995), and were the same as used in Olympic and North Cascades national parks (see Appendix C). The goal was to accurately reflect the diversity of forest carnivores throughout the park, and so efforts were made to sample both representative habitats as well as the geographic diversity of the park.

Site Selection

Using GIS, the park was divided into 4 mi^2 grids ("blocks") divided into 4-1 mi^2 "sub-blocks". Areas above treeline were automatically excluded. Half of the sample units were selected randomly to provide unbiased sample areas. The remaining units were selected with emphasis for areas of historical unconfirmed sightings and current data on prey species. Also sample units were selected with criteria for respective forest carnivore habitat preferences. In the case of fisher, we selected lower elevation mature to late-successional coniferous forest with dense canopies and medium-to-high levels of snags and downed forest debris of large diameter. For lynx we selected areas at higher elevations without extremely steep slopes. Within each sample unit two points were randomly selected, spaced more than one mile apart. Some points were relocated if they fell on or within 100 feet of a road or trail or were on extremely steep slopes or otherwise inaccessible by crew members.

According to protocol, two bait-camera stations ("sub-blocks") were located in each selected grid. These were set up in selected areas with remotely-triggered cameras to detect forest carnivores. The Trailmaster T550 infrared monitor systems were used with both Yashica and Olympus 35mm film cameras loaded with Kodak Ektachrome ASA/ISO 400 slide film. Each station was baited with either a commercial plucked chicken or a whole dead chicken. The chickens were placed in a chicken wire pouch and wired closed to prevent any single animal from easily consuming the complete chicken. In recurrent visits more chicken was added if the existing bait was extremely rotten, dried or consumed. Also mustelids are known to be attracted to fish so a can of tuna was nailed to the bait tree near the chicken on nearly every visit.

Stations were scented to attract forest carnivores to the general vicinity of the station. The animal would then be close enough to detect the less pungent bait, in turn triggering the camera. To attract mustelids, skunk scent and marten lure was applied to a branch within 75 feet of the station. To bring in lynx we set up a scratch pad station complete with pie tin and castoreum and catnip as described in the protocol (Appendix C). Also a few drops of cat lure were applied to a branch in the general vicinity.

Habitat Sampling

We used a 50 m radius circular plot, with the bait tree as the center point, to broadly characterize the vegetation composition and structure of the forest stand at each camera station. We did not measure each individual tree or downed log in the plot, but rather measured a few to describe the overall condition of the stand by categorizing the desired components into various size classes (see Appendix C). Variables collected included average diameter at breast height (dbh) of live trees, average spacing between trees, percent of dead trees, average dbh of dead trees, category of fuel load from dead and downed woody debris, average dbh of dead and downed woody debris, percent canopy closure and the three most common tree species in the canopy. A crown densitometer was used to measure canopy cover at five points: the plot center and points on the circle perimeter 50 m from center in the four cardinal directions. The five recorded values were then averaged and applied to the appropriate percent canopy closure category listed on the field form. Topographic variables included slope, aspect, topographic position of the camera station relevant to the overall slope and distance to water.

Results and Discussion

In 2007, NCCN contracted Martin Brown (Synthesis Research and Analysis, Portland, Oregon) to summarize the results of the surveys. This report is included as Appendix F. Additional tables of results are included here to allow simpler comparisons with OLYM and NOCA surveys.

Twenty 4 mi^2 blocks were sampled throughout the park (Figure 2). A total of 1913 photos were taken, detecting eighteen species in 20 sample blocks (Table 1). Six species of forest carnivores and black bear were detected: American marten; western spotted skunk (*Spilogale gracilis)*: coyote (*Canis latrans*); long-tailed weasel (*Mustela frenata)*; bobcat (*Lynx rufus*); American black bear; and red fox (*Vulpes vulpes*) (Table 2). Neither lynx nor fisher was detected.

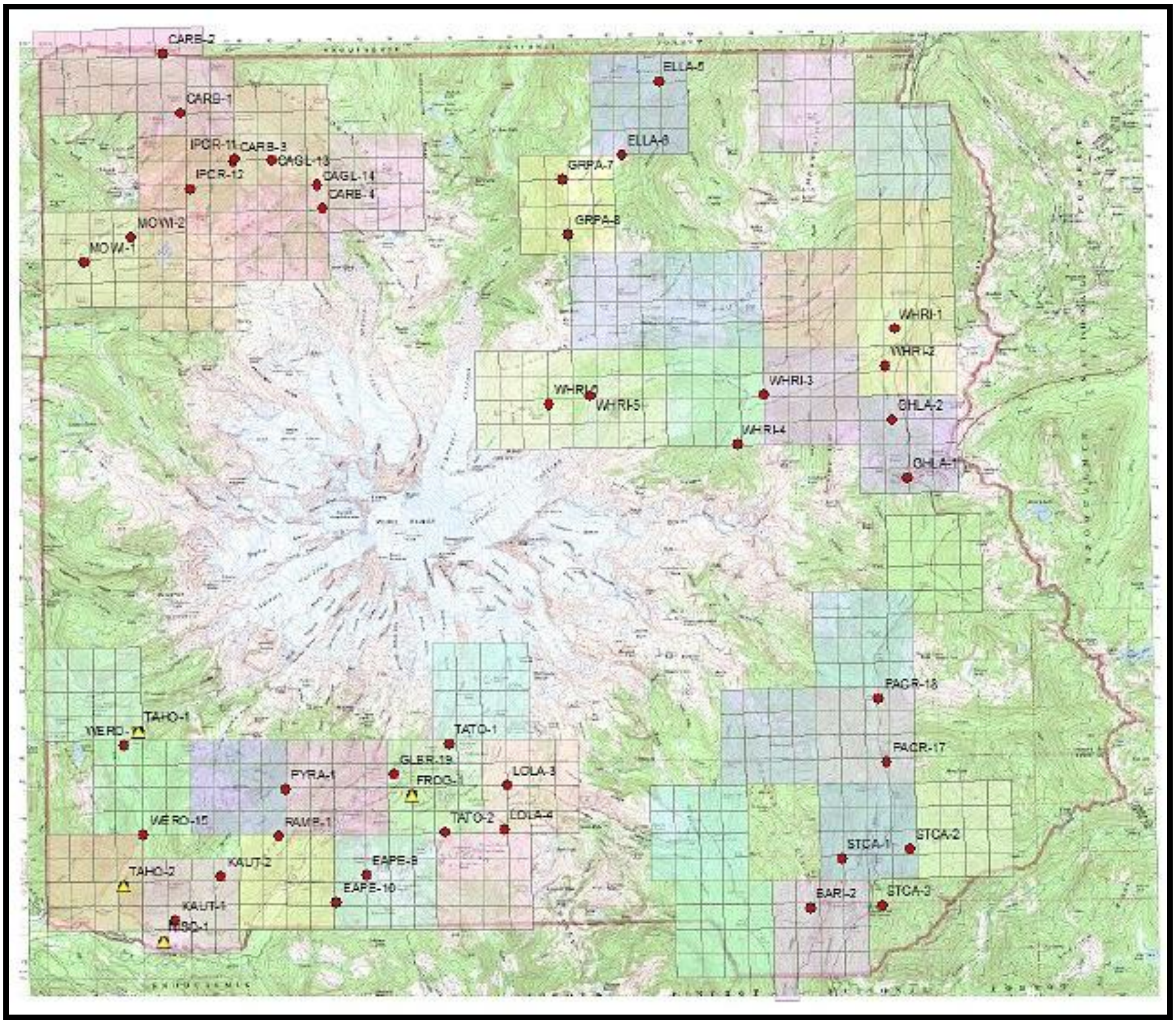

Figure 2. Four-mile^2 sampling blocks and remote camera sites, Mount Rainier National Park. Test stations are denoted in yellow.

Test stations were set up at four additional locations (Frog Heaven, Glacier Bridge, Tahoma, and Nisqually) and detected two additional carnivores—cougar (*Felis concolor*) and the non-native Virginia opossum (*Didelphis virginiana*).

Non-target species detected included snowshoe hare (*Lepus americanus)*, Douglas' squirrel (*Tamiasciurus douglasi*), northern flying squirrel (*Glaucomys sabrinus*), Townsend's chipmunk (*Tamias townsendii*), deer mouse (*Peromyscus maniculatus*), elk (*Cervus elaphus*), golden eagle (*Aquila chrysaetos*), gray jay (*Perisoreus Canadensis*), Steller's jay (*Cyanocitta stelleri*), common raven (*Corvus corax)*, and varied thrush (*Ixoreus naevius*).

Table 1. Counts of pictures taken, frequency of detections and number of total species and carnivore species detected in MORA, 2001- 2002.

Year of Survey	**2001**	**2002**	**Total**
Number of Sample Blocks	11	9	20
Average number of days surveyed per site	45.1	43.1	44.1
Number of Pictures (excludes test photos)			1913
Number of Animal Pictures	743	570	1313
Number of No Animal Pictures (includes unknowns)			600
% Animal Pictures			69
Frequency of Species Detections[1] mean (range)	4.6 (1-9)	3.7 (2-6)	4.2
Frequency of Carnivore Detections[2] mean (range)	2.1 (0-4)	2.1 (1-3)	2.1
Total Number of Species Detected	18	11	18
Number of Forest Carnivores Detected	7	6	7[3]

[1]Mean number of animal species detected summed across blocks (species that had multiple pictures in a block were counted only once).
[2]Mean number of carnivore species detected in each block summed across blocks (species that had multiple pictures in a block were counted only once).
[3]Test sites, not included in analysis, detected two additional carnivores, cougar and the non-native opossum.

A summary of species detected at each site (excluding test sites) is included in "Exhibits page 4" in Appendix F. Blocks detected from 0-4 forest carnivores, averaged 2.1 carnivore detections per block (Table 1), and remained constant between years.

American marten was the most common carnivore and most common species detected. Marten were found throughout the park with the exception of the southeast corner around Ohanapecosh. Martens were detected at 70% (14 of 20) of the sample blocks, and represented 53% (n=691) of all photos taken. Maps of detections of all carnivores are included in Appendix B.

Bobcats were the second most common carnivore detected, and were photographed in 40% (8 of 20) sample blocks. They were found throughout the lower elevation sites in the park. Red fox and spotted skunk were each detected in 30% (6 of 20) of the sample blocks. Five stations around the Paradise area detected red fox. They were not detected along the western and southeastern sections of the park. Considering the current and historical food conditioning these foxes have exhibited, this is an expected result.

Coyote were detected along the southern and eastern portions of the park, but at only 6 sites, representing 5 sampling blocks. Both black bear and long-tailed weasel were detected at 2 sites: black bear at the southeast and southwest corners, and long-tailed weasel in the eastern and northwest sections of the park. The black bear detections occurred on 15 and 19 April 2001, suggesting they were leaving the den rather than active through the winter.

Carnivores showed trends in elevational distribution (Figure 3). American marten and red fox were detected at significantly higher elevations than the mean site elevation for all samples (2-tailed t-test, p<0.05), and bobcat and spotted skunk were detected at significantly lower elevations than the mean (2-tailed t-test, p<<0.05).

Table 2. Animal species detected and percent of sample blocks and sub-blocks where species were detected using remotely triggered cameras, MORA 2001-2002.

Species	Total Photos	Sample blocks (n=20)		Sample sub-blocks (n=41)	
	No.	No.	%	No.	%
Forest Carnivores					
American marten	691	14	70.0	22	53.7
Spotted skunk	157	6	30.0	7	17.1
Coyote	7	5	25.0	5	12.2
Red fox	82	6	30.0	7	17.1
Long-tailed weasel	2	2	10.0	2	4.9
Short-tailed weasel	0	0	0.0	0	0.0
Bobcat	77	8	40.0	10	24.4
American black bear	8	2	10.0	2	4.9
Virginia opossum*	15	1	NA	1	NA
Cougar*	2	1	NA	2	NA
Misc. Mammals					
Douglas squirrel	17	5	25.0	6	14.6
Deer mouse	110	6	30.0	6	14.6
Northern flying squirrel	8	3	15.0	3	7.7
Townsend's chipmunk	1	1	5.0	1	2.4
Snowshoe hare	9	6	30.0	7	17.1
Elk	1	1	5.0	1	2.4
Birds					
Steller's jay	5	4	20.0	4	9.8
Gray jay	44	8	40.0	9	22.0
Common raven	83	5	25.0	4	9.8
Golden eagle	4	1	5.0	1	2.4
* Test sites, not included in analysis.					

Cougar were recorded only on the test sites and not on the protocol sites even though protocol sites surrounded the test sites. Cougar have been confirmed in the park on numerous occasions, primarily along the West Side Road, near where it was documented in this survey, and in the Mowich Lake area. Both areas were sampled with protocol stations, however cougar were not recorded.

The Virginia opossum was recorded at a single test site near the Nisqually River. This site is a relatively low-elevation site that represents one of the sites closest to a nearby community, Ashford, a small town of approximately 300 people. Although raccoons (*Procyon lotor*) are commonly observed in the NPS residential and administrative area of Longmire, they were not recorded.

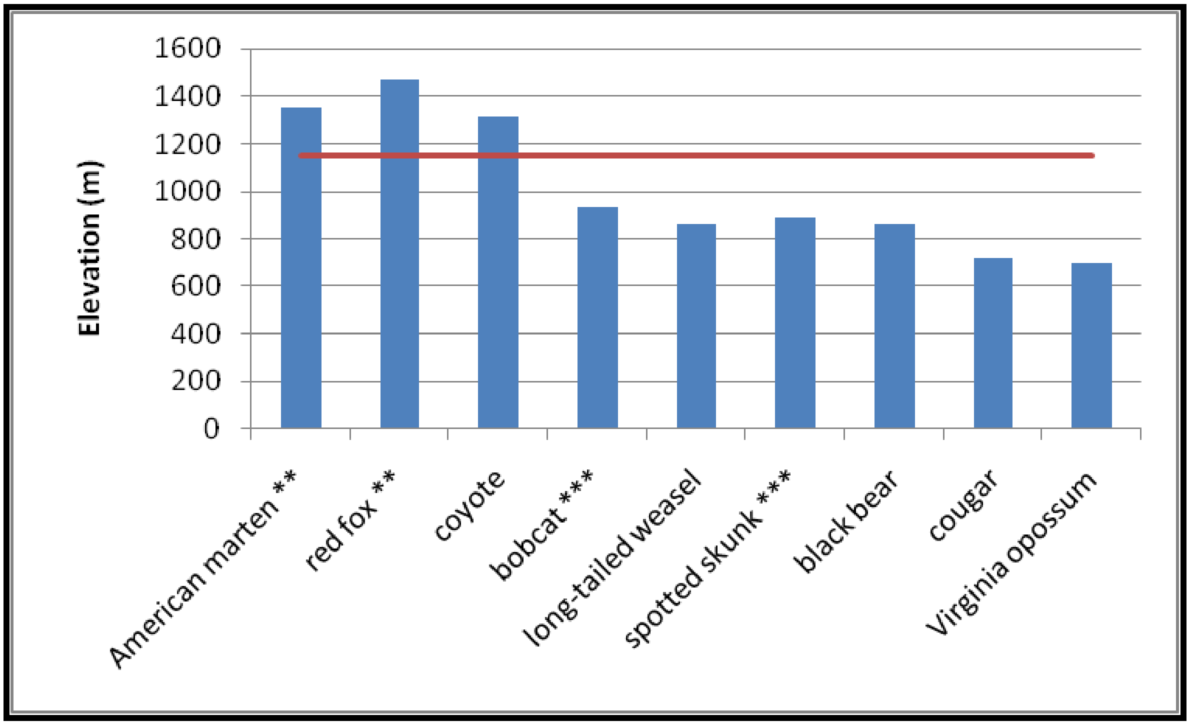

Figure 3. Mean elevation of sites where species were detected. Line represents mean elevation of sample sites. Cougar and Virginia opossum were detected at test sites only. ** denotes p<0.05, *** denotes p<0.005.

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Appendix A. Sampling stations.

Table A-1. Sampling stations used to detect forest carnivores, Mount Rainier National Park, 2000-2002. (UTM Zone 10, NAD 83)

Station ID	Sample Unit ID	Station Code	Station Name	UTME	UTMN	Elevation	Date Installed	Date Removed	Days Out
1	1	TAHO-1*	TAHOMA UPPER	585700	5182950	nr	28-Nov-00	05-Mar-01	97
2	1	TAHO-2*	TAHOMA LOWER	585222	5177852	nr	29-Nov-00	05-Mar-01	96
3	2	FROG-1*	FROG HEAVEN	594786	5180854	nr	28-Nov-00	01-Mar-01	93
4	3	NISQ-1*	NISQUALLY	586515	5175992	nr	29-Nov-00	08-Mar-01	99
5	4	KAUT-1	KAUTZ LOWER	586923	5176685	2600	08-Mar-01	21-Apr-01	43
6	4	KAUT-2	KAUTZ UPPER	588425	5178179	2650	09-Mar-01	12-Apr-01	33
7	5	RAMP-1	RAMPART RIDGE	590360	5179480	3700	10-Mar-01	12-Apr-01	32
8	6	PYRA-1	PYRAMID CREEK	590586	5181024	3650	10-Mar-01	12-Apr-01	32
9	7	CARB-1	CARBON GREEN LAKE	587076	5203511	3300	13-Mar-01	08-May-01	55
10	7	CARB-2	CARBON RIVER	586488	5205480	2075	13-Mar-01	08-May-01	55
11	7	CARB-3	CARBON IPSUT	588851	5201922	3000	14-Mar-01	21-Mar-01	7
12	7	CARB-4	CARBON GLACIER	591790	5200367	3180	14-Mar-01	08-May-01	54
13	8	TATO-1	TATOOSH CREEK	596025	5182560	4595	14-Mar-01	10-May-01	56
14	8	TATO-2	TATOOSH PARADISE	595892	5179630	5475	14-Mar-01	10-May-01	56
15	9	WHRI-1	WHITE RIVER NORTH	610824	5196353	3240	15-Mar-01	07-May-01	52
16	9	WHRI-2	WHITE RIVER RIDGE	610524	5195127	3578	16-Mar-01	07-May-01	51
17	9	WHRI-3	WHITE RIVER FPAN N	606506	5194183	3786	23-Mar-01	07-May-01	44
18	9	WHRI-4	WHITE RIVER FPAN S	605596	5192520	4028	23-Mar-01	07-May-01	44
19	9	WHRI-5	WHITE RIVER EMMONS W	600717	5194130	5259	16-Mar-01	07-May-01	51
20	9	WHRI-6	WHITE RIVER GLACIER W	599344	5193822	5790	16-Mar-01	07-May-01	51
21	10	STCA-1	STEVENS CANYON W	609085	5178732	3250	21-Mar-01	09-May-01	48
22	10	STCA-2	STEVENS CANYON LAUGHING WATER	611364	5179087	3104	13-Mar-01	01-May-01	48
23	10	STCA-3	STEVENS CANYON WATER TANK	610422	5177184	2080	20-Mar-01	09-May-01	49
24	11	BARI-1	BACKBONE HAIRPIN	607360	5173250	3200	13-Mar-01	09-May-01	56
25	11	BARI-2	BACKBONE RIDGE	608046	5177100	4700	13-Mar-01	09-May-01	56
26	12	MOWI-1	MOWICH LOWER	583875	5198579	3630	06-Apr-01	08-May-01	32
27	12	MOWI-2	MOWICH UPPER	585455	5199397	4388	06-Apr-01	08-May-01	32
28	13	GHLA-1	GHOST LAKE UPPER	611279	5191433	4602	11-Dec-01	11-Jan-02	30
29	13	GHLA-2	GHOST LAKE LOWER	610771	5193319	3790	11-Dec-01	11-Jan-02	30
30	14	LOLA-1	LOUISE LAKE UPPER	597961	5181190	5270	12-Dec-01	17-Jan-02	35
31	14	LOLA-2	LOUISE LAKE LOWER	597854	5179711	4638	17-Dec-01	11-Feb-02	54

Table A-1(continued). Sampling stations used to detect forest carnivores, Mount Rainier National Park, 2000-2002. (UTM Zone 10, NAD 83)

Station ID	Sample Unit ID	Station Code	Station Name	UTME	UTMN	Elevation	Date Installed	Date Removed	Days Out
32	15	ELLA-1	ELEANOR LAKE LOWER	602987	5204595	4820	20-Dec-01	11-Feb-02	51
33	15	ELLA-2	ELEANOR LAKE UPPER	601778	5202132	5600	19-Dec-01	05-Feb-02	46
36	17	IPCR-1	IPSUT CREEK LOWER	588859	5201986	2777	19-Dec-01	05-Feb-02	46
37	17	IPCR-2	IPSUT CREEK UPPER	587411	5200974	3870	22-Jan-02	28-Feb-02	36
38	18	CAGL-1	CARBON GLACIER LOWER	591614	5201115	2974	05-Feb-02	06-Mar-02	31
39	18	CAGL-2	CARBON GLACIER UPPER	590105	5201952	3050	23-Jan-02	07-Mar-02	44
40	19	PACR-1	PANTHER CREEK LOWER	610588	5181953	2300	23-Jan-02	07-Mar-02	44
41	19	PACR-2	PANTHER CREEK UPPER	610306	5184055	2400	07-Feb-02	14-Mar-02	37
42	20	EAPE-1	EAGLE PEAK UPPER	593290	5178194	5300	07-Feb-02	26-Mar-02	49
43	20	EAPE-2	EAGLE PEAK LOWER	592286	5177298	4120	16-Jan-02	26-Feb-02	40
44	21	WERO-1	WESTSIDE ROAD LOWER	585868	5179555	2480	16-Jan-02	05-Mar-02	49
45	21	WERO-2	WESTSIDE ROAD UPPER	585218	5182495	3000	06-Feb-02	28-Mar-02	52
46	22	GLBR	GLACIER BRIDGE	594186	5181555	4030	06-Feb-02	28-Mar-02	52

*Test sites not performed to protocol

Appendix B. Species detections at remote camera sites in Mount Rainier National Park, 2000-2002. Black crosses denote sites where the named species was detected. Red dots represent sites without detections.

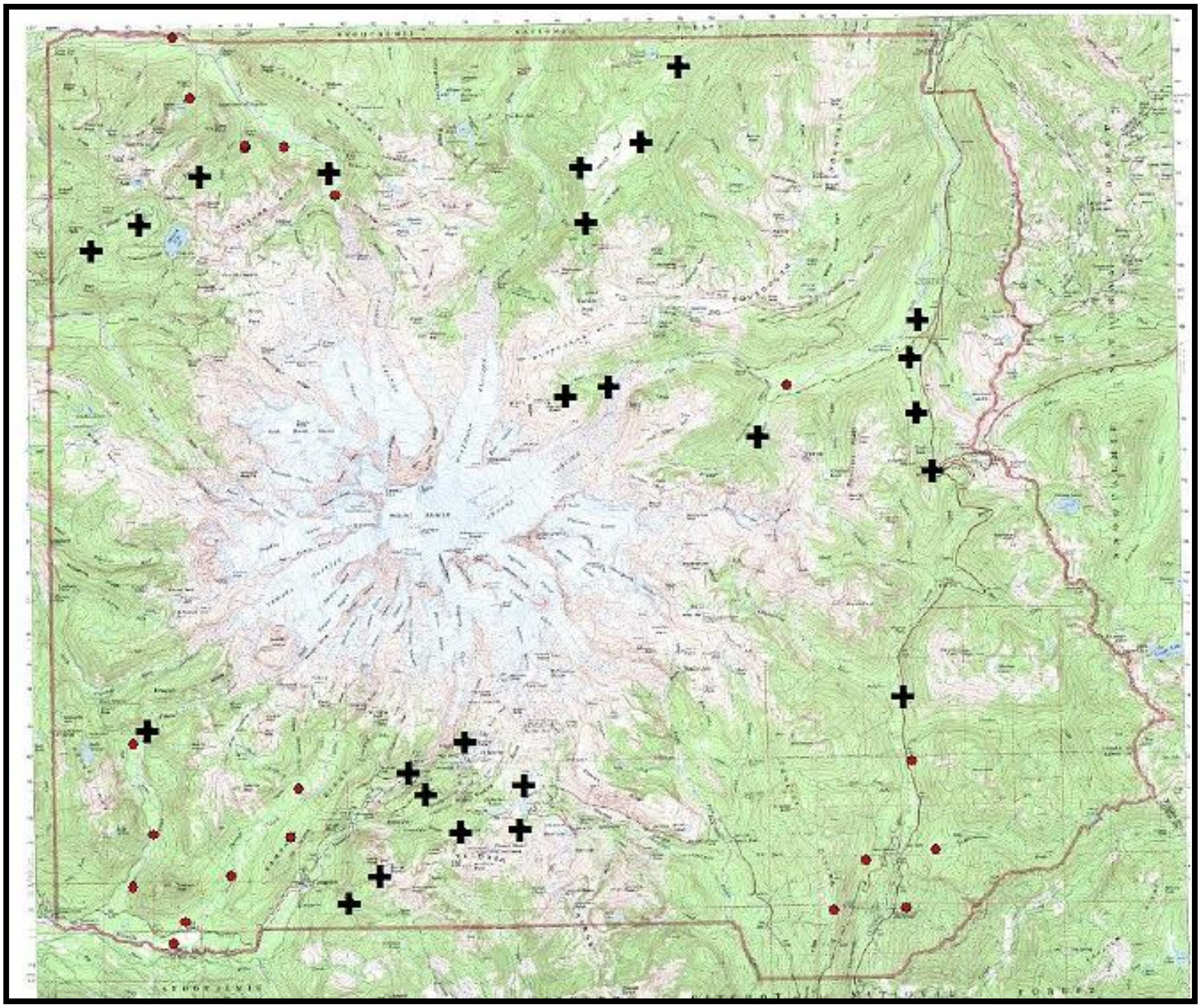

Figure B-1. American marten detections, Mount Rainier National Park.

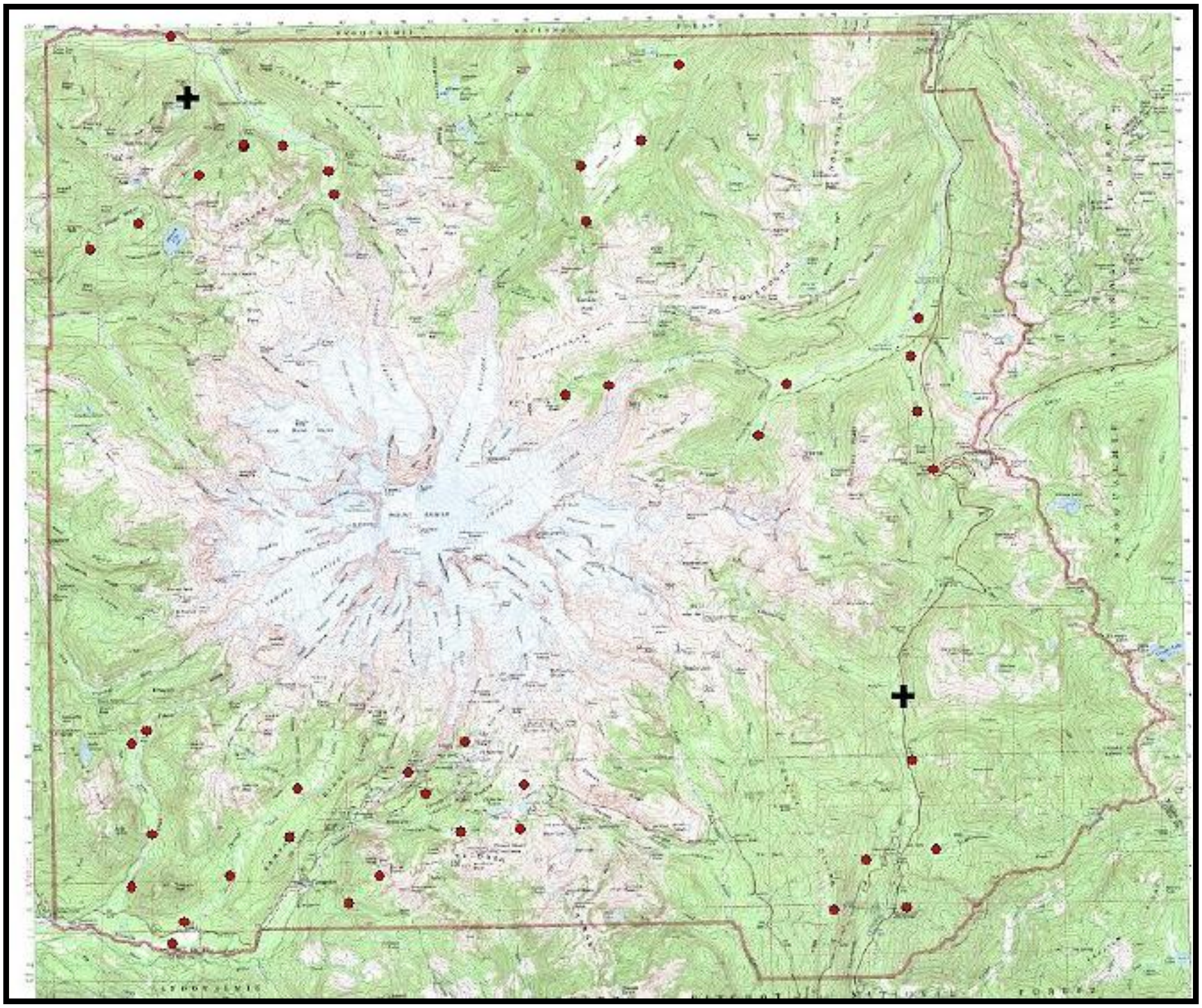

Figure B-2. Long-tailed weasel detections, Mount Rainier National Park.

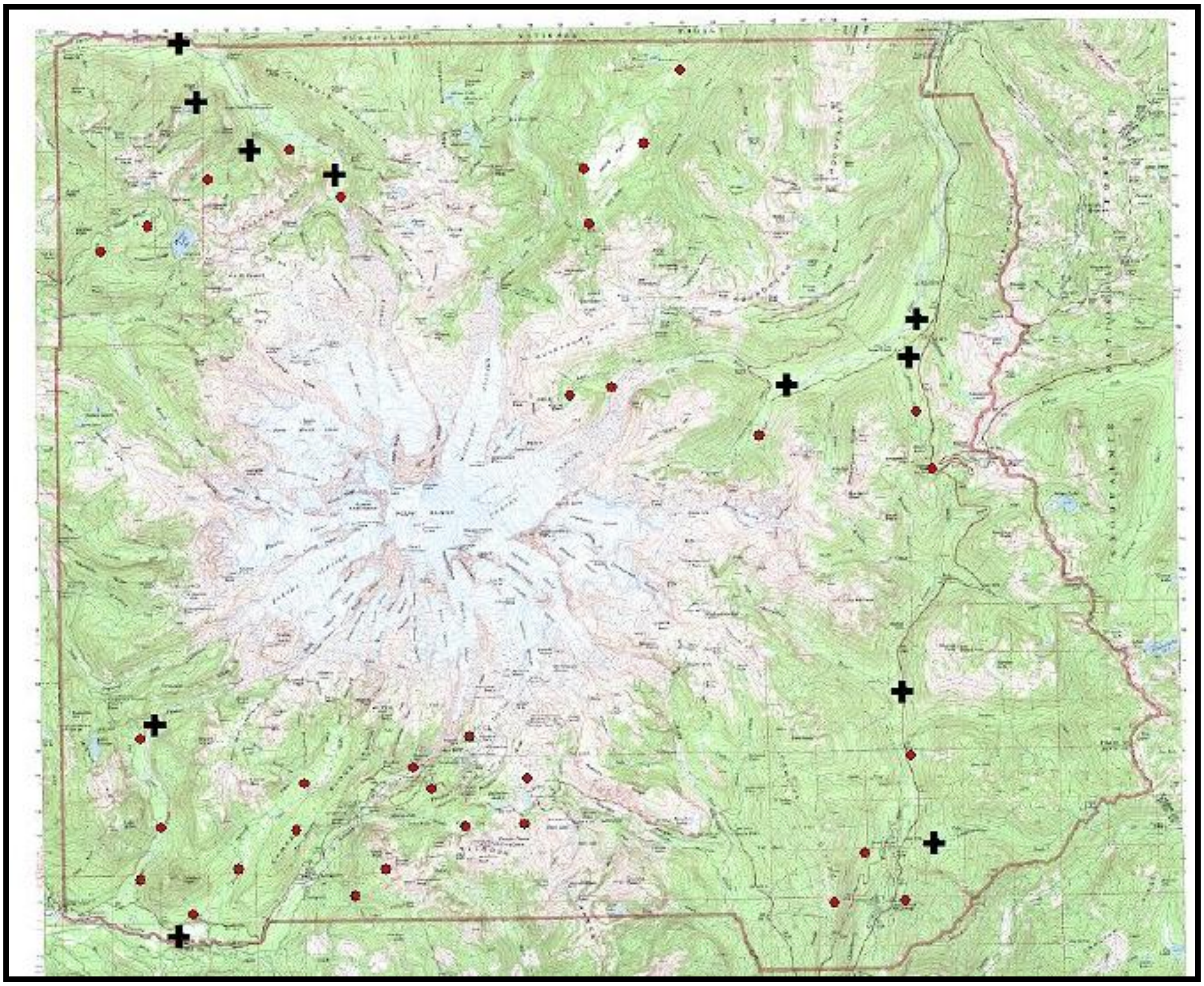

Figure B-3. Bobcat detections, Mount Rainier National Park.

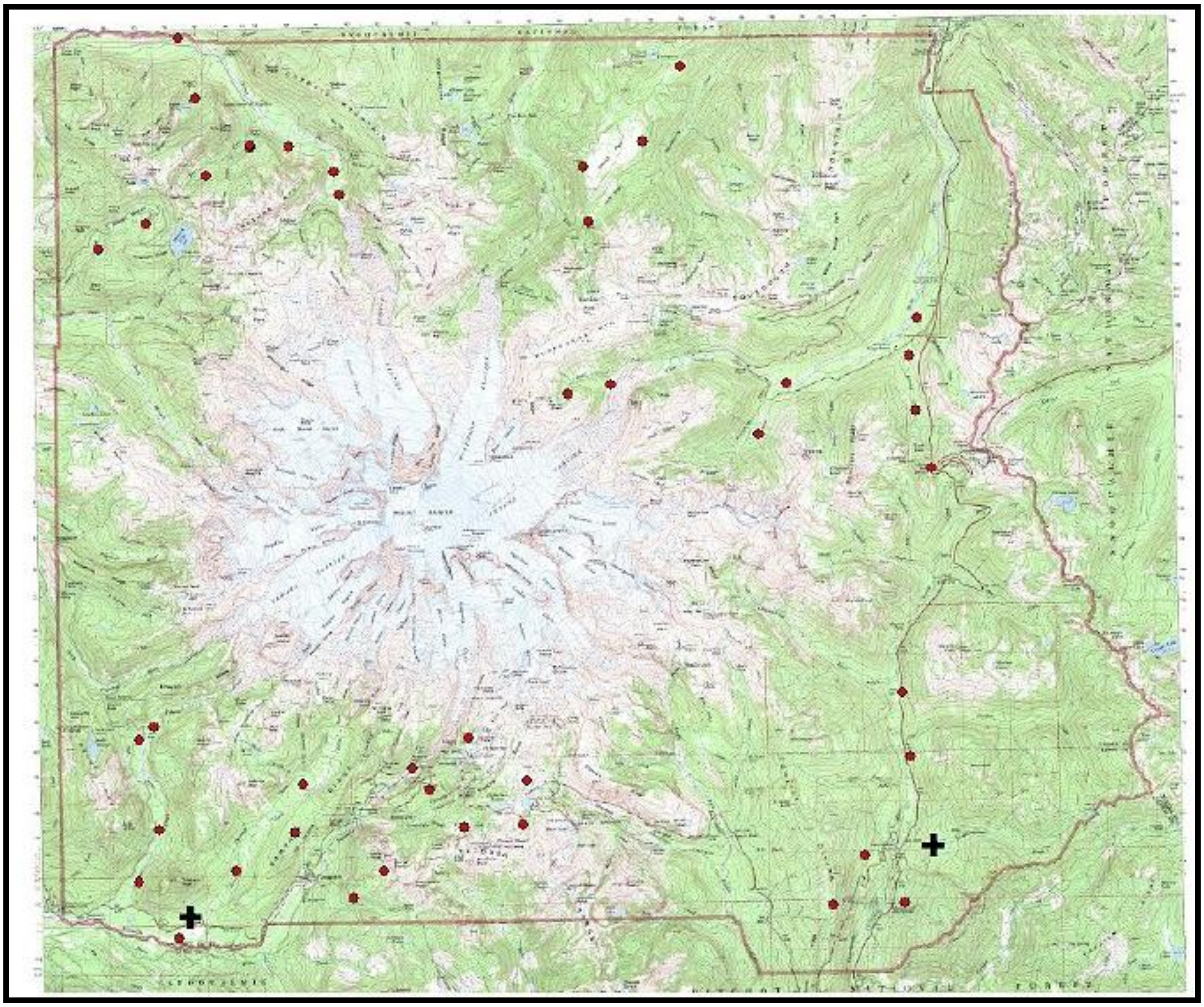

Figure B-4. Black bear detections, Mount Rainier National Park.

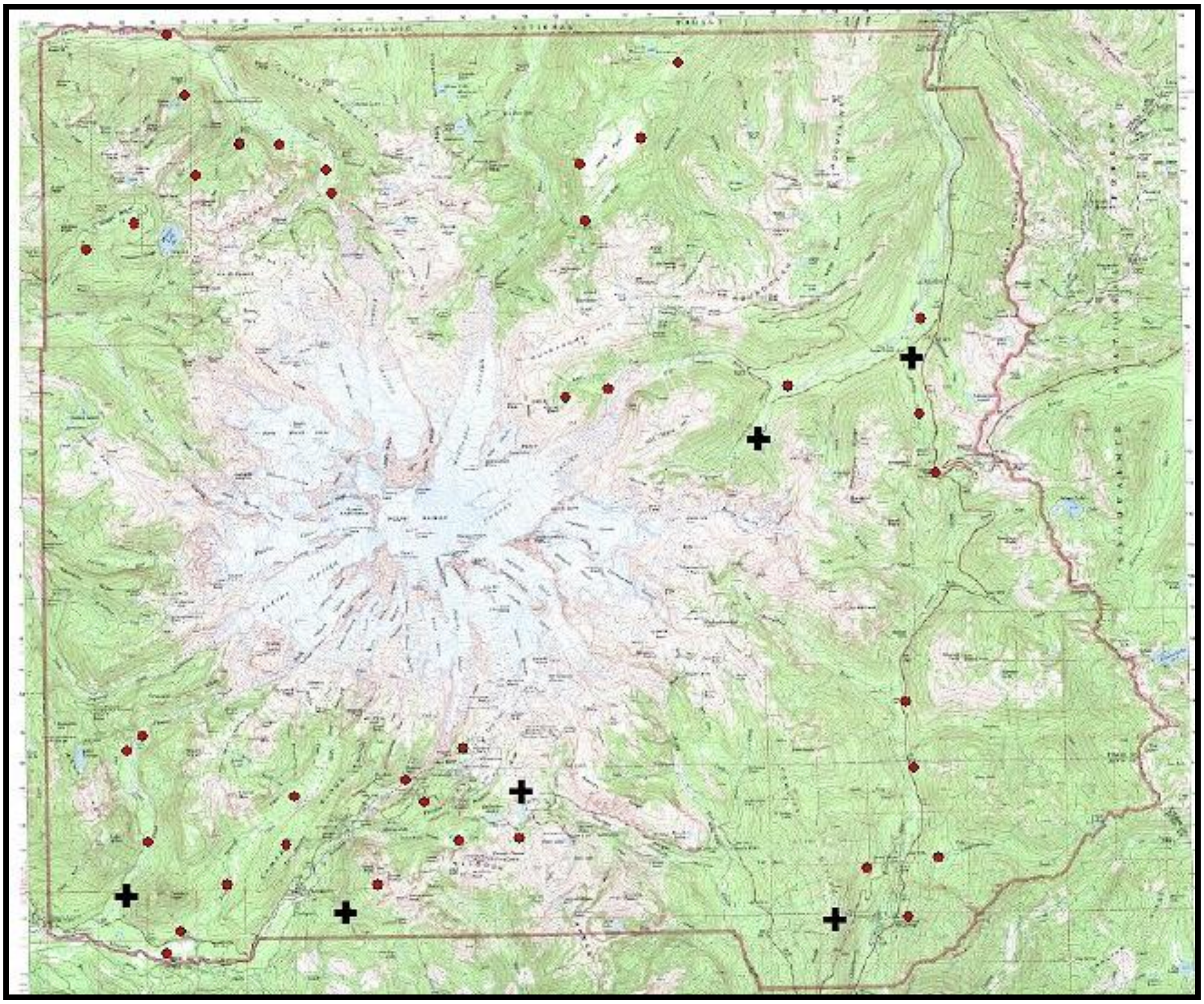

Figure B-5. Coyote detections, Mount Rainier National Park.

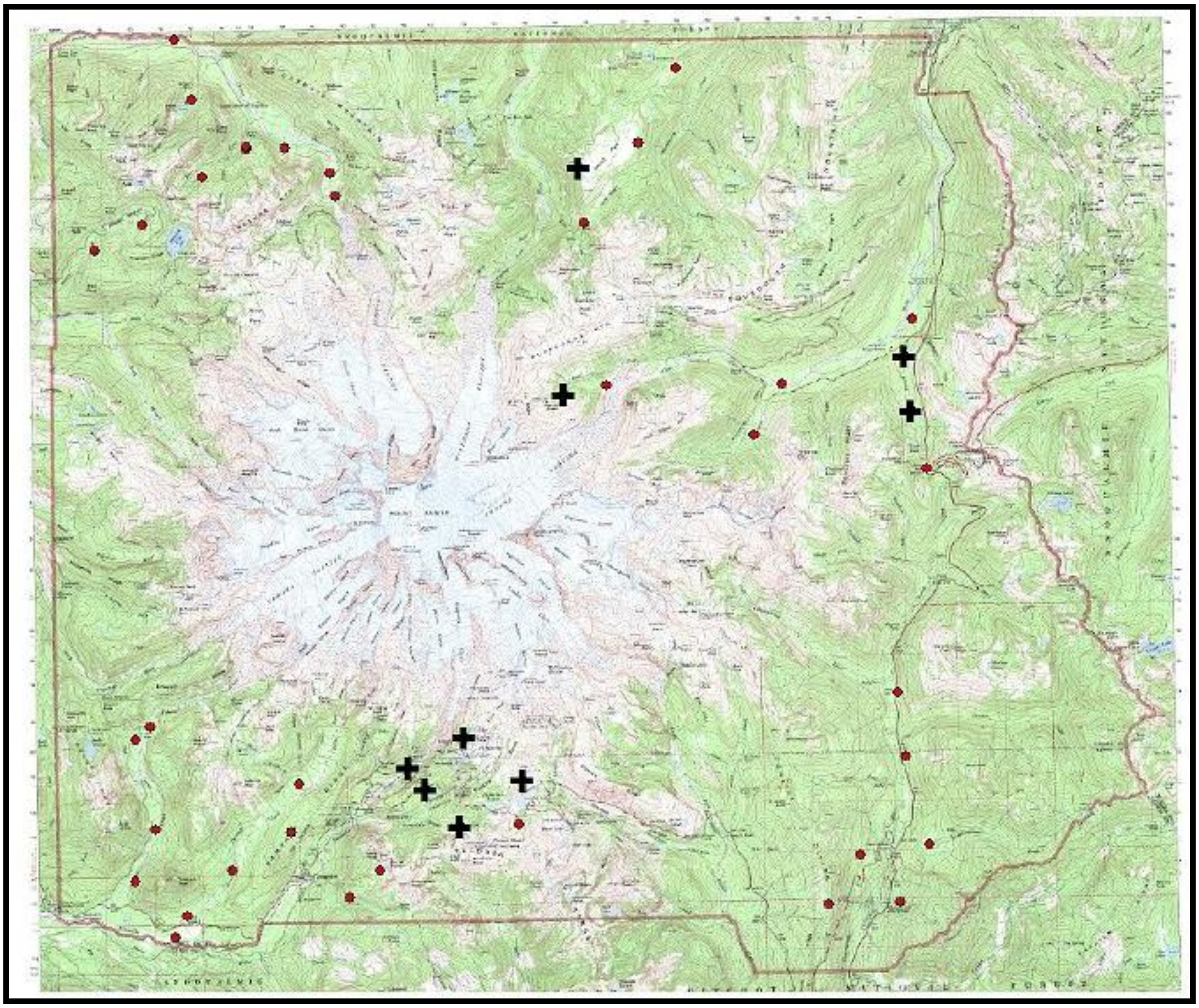

Figure B-6. Red fox detections, Mount Rainier National Park.

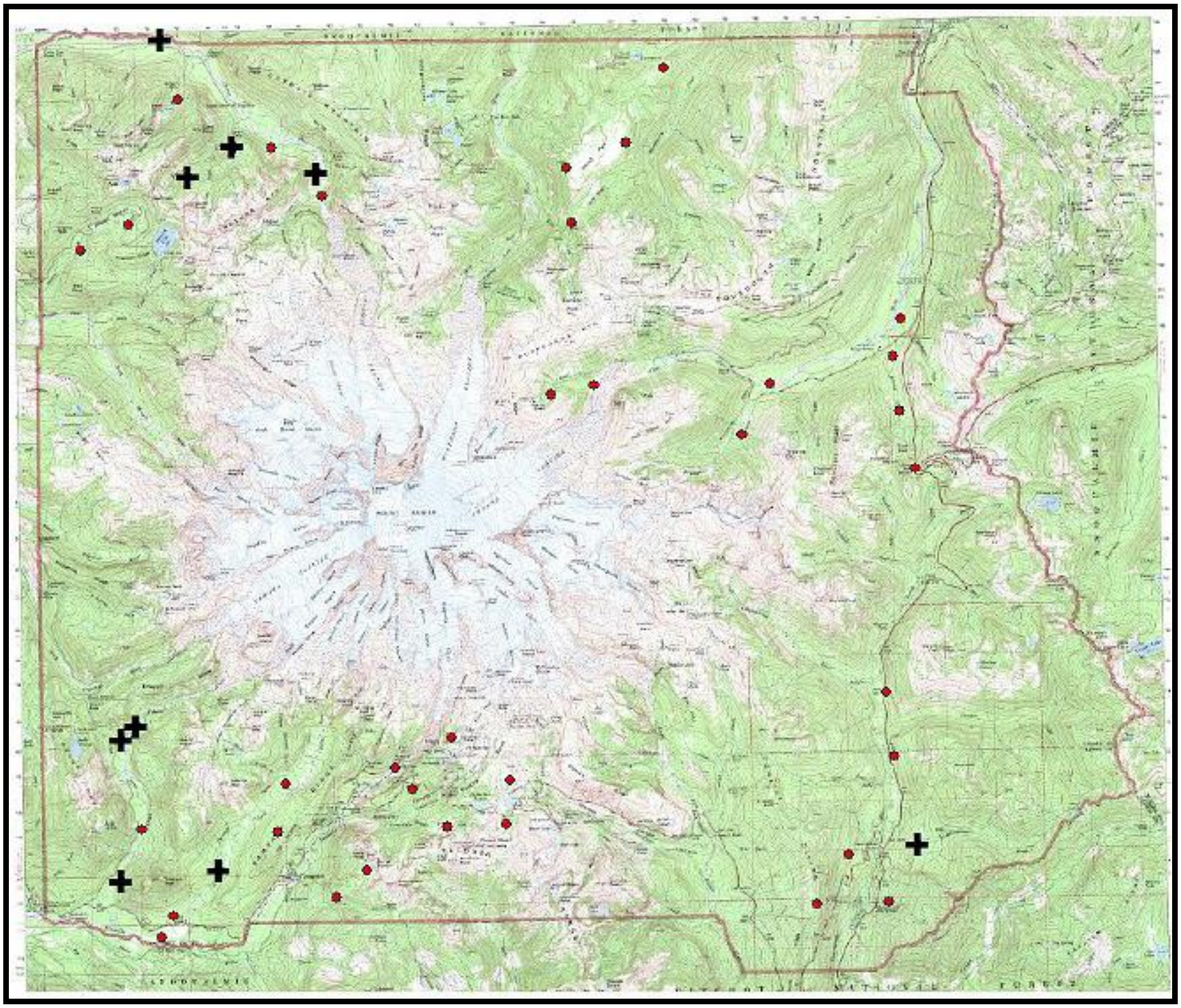

Figure B-7. Spotted skunk detections, Mount Rainier National Park.

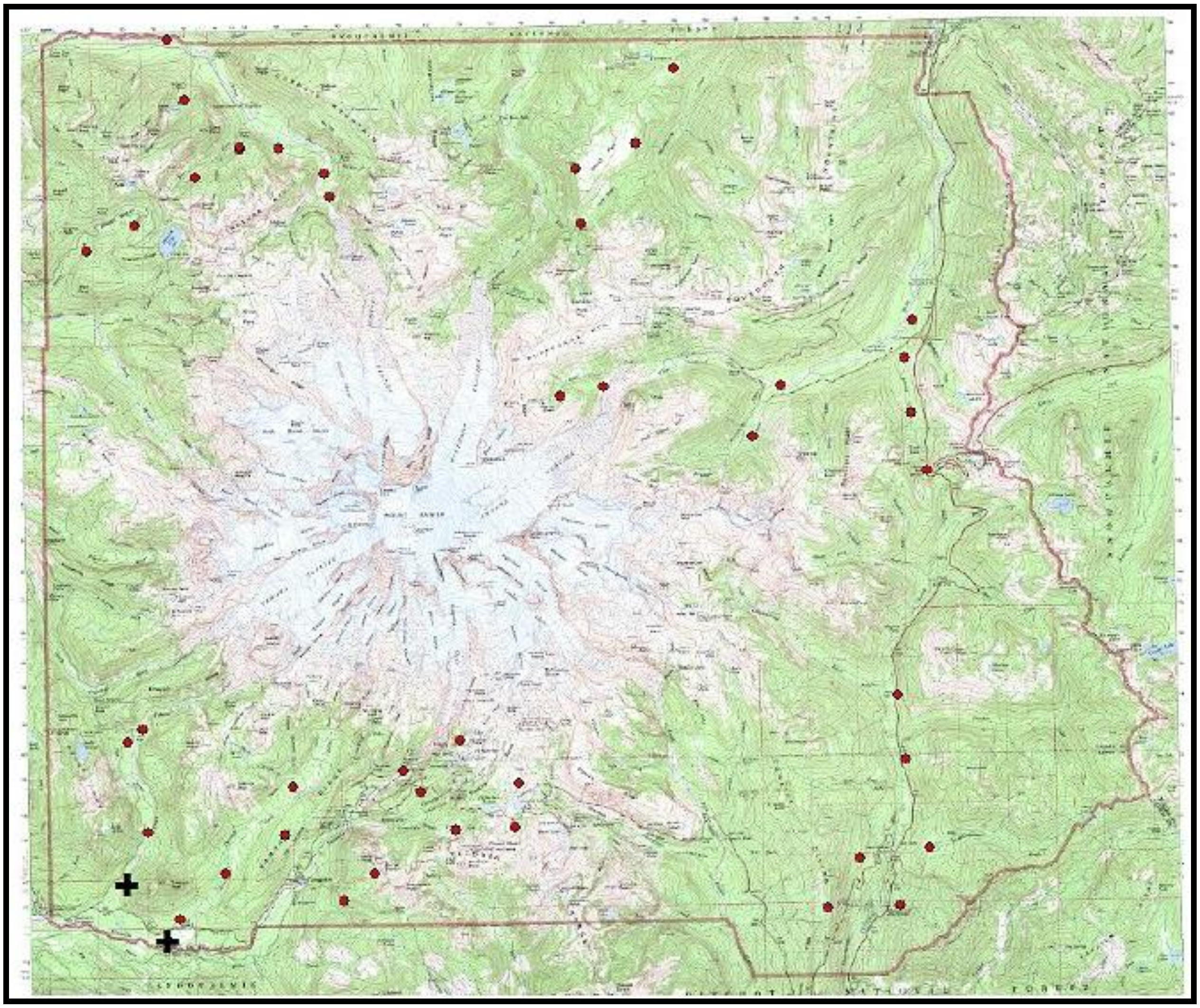

Figure B-8. Cougar detections, Mount Rainier National Park.

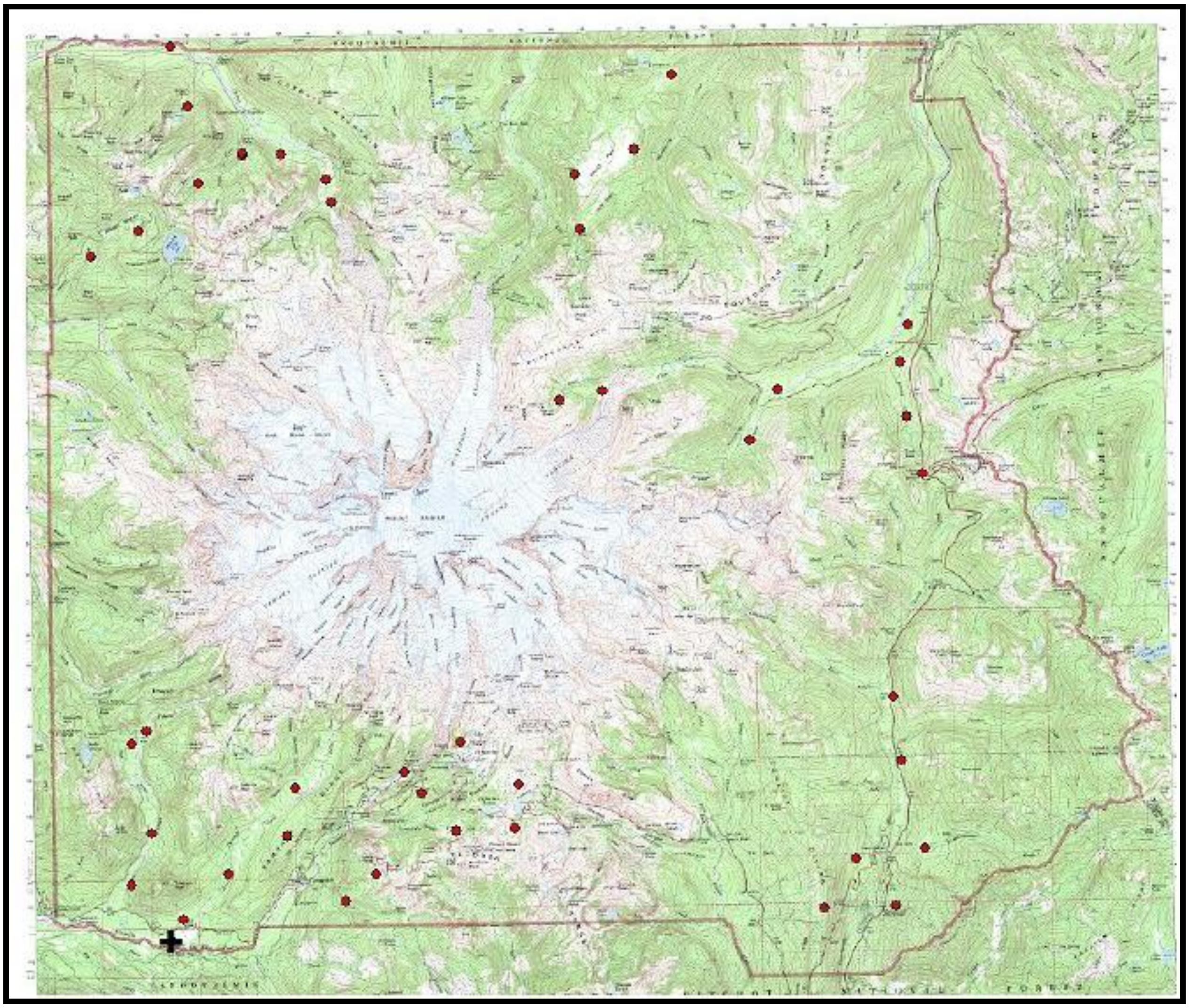

Figure B-9. Virginia opossum detections, Mount Rainier National Park.

Appendix C. Remote camera sampling protocol.

REMOTE CAMERA SURVEY TO DETECT THE PRESENCE OF FOREST CARNIVORES IN MT. RAINIER N.P.

SAMPLING PROTOCOL

19 March 2001

Adapted from protocol developed by
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Introduction

In a recent analysis of Washington State National Parks that looked at which terrestrial vertebrate taxa were in most need of further work to assess status, forest carnivores rated second. This taxonomic group was ranked a high priority for several reasons. Firstly, all the national parks in the network have very little information on forest carnivores. This lack of data stems primarily from the fact that forest carnivores have historically been very difficult to study, especially in remote, wilderness areas. However, several recently developed techniques and protocols for surveying forest carnivores offer alternatives that are cost effective, non-intrusive, and amenable to a wilderness environment (Aubry 1997, Zielinski and Kucera 1995). In addition, these methods can be used for more than one species at a time. These survey protocols have wide acceptance region wide, and have been employed by multiple land management agencies. However, the NPS has yet to systematically employ them in Washington.

Additionally, several forest carnivore species are listed on either federal or state endangered species lists (Federal: lynx, wolf, grizzly bear. State: fisher), have recently been petitioned for listing (wolverine), are soon to be proposed for listing (Federal: fisher, coastal marten), or are of special management concern (cougar). Many species of forest carnivores experience numerous threats that have caused for concern about their status (habitat loss, isolation of any remnant populations in protected areas such as national parks, long standing effects of historic harvest pressure, and loss of major food sources – i.e. salmon) (Ruggiero et al. 1994). Most recently, wildlife biologists from state and federal agencies in Oregon and Washington met and formed and *ad hoc* Pacific Northwest Forest Carnivore Group. The groups' goal is to work together across jurisdictional boundaries to gather more information on these key taxa. Better quality data on forest carnivore presence and distribution within the parks in the region is key piece in that effort.

The primary objective of the forest carnivore camera survey is to gain information on species presence (i.e. complete the 90% accurate species list with current data). For most of the larger parks, some forest carnivore species have not been documented for over 40 years, and several are suspected to be extirpated (fisher in MORA, NOCA, and OLYM, wolverine in NOCA, MORA, wolf in OLYM, MORA, and Canada lynx in MORA). The only objective at the smaller parks is to generate an updated presence/absence list of mammal species occurring that reflects the servicewide target of 90% completeness. The secondary objective at larger parks is to gain insight on species distribution patterns across broad geographic, elevational and precipitation gradients. However, sample sizes are expected to be too low for statistical analysis.

Sample Units

During each 30 day sampling session, the 2 person crew will attempt to establish and simultaneously maintain a total of 20 cameras located in 10 sample units. We have a total of 25 cameras; thus, each crew will have 5 complete backup systems available In the event of equipment failures. In each 4-mi^2 sample unit, we will set 2 camera systems spaced at least 1 mile apart. The sample units we will be targeting during this survey have been identified and marked on maps. Ideally, it would be best to sample as many contiguous or nearby units as possible. However, with winter field work, logistical constraints are usually the primary drivers. So, we will try to sample units as close together as possible, but selection of units will be determined by what makes the most sense in terms of access and efficiency of sampling units simultaneously.

Camera Operation and Trailmaster System Settings

Carefully read the chapter by Kucera, Soukkala, and Zielinski on Photographic Bait Stations in the detection manual by Zielinski and Kucera (1995. American marten, fisher, lynx, and wolverine: survey methods for their detection. USDA For. Serv. Gen. Tech. Rep. PSW-GTR-157) several times before beginning the surveys. We will be using only Trailmaster TM550 infrared monitor systems in this survey, with Yashica T4 cameras. Detailed instructions for establishing the stations and operating the system units are included in both the detection manual and the Trailmaster TM550 system manual, and won't be repeated here. However, do read the manuals for both the TM550 and camera to review the procedures for configuring the stations and operating each unit before going out in the field, and practice setting up stations as often as possible before going out in the sample units. With snow on the ground, and only about 9-10 hours of daylight, it will probably take an entire day to set up the 2 cameras in each sample unit. Thus, it will probably take at least 2 weeks to get all the cameras set up.

Set-up Procedures

1 Before going out in the field, set each camera back to record Month/Day/Year and set it for today's date and the correct time. The Yashica cameras are powered by the single CR-123A lithium battery, which are rated to last 3 years under "normal" use. We will need to periodically check the voltage however, due to the extreme demands we will put on these cameras.

2 In the field, set the flash on the Yashica cameras for "Flash On"; in this mode, the flash will always function, regardless of ambient light conditions.

3 Always carry a copy of the Trailmaster TM550 system and camera manual with you in the field.

4 Set the sensitivity of the system: **"P"=3.0**; **"Pt"=3.5**. If you obtain a lot of false exposures or pictures of non-target species, especially birds, which tend to move in and out of the sensor beam, increase the sensitivity setting to 5.

5 Set the camera delay ("cd" setting on the display, which is the number of minutes between photos)
to **cd= 5**.

6 Camera Time Zone (CTZ). Make sure the system is set to operate 24 hours a day. Set "ON TIME" to: **[0:on][on:0]** and "OFF TIME" to: **[--: of]**

7 Try to find a bait tree that is positioned to the north of the tree where the TM550 and camera are attached. By pointing the camera so that it is pointing to the north, odds will be reduced that the TM550 will be inadvertently triggered by sunlight striking the front lens of the unit during midday hours.

Other considerations:

8 We will be using ASA 400 slide film. With this speed of film, the flash on the Yashicas are rated at about 1.5 to 21 ft. To ensure that the flash provides sufficient illumination to identify all animals photographed, set the camera 8-12 feet from the bait to maximize the likelihood of getting a good exposure.

9 Make sure that the cord that plugs into the camera does not pass in front of the lens.

10 Always carry extra camera cables with you into the field. Corrosion of the plug into the camera and bad connections due to animals chewing through the cables are some of the more common problems that have been encountered previously. If you replace a cable, make sure to discard the old one, so it won't get re-used.

12 Whenever you open a camera back to remove film use rubbing alcohol and a cotton swab to clean

the rubber gasket before replacing the film to ensure that the seal remains intact and moisture does not get into the camera.

13 Another problem that has been encountered are pictures that are completely obscured by fogging of the camera lens. Carry a "no-fog" cloth with you in the field and clean the camera lens and automatic exposure window each time you check the station.

<u>Choosing Locations for Camera Stations</u>

Lynx and fisher prefer different habitat types and attempts will be made to locate stations throughout the park in a range of habitats to maximize the chances at detecting either species. In Mt. Rainier N.P., lynx would generally prefer higher elevation habitats that accumulate more snow than fisher would. Situations to key in on for locating stations in lower elevation fisher habitat include: late-successional forest with fairly dense canopy cover and lots of structural diversity for ameliorating snow depths and providing access to prey; riparian corridors, especially in old-growth forest conditions; upland strips of mid- to late-successional forest connecting larger patches of similar habitat; and saddles on ridges. Fishers do move thru many different habitat types, however, especially when they are foraging, so there are no hard and fast rules about where to locate stations. Stand-scale characteristics are probably more important for determining where fishers may occur than are physiographic or landscape-scale characteristics. Probably the single most important consideration for locating stations will be to find areas that provide both habitat for prey and access to them by fishers. This mainly means sites that do not accumulate dense snowpacks that completely cover the ground--fishers simply cannot hunt effectively under these conditions. So, once you have located the general area by referring to the target UTM coordinates, look in the immediate vicinity (about a 50 m radius) for a large diameter tree for attaching the bait. By selecting a large tree, the animal must pass in front of the camera for a larger distance to reach the bait, thus increasing the odds that a picture will be taken. Try to find bait trees in forest stands with good canopy cover for intercepting snow and reducing the depth of snow accumulating under the canopy, and those that have a lot of structural diversity at or near the ground. Stands that have a lot of large coarse woody debris sticking up thru the snow, branches low to the ground that intercept snow, and tree wells where snow has not accumulated around the bole of large trees provide cover for prey and at the same time provide opportunities for fishers to effectively hunt them. Track evidence showing that either marten, fisher, lynx or their prey species such as grouse, snowshoe hare, Douglas' squirrels, etc. have been active in a stand is a good sign that this may be a place that fishers or lynx will eventually forage in. However, the fact that you don't see tracks of mustelids or cats does not necessarily mean it is not a good site. Sometimes, you will just have to use your professional judgement and your intuition. To minimize the probability that the station will be found and vandalized, use flagging sparingly, but do use enough of them to be able to quickly re-locate the station.

<u>Numbering System for Identifying Stations</u>

At each station, we will mount a white placard made of kitchen flooring material (masonite with a white, shiny surface on one side) directly above the bait using nails, making sure the numbers can be read in the photo. Angle the placard slightly away from the focal plane of the camera so that the flash will not be reflected directly back to the camera. Each station will be numbered on the placard with a grease pencil according to the following system: Site name and 5 letter acronym that differentiates between camera stations within the sample unit. For example, the first camera station located in a sample unit situated in the White River could read on the placard:

WHRI-1

Batteries

C-cells: The 4 C-cells in the Trailmaster 550 units should last anywhere from 12-16 weeks, depending on ambient temperatures. Because C-cells are relatively inexpensive, we will replace all 4 C-cells after the first 12 weeks of operation.

Lithium Batteries: In a field trial of photographic bait stations in Montana, Foresman and Pearson (1995. Testing of proposed survey methods for the detection of wolverine, lynx, fisher, and American marten in Bitterroot National Forest. Unpubl. Final Rep. USDA Forest Service Agreement INT-94918, Intermountain Research Station, Missoula, MT) found that in the very cold temperatures they encountered in the Bitterroot Mountains in Montana, the lithium batteries were often depleted in a week. Because the CR-123A lithium battery powers the flash, the life span of the battery is directly related to the number of pictures taken as well as to how cold ambient temperatures have been during the survey. Thus, the lithium batteries may be depleted in a week or they may last the entire survey period. It would be prohibitively expensive to replace the lithium batteries each time we check the camera. Consequently, we will test them with a battery tester each time we remove film from the camera. We will take a slightly less restrictive approach than the one recommended by Foresman and Pearson, and replace the lithium batteries only if the voltage reading falls **below** 2.8 volts. When turning off the camera when removing film, checking frame number, or testing batteries, **carefully** unplug the cable at the camera, since this is a weak point in the system, and the less plugging and unplugging we do there, the better. This will prevent the Trailmasters from triggering any photos when you are gathering data from the sensors, removing film, or checking the camera batteries.

Bait and Lures

To the extent possible, we will standardize both the bait and scent lure used at each station in both study areas. To bait each station, we will make chicken wire pouches about 16” square and insert a whole, feathered chicken into the pouch and use wire to “sew” the open end closed. The wire pouch will then be nailed to the bait tree using fencing staples and/or nails. The TM550 should be directed towards the bait tree 8 to 12 inches below the bait and about 5 feet from the ground. Fish is especially attractive to mustelids, so we will also nail a can of tuna to the tree enxt to the chicken. Make sure you bring extra bait along each time you check the stations in case the bait has been taken. If there is still plenty of bait present, but it is starting to rot, leave it where it is; there is no need to replace rotting bait with fresh meat. If anything, rotting bait is likely to be more attractive to forest carnivores than fresh meat. If the bait is getting small, however, just add fresh meat to whatever rotting meat is still at the station.

Each station will be scented with skunk essence, cat lure, and the lynx nail pads will have a catnip/castor oil solution applied to the carpet. The purpose of the scent or lure is to get animals to come into the vicinity of the bait station; not to get them to come to the bait itself--the scent of the bait serves that purpose. So, do not place the lure directly on or near the bait. Find a spot nearby that will get the scent into the wind (a conifer branch, a small tree trunk in the bottom of a drainage or on a little saddle, etc.). Take a stick and pick up a small blob of the scent, then smear it on a nearby tree branch or trunk. If you return to a station in a week and can’t smell the scent, don't worry about it; carnivores will smell it even if you can't. Re-scent the station about every 2 weeks, or after a heavy rain.

The lynx carpet pads will be nailed to a tree about 2 feet above the ground, and a pie plate will be hung from a tree branch of the same tree. In a manner analogous to the olfactory scent cues, the pie plate is a visual cue used to attract the animal to the general area, where it will then come closer to the bait and hopefully have its picture taken or rub against the carpet pad.

Re-checking Stations
Downloading Data

1 Upon arriving at the site, approach the TM550 unit and camera from behind and to the side of the unit to avoid accidentally triggering the camera.
2 Observe what the event counter reads on the TM550. If it reads "1" or the same event number as when the TM550 was read on the last visit, then immediately go and stand at the base of the bait tree to try to get the camera to trigger. If the camera does not trigger, this indicates that the TM550-camera system has not been functioning properly since the last visit. If the camera does trip, it means that the system is operational and that there have simply not been any visitors that have tripped the unit since the last visit.
3 Remove the camera cable connector from the TM550 unit. Do not unplug the cable at the camera end, since the connector is so fragile on the camera housing itself and prone to corrosion if it is repeatedly unplugged.
4 Attach the TM Data Collector to the TM550 by using the gray end connector and plugging it into the Data Collector on the bottom of the unit and then plug the ¼" phono plug end into the "Printer" port in the bottom of the TM550.
5 Turn the Data Collector switch "ON" and press the "Coll Data" button on the front of the unit until "col!" is displayed. Then press the "Set-up" button on the TM550 until the screen reads' "Snd?" At this point, press the "R/O" advance button on the TM550 until "Snd!" is displayed. After the data is sent the TM550 display will change to "thru" and the Data Collector display will read "cnf!". Then press "Set-up" again on the TM550 and "R/O" advance to resend the data. At this point "snd!" will again be displayed at first, followed by "thru". The Data Collector will indicate that data has successfully been resent and checked against the first download by the display reading "done."
6 Disconnect the Data Collector from the TM550 and turn off the TM550 by simultaneously pressing "Time-Set" and "Set-up." This will prevent additional events from being recorded while you are checking the bait and moving in the vicinity.
7 Check the data that has just been downloaded from the TM550 by pressing the "Coll data" on the Data Collector until "16:un" or another similar display is read. Then scroll through using the "R/O" advance button until "un:01" is displayed and continue pressing the "R/O" button until you see the associated event number/time/date information flashing on the screen. A dot preceeding the event number (e.g. **. 10**) indicates that a picture has been taken.
8 While scrolling through the event data, record the times and event numbers that are associated with the correct camera frames on the datasheet. It is also possible to scroll through the event data directly by pressing "R/O" on the TM550 prior to turning it off before checking the bait on the bait tree.
9 Fill out the back of the datasheet for the appropriate check # and indicate if you put more

bait out, reapplied scent, etc.

10 Unscrew the camera bolt and check to see what the camera counter reads and to make sure that the flash on lightning bolt is still set correctly. Do not turn off the camera or unplug the cable connection at the camera end. If all is well, set the camera back onto the L-bracket, put the shroud back on, tighten the bolt, and re-position the camera so that it points at the base of the bait tree.

11 After you have completed all the tasks at the site, the last thing to do is plug the camera cable back into the bottom of the TM550 and take a test photo. Be sure to plug the cable into the "camera" port and not the "printer" port on the TM550. Turn the TM550 back on by pressing the Time Set and Set up buttons simultaneously, and wait for the display to stop flashing until it reads the same event number you observed when you first arrived at the site during this visit. Then walk to the base of the bait tree and watch to see if the flash goes off and the event number increments. Be sure to quickly back up out of the TM550 range so that no more events are recorded. Finally, write down the new event number and the correct frame number from the camera counter on the back of the datasheet.

12 When back in the office, be sure to put the datasheets back into the blue 3-ring binder, write the date checked on the correct tally sheet, and return the maps to the folder in the file cabinet.

Schedule for Checking Stations

Once they are all deployed, the goal will be to check the cameras once per week. Do the best you can and keep me informed of your progress. If it turns out that we have greatly underestimated the time it will take to maintain 20 cameras, then we will probably have to reduce the numbers deployed or check them less frequently. Zielinski and Kucera's protocol calls for a 28-day sample. Thus, if the systems are removed on the 28th day, they would have been out for 27 sample-nights. It is not necessary that both cameras be operating for a 24-hr period in order to obtain a sample-night. We will add days onto the total sampling period only if both cameras in a unit were not operating at any time between the hours of 6 p.m. and 6 a.m. If both cameras are down during all or part of this period due to technical failures or because the film had been fully exposed prior to your arrival at the station, then add a day onto the sampling period.

I am anticipating that each time you check a station, there will be unexposed film in the camera. However, if all of the film has been exposed, then you will need to determine when the last photo was taken (this information is part of what you will be reviewing on the sensor units and recording on the data sheet each time you check a station) because the day that the last picture was taken is the last day that the station was actively sampling.

Deciding Whether to Remove the Film from Cameras in the Middle of a Survey

The rolls of film we will be using are 24-exposure rolls (Ektachrome color slide film, ASA 400). In most cases, this will mean 24 or 25 pictures per roll (at least one frame will be used to test the integrity of the system after set-up and at each check). If you check a station and there are 10 or more frames that have been exposed on a roll of film, remove the film from the camera and replace it with a fresh roll. If, however, you come up to a station and see what you think are either fisher or lynx tracks around the station, pull the film regardless of how many pictures were taken. Make sure that you write the station identification number on the film canister with the fine point Sharpie as soon as you remove the film from the camera. This will enable us to identify the station location of the photos, even if the placard is not legible in the photo.

Film Processing

We will expedite film development by using a developing service at Kirk's Pharmacy in Eatonville. They generally produced developed slides in 2 business days. Upon deciding to pull film from a camera, using the criteria described above, make a photocopy of the data sheet(s) that goes with that roll of film. Put the originals in the datasheet 3-ring binder in the office and the copies in the other folder in the file cabinet. Within 2 days after the slides have been developed and received, use the light table or slide projector to examine the slides and record the matching Species information with the associated frame numbers on the datasheets. This will enable crewmembers to quickly get feedback on whether stations have recorded target species and evaluate how each station is working and make adjustments, if necessary.

The Data Sheet

We will use a separate data sheet for each roll of film. If you pull the film and replace it with a fresh roll, start a new datasheet and record all pertinent information. Record the Roll # for each station whenever you replace the film and start a new datasheet. The front of the data sheet is shown on the next page; fill it out as follows:

FRONT OF DATA SHEET

Station ID: The same number you put on the placard identifying the 5 letter acronym of the camera station, e.g., WHRI-2.
Station Name: The name of the camera station that includes the 3rd or 4th order stream that is in closest proximity, e.g. WHITE RIVER - LOWER.
TM550 ID No: Record the identifying number of the Trailmaster passive monitor that has been put on the masking tape on the unit (e.g. T-1).
Camera Type and NPS Number: Record the camera unit's identifying name and NPS property number (i.e., Yashica - 14456).
UTM: Identify the actual UTM location of the camera station to the nearest 10 m once you reach the site.
Date Station Installed: Put down the date that you install the system; do not use numbers and slashes (e.g., 1/6/01), records dates with the day first, the 3 or 4 letter abbreviation of the month, and the year using all 4 digits; e.g., 6 Jan 2001.
Date Station Removed: Record the date the station was removed only on the last data sheet in each set. Thus, if you used 2 data sheets at a station, put N/A in this space on the first data sheet and record the date on the second data sheet.
Roll No.: When you replace film and start a new data sheet, record which roll of film it is for this particular station.
Date Film Installed in Camera: Record when the film was put into the camera.
Initial Frame No.: Record the frame number left on the camera when the initial set up is completed. This should be at least 2, since you need to take at least one test picture when setting up the station. **and Initial Event No.:** Record the Event No. left on the Trailmaster sensor when the initial set up is completed. Note that events don't automatically advance the way frames on the camera does, so if there has been 1 event, the sensor will read 1.
Date Film Removed from the Camera: If you remove film from the camera, record the date in this space regardless of whether you are pulling the film in the middle of the sampling period or at the end.
Columns: Date, Event, Time, Species: The data lines in the main part of the data sheet are only filled out when pictures are taken. As you scroll through the sensor output, events which resulted in a picture being taken will have a dot next to the event number. When you see this, record the **Date**, the **Event** on which a picture was taken, and the **Time**. Leave the **Species** column blank; this will be filled out after the film is developed. Ignore events for which no picture was taken, except for recording the last event shown when you remove a roll of film (this information is recorded on the back of the data sheet). At the end of each check, make a mark to the left of the columns indicating the last frame exposed. For example, if on check 1 there have been 5 frames exposed, write Check 1 --> in the left hand margin next to Frame 5.

BACK OF DATA SHEET:

<u>Box 1: Setup/New Roll</u>: Circle setup or new roll depending on whether it is the initial setup or a new roll of film.
Date: Record the date when the setup occurred or the new roll was installed (which ever is appropriate).
Sensitivity, Camera Delay, Bait, and Scent: Record the settings for the sensitivity (P and Pt) of the TM550 sensor and the camera delay, and record the type of bait(s) and scent lure(s) used.
Snow: Snow and Snow Condition are self-explanatory, the 3 Snow Depth measurements are taken in representative areas within 5 m of the bait station.
Comments: Write down any comments you think may be of interest, including a brief description of the site, the presence of tracks, the proximity of a creek, etc.
<u>Boxes 2-4: Checks #1, 2 3, and 4</u>
Date and Last Event: Record the date you check the station, and the last event shown on the sensor when you arrive at the station; this will enable us to determine how many events there have been since the last picture was taken.
Snow Conditions and Comments: Describe snow conditions and put down any pertinent information on the condition of the site when you found it, the condition of the bait, whether you re-scented the station, the presence of tracks, whether or not you changed the batteries, if you adjusted the sensitivity or camera delay, and anything else that may be of interest.
Left on Frame No.: Record the frame number left on the camera when you leave the station. This should be at least 1 higher than the last frame shown on the front of the data sheet, since you will again need to take a test picture when you reset the system. **and Event No.:** Record the event number left on the Trailmaster sensor when you finish re-setting the system and leave the station.
Volt Meter Reading: Record the volt meter reading for the lithium camera battery.

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Station Name ____________________________ Camera Name/ NPS No. _____________
Station ID No. _____________________________TM550 ID No. ______________________
UTMs: N _______________________________ E ___________________________________
Date Station Installed _________________Date Station Removed ____________________
Roll No. _________ Date Film Installed in Camera _____________________
Initial Frame No. _____and Initial Event No. _______ Date Film Removed from Camera ______

Date	Event #	Frame	Time	Species
________	________	1	________	________________________
________	________	2	________	________________________
_______	________	3	________	________________________
________	________	4	________	________________________
________	________	5	________	________________________
________	________	6	________	________________________
________	________	7	________	________________________
________	________	8	________	________________________
________	________	9	________	________________________
________	________	10	________	________________________
________	________	11	________	________________________
________	________	12	________	________________________
________	________	13	________	________________________
________	________	14	________	________________________
________	________	15	________	________________________
________	________	16	________	________________________
________	________	17	________	________________________
________	________	18	________	________________________
________	________	19	________	________________________
________	________	20	________	________________________
________	________	21	________	________________________
________	________	22	________	________________________
________	________	23	________	________________________
________	________	24	________	________________________
________	________	25	________	________________________
________	________	26	________	________________________

Setup/New Roll: Date: ___________ Sensitivity (P/Pt):_____________ Camera Delay: __________
Bait(s) _________________________________
Scent(s)___________________________________
Snow (circle one): None, Patchy, Complete Cover
Snow Condition (circle one): Crusty, Powdery, Wet/Packy, Powder on Crust
Snow Depth (average of 3 measurements in cm): ____________________________
Comments: ____
____
____
____
____
____

Check #1: Date:__________________ Last Event: ______________________
Snow (circle one): None, Patchy, Complete Cover
Snow Condition (circle one): Crusty, Powdery, Wet/Packy, Powder on Crust
Snow Depth (average of 3 measurements in cm): ____________________________
Comments (condition of site and bait, batteries, tracks, etc): __________________________________
____
____
____
____
____
Left on Frame # ___________ and Event # __________ Volt Meter Reading: _________________

Check #2: Date:__________________ Last Event: ______________________
Snow (circle one): None, Patchy, Complete Cover
Snow Condition (circle one): Crusty, Powdery, Wet/Packy, Powder on Crust
Snow Depth (average of 3 measurements in cm): ____________________________
Comments (condition of site and bait, batteries, tracks, etc): __________________________________
____
____
____
____
____
Left on Frame # ___________ and Event # __________ Volt Meter Reading: _________________

Check #3: Date:__________________ Last Event: ______________________
Snow (circle one): None, Patchy, Complete Cover
Snow Condition (circle one): Crusty, Powdery, Wet/Packy, Powder on Crust
Snow Depth (average of 3 measurements in cm): ____________________________
Comments (condition of site and bait, batteries, tracks, etc): __________________________________
____
____
____
Left on Frame # ___________ and Event # __________ Volt Meter Reading: _________________

Check #4: Date:__________________ Last Event: ______________________
Snow (circle one): None, Patchy, Complete Cover
Snow Condition (circle one): Crusty, Powdery, Wet/Packy, Powder on Crust
Snow Depth (average of 3 measurements in cm): ____________________________
Comments (condition of site and bait, batteries, tracks, etc): __________________________________
____
____
____
Left on Frame # ___________ and Event # __________ Volt Meter Reading: _________________

CAMERA SITE MAPS

Draw two detailed maps, one a general map showing how to find the site and the other that demonstrates how the camera, bait, and lynx pads are set out on the site itself.

Appendix D. Habitat classification datasheet.

HABITAT INFORMATION – Site Name ________________________________

Describe the overall condition of the stand where the camera station is located.

Average DBH of live Trees: < 6" 6-12" 12-20" > 20"

Average Spacing Between Trees: <4' 4-8' 8-12' > 12'

Do standing dead trees comprise 10% or more of the overall stand? Yes No

If Yes, average DBH of dead trees: < 6" 6-12" 12-20" >20"

Would you categorize the fuel load of dead and downed woody debris as: L M H

The average DBH of dead and downed woody debris: < 6" 6-12" 12-20" >20"

Three most common tree species in Canopy: 1. 2. 3.

Average percent canopy closure of the stand (Ocular Estimate)
< 40% 40-70% > 70%

Elevation (ft., m)

Topographic Position of camera station:
Riparian (<50m to stream/river) Valley Bottom Lower 1/3 slope
Mid 1/3 slope Upper 1/3 slope Ridge top

Tracks Observed at Station

Species Date Observed

	Date	Initials	CAMERA OPERATIONAL	CAMERA MALFUNCTION	CAMERA STOLEN	FILM DEPLETED	FILM REPLACED	BATTERIES DEAD	BATTERIES REPLACED
Camera Station Established:									
Station Checked:									
Station Checked:									
Station Checked:									
Station Checked/Removed:									

Appendix E. Vegetation characteristics of sample stations.

Table E-1. Vegetation characteristics of sample stations.

Block	Subblock	Common Canopy Tree 1	Common Canopy Tree 2	Common Canopy Tree 3	% Canopy Cover	DBH Live Trees (in)	Avg. Spacing Live Trees (ft)	Dead Trees >10% of stand	Avg DBH Dead Trees (in)	Fuel Load
1	1	*Acer macrophyllum*	*Abies grandis*	*Alnus rubra*	40-70%			N		
8	5	*Tsuga heterphylla*	*Thuja plicata*	*Pseudotsuga menziesii*	40-70%	12-20in.	>12'	N	6	M
9	6	*Tsuga heterphylla*	*Thuja plicata*	*Pseudotsuga menziesii*	40-70%	12-20in.	8-12'	Y	12-20in.	L
38	7	*Pseudotsuga menziesii*	*Thuja plicata*	*Tsuga heterphylla*	40-70%	12-20in.	8-12'	N	6-12in.	L
30	8	*Pseudotsuga menziesii*	*Tsuga heterphylla*	*Picea engelmannii*	40-70%	12-20in.	>12'	N	12-20in.	L
19	9	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Thuja plicata*	40-70%	12-20in.	4-8'	N	12-20in.	M
20	10	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Thuja plicata*	>70%	12-20in.	4-8'	N	12-20in.	M
21	11	*Tsuga heterphylla*	*Abies amabilis*			12-20in.	8-12'	N	12-20in.	
22	12	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Tsuga mertensiana*	40-70%	6-12in.	<4'	N	6-12in.	L
15	13	*Abies amabilis*	*Thuja plicata*	*Pseudotsuga menziesii*	<40%	12-20in.	>12'	Y		
14	14	*Pseudotsuga menziesii*	*Abies amabilis*		<40%	>20in.	8-12'	N		
13	15	*Picea engelmannii*	*Pseudotsuga menziesii*	*Thuja plicata*	>70%	6-12in.	8-12'	N	6-12in.	M
52	16	*Pseudotsuga menziesii*	*Tsuga heterphylla*	*Thuja plicata*	40-70%	6-12in.	8-12'	N	12-20in.	M
10	17	*Pseudotsuga menziesii*	*Tsuga heterphylla*		<40%	12-20in.	>12'	N	6	M
11	18	*Pseudotsuga menziesii*	*Tsuga heterphylla*		>70%	6-12in.	8-12'	N		
7	19	*Abies amabilis*	*Tsuga heterphylla*	*Thuja plicata*	40-70%	6-12in.	4-8'	N		
6	20	*Abies amabilis*	*Picea engelmannii*	*Thuja plicata*	<40%	>20in.	8-12'	N		
4	21	*Abies amabilis*	*Tsuga heterphylla*	*Pseudotsuga menziesii*	40-70%	>20in.	>12'	Y	12-20in.	L
29	22	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Thuja plicata*	40-70%	12-20in.	8-12'	Y	12-20in.	M
5	23	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Acer circinatum*	40-70%	12-20in.	>12'	Y	12-20in.	L
53	24	*Pseudotsuga menziesii*	*Thuja plicata*		40-70%	6-12in.	8-12'	N	6-12in.	L
18	25	*Tsuga heterphylla*	*Pseudotsuga menziesii*		40-70%	6-12in.	8-12'	N		L
17	26	*Abies amabilis*	*Pseudotsuga menziesii*		>70%	6-12in.	4-8'	Y	6-12in.	H

Table E-1 (continued). Vegetation characteristics of sample stations.

Block	Subblock	Common Canopy Tree 1	Common Canopy Tree 2	Common Canopy Tree 3	% Canopy Cover	DBH Live Trees (in)	Avg. Spacing Live Trees (ft)	Dead Trees >10% of stand	Avg DBH Dead Trees (in)	Fuel Load
16	27	*Pseudotsuga menziesii*	*Thuja plicata*	*Abies amabilis*	40-70%	>20in.	>12'	Y		
31	30	*Abies amabilis*	*Pseudotsuga menziesii*		<40%	6-12in.	4-8'	N		L
32	31	*Abies amabilis*	*Tsuga mertensiana*	*Chamaecyparis nootkatensis*	<40%		<4'	N		L
46	32	*Pseudotsuga menziesii*	*Tsuga mertensiana*	*Cornus nuttallii*	40-70%	>20in.	>12'	N	12-20in.	M
47	33	*Picea engelmannii*	*Achlys triphylla*		40-70%	12-20in.	4-8'	Y		
44	34	*Abies amabilis*	*Abies grandis*		40-70%	12-20in.	4-8'	N	6-12in.	M
45	35	*Abies grandis*	*Abies amabilis*	*Tsuga mertensiana*	40-70%	6-12in.	4-8'	N	<6in.	L
35	36	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Thuja plicata*	40-70%	12-20in.	8-12'	N	12-20in.	H
25	37	*Tsuga heterphylla*	*Pseudotsuga menziesii*	*Abies amabilis*	40-70%	>20in.	8-12'	Y	12-20in.	M
33	38	*Pseudotsuga menziesii*	*Tsuga heterphylla*	*Thuja plicata*	40-70%	12-20in.	4-8'	N	12-20in.	H
34	39	*Thuja plicata*	*Tsuga heterphylla*	*Pseudotsuga menziesii*	<40%	6-12in.	4-8'	N	<6in.	M
42	40	*Tsuga heterphylla*	*Thuja plicata*		40-70%	12-20in.	8-12'	N	>20in.	H
39	41	*Pseudotsuga menziesii*	*Tsuga heterphylla*	*Thuja plicata*	40-70%	12-20in.	4-8'	N		
23	42	*Tsuga heterphylla*	*Tsuga mertensiana*	*Pseudotsuga menziesii*	40-70%	12-20in.	8-12'	N		
51	43	*Tsuga heterphylla*	*Tsuga mertensiana*	*Pseudotsuga menziesii*	40-70%	12-20in.	8-12'	N		
50	44	*Tsuga heterphylla*	*Thuja plicata*	*Pseudotsuga menziesii*	40-70%	>20in.	8-12'	N		H
43	45	*Pseudotsuga menziesii*	*Tsuga heterphylla*	*Thuja plicata*	40-70%	12-20in.	8-12'	N	6-12in.	L
40	46	*Abies amabilis*	*Thuja plicata*	*Tsuga heterphylla*	40-70%	12-20in.	>12'	N		L

Appendix F. M.J. Brown contract report.

Animals detected with photo stations in Mount Rainier National Park, winters 2001 and 2002

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Introduction

In this report I provide basic results from a survey for animals in Mt. Rainier National Park (MORA). Though mammalian carnivores such as marten (*Martes americana*) were the primary interest of the survey, other mammals and birds were recorded as well. The survey work was conducted in winters 2001 and 2002. Jim Schaberl (JS), a current wildlife biologist at MORA, provided me with a computer file of survey data in October 2007. I produced this summary and analysis in November 2007.

JS described the field method to me. The basic design comes from Zielinski & Kucera's 1995 General Technical Report, "American Marten, Fisher, Lynx, and Wolverine: Survey Methods for Their Detection" (PSW GTR-157). In particular:

- The survey area was divided into 20 four-square mile "blocks." These blocks are described in Exhibit 1A.

- Within each block, two camera stations, separated by a distance of at least one mile, were set up. (One block, "Stevens Canyon," had three stations.) These stations are described in Exhibit 1B.
- Five additional stations, spread over four additional blocks, were established and studied as "test" sites. These stations and blocks are listed and identified in Exhibits 1A and 1B, but data from them did not contribute to the formal results here.
- Each camera station used a "Trailmaster" datalogger and infrared trigger with attached film camera to sense and photograph animals. Each camera station was operational for 28 consecutive days, though at busier traps, the camera roll might fill up early, reducing the effective duration of the survey.
- Surveys at each station included some basic descriptors of vegetation and forest structure.
- Each block was surveyed in only one field season. Eleven blocks were surveyed in the 2001 field season, which ranged from mid-March to early May of that year. Nine blocks were surveyed in the 2002 field season, which ranged from mid-December 2001 to mid-March of 2002. Some dates within the field records were contradictory and I relied on JS's discretion to separate valid survey data from spurious or test data.

MORA staff examined the datalogger records and photos, edited out records representing non-animal events (for example, swaying branches that triggered the camera), and identified the species in the valid photos. Each data record that could be matched with an identifiable animal photo was called a "photo event".

Data Processing and Analysis

JS provided me with a Microsoft Access database containing a table listing all valid photo events at each station. The database also contained a table describing stations in terms of location, elevation, etc, and a key to species codes used in the events table. However, the design calls for species and animals to be evaluated within each *block*, not each station, and blocks were not specifically described in this database. JS provided me with supplementary tables listing the stations making up each block, as well as a precipitation classification describing each block as "dry" or "wet" based on placement vis-a-vis the Mt. Rainier rain shadow. This additional information is incorporated into the aforementioned Exhibits 1A and 1B.

I summed the number of photo events for each species within each block. The resulting record of species records within blocks is broad and efficient in that it records numerous species within a single survey – in fact, any species that triggers the camera. However, the number of photo events is probably not a reliable index to the relative abundance of species or animal richness of individual blocks. Species have different habits and inherent detectabilities, and individual animals may repeatedly visit the same camera station. For these reasons, on JS's suggestion, I simplified photo events into "detections." If a species had one or more photo events in a block, that counted as one detection. Zero photo events counted as zero detections.

My analysis of this material was mostly descriptive. There were not specific hypotheses to test. Using frequency tables, bar graphs, and standard descriptive statistics, I compared species based on the number of blocks in which they were detected, and blocks based on the number of species detected.

JS was interested in the general proposition that some species might be more common on one side or the other of the Mt. Rainier, in association with rain shadow effects. I explored this idea by crosstabulating the detection status for each species (detected or not detected) with their precipitation class (dry or wet) and applying Fisher's Exact Test (see Zar, Biostatistical Analysis, 4th ed., 2000). I made a similar comparison of detection status and field seasons (2001 vs 2002).

Results

The complete record of photo events per species and location is shown in the first table of Exhibit 2, while the the complete record of detections is in the second table.

18 species were recorded over the twenty blocks in the formal survey. The forest carnivores were Western spotted skunk, black bear, long-tailed weasel, marten, bobcat, coyote, and red fox. Other mammals were snowshoe hare, Douglas' squirrel, flying squirrel, Townsend's chipmunk, deer mouse, and wapiti (elk). The birds were golden eagle, gray jay, Steller's jay, common raven, and varied thrush.

Three additional species (opossum, cougar, and black-tailed deer) were detected only at the "test" stations, outside of the formal record.

Blocks varied considerably in the number of photo events and detections recorded (Exhibits 3A, 3B). The "Stevens Canyon" block had the most abundant record, with 160 photo events representing 8 species detected. (There may be an effect of sampling intensity here, since Stevens Canyon had three stations instead of two – see Exhibit 1A.) Meanwhile "Carbon Upper" had just 3 photo events from 1 species. The median number of photo events per block was 65; the median number of species detected was 3 (Exhibit 3C). When only carnivore species are considered, the medians were 47 photo events and 2 species detected.

Species varied in the number of photo events and the number of blocks in which they were detected (Exhibits 4A, 4B). Marten had the greatest apparent abundance and apparent geographic spread, with 691 photo events (more than 50% of all photo events across the entire study, see Exhibit 4A) and detections in 13 blocks, or 65% of those studied. Meanwhile the long-tailed weasel was recorded just twice, once in each of two blocks. The median number of of photo events per species was 8.5; the median number of blocks in which each species was detected was 5 (Exhibit 4C), or 25% of blocks studied.

When photo events and detections were compared, for each species, between wet and dry precipitation classes, a few species showed some possible differences (Exhibit 5). The western spotted skunk, gray jay, and Douglas' squirrel were observed in more "wet" than dry blocks. However, there were more wet blocks *studied* than dry blocks (Exhibit 1). When the frequencies are formally tabled and compared in a standardized way (Exhibit 6A), only the Douglas' squirrel shows a significant difference ($p<0.05$) in the Fisher's Exact Test (Exhibit 6B).

I made similar comparisons for each species on the basis of field season (2001 or 2002) instead of precipitation class (Exhibit 7). Deer mouse, bobcat, and flying squirrel had noticeably more detections in 2001 compared to 2002, but upon standardized tabling (Exhibit 8A) and calculation of Fisher's Exact Test (Exhibit 8B) only the deer mouse shows a significant difference.

The vegetation descriptors recorded for each station may offer a more promising and reasonable way of explaining or predicting animal detections. However, I did not look for any correlations between those descriptors and the available vegetation data. The vegetation data is at the station level of detail, while according to JS, the most reasonable scale for evaluating the animal observations is the block level. Moreover, I was not provided with any particular vegetation-related hypotheses to explore, and I had insufficient time and resources to explore every possible combination of factors. I would be happy to evaluate any such hypotheses should they be spelled out.

The accompanying data set

The accompanying Microsoft Excel workbook contains spreadsheet versions of the SPSS tables I created to generate the results in this report. This workbook contain fields (for example, describing vegetation) that may be of use in the further analyses. The Excel file contains keys to the fields in each table; here is a short orientation to the tables themselves.

EVENTS is a raw, unstandardized record of all photo events, including those from the test stations and blocks. Analysis may be more accurate with S-EVENTS (see below).

STATIONS describes all the camera stations with their block memberships, geographic coordinates, vegetation descriptors, etc.

SPECIES is a key to the species codes used in the study.

S-EVENTS is a standardized listing of EVENTS. It limits itself only to valid (non-test) blocks and stations. It contains cells for photo events and detections for every possible combination of block and species. Most of these cells are filled with zeros, but listing the data this way allows the correct computation of averages, standard deviations, etc, when summarizing blocks or species. Applying such functions (for example, in a spreadsheet formula) to unstandardized data will lead to errors unless precautions are taken.

Exhibit 1. Blocks and stations surveyed

1A. Blocks sampled in Mt. Rainier NP.

			Block	Precipitation class	Field season	Elevation of lowest station (ft)	Elevation of highest station (ft)	No. stations
Station type	study	1	Backbone	Dry	2001	3200	4700	2
		2	Carbon Glacier	Wet	2002	2974	3050	2
		3	Carbon Upper (Ipsut & Glacier)	Wet	2001	3000	3180	2
		4	Carbon Low (River & Green Lake)	Wet	2001	2075	3300	2
		5	Eagle Peak	Wet	2002	4120	5300	2
		6	Eleanor Lake	Dry	2002	4820	5600	2
		7	Ghost Lake	Dry	2002	3790	4602	2
		8	Grand Park	Dry	2002	5140	5420	2
		9	Ipsut Creek	Wet	2002	2777	3870	2
		10	Kautz (lower)	Wet	2001	2600	2650	2
		11	Louise Lake	Wet	2002	4638	5270	2
		12	Mowich	Wet	2001	3630	4388	2
		13	Panther Creek	Dry	2002	2300	2400	2
		14	Kautz upper (Rampart/Pyramid)	Wet	2001	3650	3700	2
		15	Stevens Canyon	Dry	2001	2080	3250	3
		16	Tatoosh	Wet	2001	4595	5475	2
		17	Westside Road	Dry	2002	2480	3000	2
		18	White upper	Wet	2001	5259	5790	2
		19	White middle	Dry	2001	3786	4028	2
		20	White low	Dry	2001	3240	3578	2
	test	1	Frog Heaven	.	.	.	.	1
		2	Glacier Bridge	.	.	4030	4030	1
		3	Nisqually	.	.	.	.	1
		4	Tahoma	.	.	.	.	2

1B. Stations surveyed in Mt. Rainier park.

					Station ID	Station Code	Elevation (ft)	UtmX	UtmY	DateInstalled	DateRemoved
Station type	study	Block	Kautz (lower)	1	5	KAUT-1	2600	586923	5176685	08-MAR-2001 00	21-APR-2001
				2	6	KAUT-2	2650	588425	5178179	09-MAR-2001 00	12-APR-2001
			Kautz upper (Rampart/Pyramid)	1	7	RAMP-1	3700	590360	5179480	10-MAR-2001 00	12-APR-2001
				2	8	PYRA-1	3650	590586	5181024	10-MAR-2001 00	12-APR-2001
			Carbon Low (River & Green Lake)	1	9	CARB-1	3300	587076	5203511	13-MAR-2001 00	08-MAY-2001
				2	10	CARB-2	2075	586488	5205480	13-MAR-2001 00	08-MAY-2001
			Carbon Upper (Ipsut & Glacier)	1	11	CARB-3	3000	588851	5201922	14-MAR-2001 00	21-MAR-2001
				2	12	CARB-4	3180	591790	5200367	14-MAR-2001 00	08-MAY-2001
			Tatoosh	1	13	TATO-1	4595	596025	5182560	14-MAR-2001 00	10-MAY-2001
				2	14	TATO-2	5475	595892	5179630	14-MAR-2001 00	10-MAY-2001
			White low	1	15	WHRI-1	3240	610824	5196353	15-MAR-2001 00	07-MAY-2001
				2	16	WHRI-2	3578	610524	5195127	16-MAR-2001 00	07-MAY-2001
			White middle	1	17	WHRI-3	3786	606506	5194183	23-MAR-2001 00	07-MAY-2001
				2	18	WHRI-4	4028	605596	5192520	23-MAR-2001 00	07-MAY-2001
			White upper	1	19	WHRI-5	5259	600717	5194130	16-MAR-2001 00	07-MAY-2001
				2	20	WHRI-6	5790	599344	5193822	16-MAR-2001 00	07-MAY-2001
			Stevens Canyon	1	21	STCA-1	3250	609085	5178732	21-MAR-2001 00	09-MAY-2001
				2	22	STCA-2	3104	611364	5179087	13-MAR-2001 00	01-MAY-2001
				3	23	STCA-3	2080	610422	5177184	20-MAR-2001 00	09-MAY-2001
			Backbone	1	24	BARI-1	3200	607360	5173250	13-MAR-2001 00	09-MAY-2001
				2	25	BARI-2	4700	608046	5177100	13-MAR-2001 00	09-MAY-2001
			Mowich	1	26	MOWI-1	3630	583875	5198579	06-APR-2001 00	08-MAY-2001
				2	27	MOWI-2	4388	585455	5199397	06-APR-2001 00	08-MAY-2001
			Ghost Lake	1	28	GHLA-1	4602	611279	5191433	11-DEC-2001 00	11-JAN-2002
				2	29	GHLA-2	3790	610771	5193319	11-DEC-2001 00	11-JAN-2002
			Louise Lake	1	30	LOLA-1	5270	597961	5181190	12-DEC-2001 00	17-JAN-2002
				2	31	LOLA-2	4638	597854	5179711	17-DEC-2001 00	11-FEB-2002
			Eleanor Lake	1	32	ELLA-1	4820	602987	5204595	20-DEC-2001 00	11-FEB-2002
				2	33	ELLA-2	5600	601778	5202132	19-DEC-2001 00	05-FEB-2002
			Grand Park	1	34	GRPA-1	5420	599810	5201301	19-DEC-2001 00	05-FEB-2002
				2	35	GRPA-2	5140	599997	5199492	19-DEC-2001 00	05-FEB-2002
			Ipsut Creek	1	36	IPCR-1	2777	588859	5201986	19-DEC-2001 00	05-FEB-2002
				2	37	IPCR-2	3870	587411	5200974	22-JAN-2002 00	28-FEB-2002
			Carbon Glacier	1	38	CAGL-1	2974	591614	5201115	05-FEB-2002 00	06-MAR-2002
				2	39	CAGL-2	3050	590105	5201952	23-JAN-2002 00	07-MAR-2002
			Panther Creek	1	40	PACR-1	2300	610588	5181953	23-JAN-2002 00	07-MAR-2002
				2	41	PACR-2	2400	610306	5184055	07-FEB-2002 00	14-MAR-2002
			Eagle Peak	1	42	EAPE-1	5300	593290	5178194	07-FEB-2002 00	26-MAR-2002
				2	43	EAPE-2	4120	592286	5177298	16-JAN-2002 00	26-FEB-2002
			Westside Road	1	44	WERO-1	2480	585868	5179555	16-JAN-2002 00	05-MAR-2002
				2	45	WERO-2	3000	585218	5182495	06-FEB-2002 00	28-MAR-2002
	test	Block	Frog Heaven	1	3	FROG-1	.	594786	5180854	28-NOV-2000 00	01-MAR-2001
			Glacier Bridge	1	46	GLBR	4030	594186	5181555	06-FEB-2002 00	28-MAR-2002
			Nisqually	1	4	NISQ-1	.	586515	5175992	29-NOV-2000 00	08-MAR-2001
			Tahoma	1	1	TAHO-1	.	585700	5182950	28-NOV-2000 00	05-MAR-2001
				2	2	TAHO-2	.	585222	5177852	29-NOV-2000 00	05-MAR-2001

Exhibits page 2

Exhibit 2. Detailed field results for photo events and detections.

No. of photo events

		Total																				
		Block																				
Category	Species code	Backbone	Carbon Glacier	Carbon Upper (Ipsut & Glacier)	Carbon Low (River & Green Lake)	Eagle Peak	Eleanor Lake	Ghost Lake	Grand Park	Ipsut Creek	Kautz (lower)	Louise Lake	Mowich	Panther Creek	Kautz upper (Rampart/Pyramid)	Stevens Canyon	Tatoosh	Westside Road	White upper	White middle	White low	**Total**
Forest carnivores	Western spotted skunk	0	18	0	6	0	0	0	0	51	46	0	0	0	0	11	0	25	0	0	0	**157**
	black bear	0	0	0	0	0	0	0	0	0	6	0	0	0	0	2	0	0	0	0	0	**8**
	long-tailed weasel	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**2**
	marten	0	1	0	0	4	31	47	95	48	0	48	88	54	0	0	88	0	121	29	37	**691**
	bobcat	1	6	3	43	0	0	0	0	0	0	0	0	19	0	2	0	0	0	1	2	77
	coyote	1	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	2	1	7
	red fox	0	0	0	0	0	0	48	5	0	0	1	0	0	0	0	22	0	2	0	4	**82**
	Total	**2**	**25**	**3**	**50**	**5**	**31**	**95**	**100**	**99**	**52**	**51**	**88**	**74**	**0**	**15**	**110**	**25**	**123**	**32**	**44**	**1024**
Misc. mammals	snowshoe hare	1	0	0	0	1	0	1	4	0	1	0	0	0	0	0	0	1	0	0	0	**9**
	Douglas' squirrel	0	0	0	1	0	0	0	0	2	2	0	0	0	1	0	0	0	11	0	0	**17**
	Flying Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	2	**8**
	Townsend's chipmunk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
	deer mouse	0	0	0	17	0	0	0	0	0	7	0	2	0	2	79	0	0	0	0	3	**110**
	wapiti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
	Total	**1**	**0**	**0**	**18**	**1**	**0**	**1**	**4**	**2**	**10**	**0**	**2**	**0**	**6**	**80**	**0**	**1**	**11**	**3**	**6**	**146**
Birds	Golden eagle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	**4**
	gray jay	0	0	0	0	3	1	3	0	0	0	19	0	0	3	0	2	0	11	0	2	**44**
	Steller's jay	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	1	1	0	**5**
	common raven	0	0	0	0	0	18	8	0	0	0	1	0	0	0	55	0	0	1	0	0	**83**
	varied thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	7
	Total	**0**	**0**	**0**	**0**	**3**	**19**	**11**	**0**	**0**	**0**	**22**	**0**	**1**	**3**	**65**	**2**	**0**	**13**	**1**	**3**	**143**
Total	**Total**								**104**	**101**	**62**	**73**	**90**	**75**	**9**	**160**	**112**	**26**	**147**	**36**	**53**	**1313**

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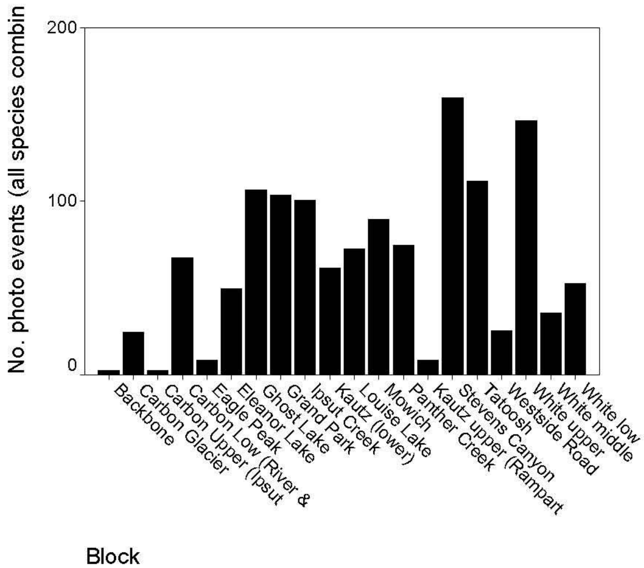
Species detections

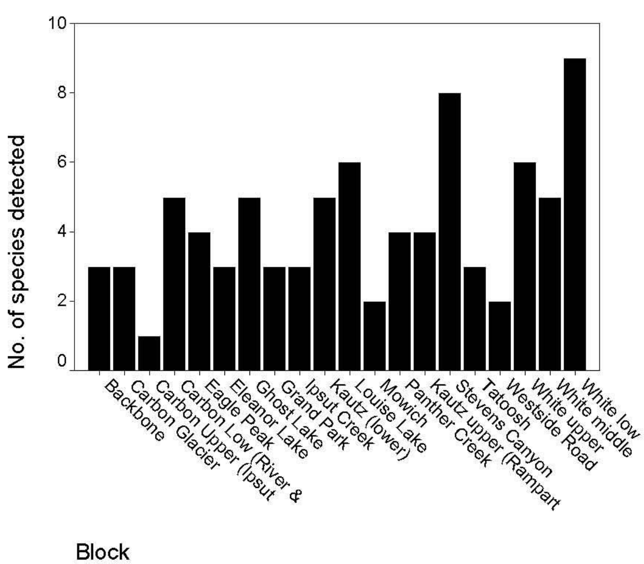
		Total																				
		Block																				
Category	Species code	Backbone	Carbon Glacier	Carbon Upper (Ipsut & Glacier)	Carbon Low (River & Green Lake)	Eagle Peak	Eleanor Lake	Ghost Lake	Grand Park	Ipsut Creek	Kautz (lower)	Louise Lake	Mowich	Panther Creek	Kautz upper (Rampart/Pyramid)	Stevens Canyon	Tatoosh	Westside Road	White upper	White middle	White low	**Total**
Forest carnivores	Western spotted skunk	0	1	0	1	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	**6**
	black bear	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	**2**
	long-tailed weasel	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**2**
	marten	0	1	0	0	1	1	1	1	1	0	1	1	1	0	0	1	0	1	1	1	**13**
	bobcat	1	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	**8**
	coyote	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	**5**
	red fox	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	1	0	1	**6**
	Total	**2**	**3**	**1**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**3**	**1**	**3**	**0**	**3**	**2**	**1**	**2**	**3**	**4**	**42**
Misc. mammals	snowshoe hare	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	**6**
	Douglas' squirrel	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	**5**
	Flying Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	**3**
	Townsend's chipmunk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
	deer mouse	0	0	0	1	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	1	**6**
	wapiti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
	Total	**1**	**0**	**0**	**2**	**1**	**0**	**1**	**1**	**1**	**3**	**0**	**1**	**0**	**3**	**2**	**0**	**1**	**1**	**1**	**3**	**22**
Birds	Golden eagle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
	gray jay	0	0	0	0	1	1	1	0	0	0	1	0	0	1	0	1	0	1	0	1	**8**
	Steller's jay	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	**4**
	common raven	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	1	0	0	**5**
	varied thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	**2**
	Total	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**	**0**	**0**	**3**	**0**	**1**	**1**	**3**	**1**	**0**	**3**	**1**	**2**	**20**
Total	**Total**							**5**	**3**	**3**	**5**	**6**	**2**	**4**	**4**	**8**	**3**	**2**	**6**	**5**	**9**	**84**

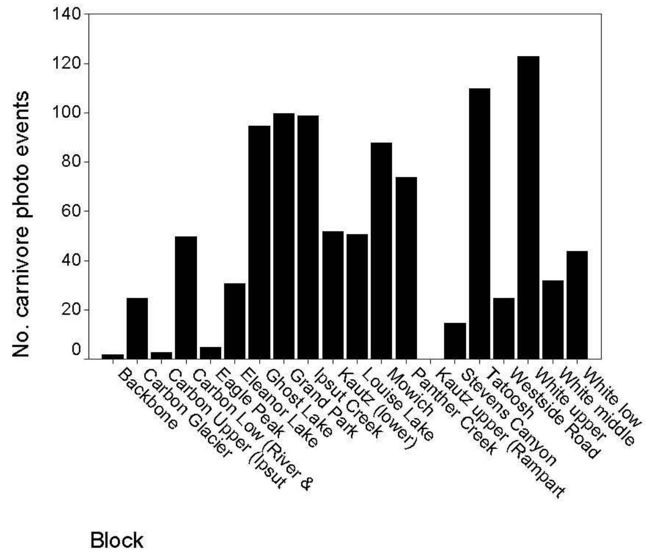
Exhibits page 4

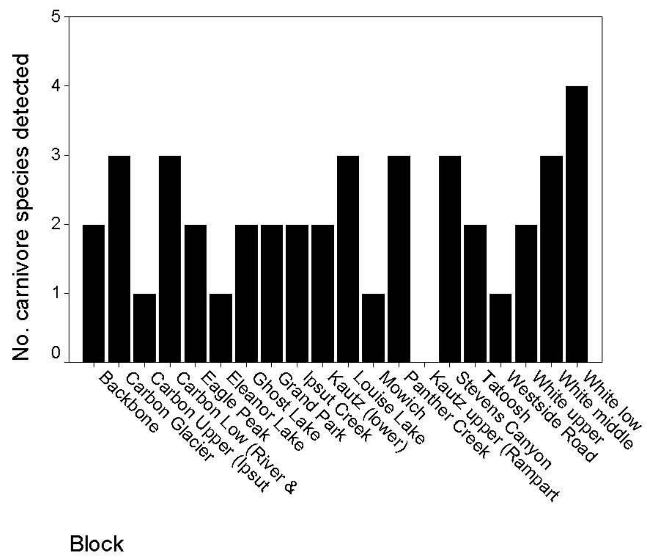
Exhibit 3. How the number of photo events and species detections varied among blocks studied.

3A. Graphs illustrating variation in photo events and species detections among blocks









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3B. Tabular summary of photo events and detections by block

	Block	Precipitation class	Field season	No. photo events (all species combined)	No. of species detected	No. carnivore photo events	No. carnivore species detected
1	Backbone	Dry	2001	3	3	2	2
2	Carbon Glacier	Wet	2002	25	3	25	3
3	Carbon Upper (Ipsut & Glacier)	Wet	2001	3	1	3	1
4	Carbon Low (River & Green Lake)	Wet	2001	68	5	50	3
5	Eagle Peak	Wet	2002	9	4	5	2
6	Eleanor Lake	Dry	2002	50	3	31	1
7	Ghost Lake	Dry	2002	107	5	95	2
8	Grand Park	Dry	2002	104	3	100	2
9	Ipsut Creek	Wet	2002	101	3	99	2
10	Kautz (lower)	Wet	2001	62	5	52	2
11	Louise Lake	Wet	2002	73	6	51	3
12	Mowich	Wet	2001	90	2	88	1
13	Panther Creek	Dry	2002	75	4	74	3
14	Kautz upper (Rampart/Pyramid)	Wet	2001	9	4	0	0
15	Stevens Canyon	Dry	2001	160	8	15	3
16	Tatoosh	Wet	2001	112	3	110	2
17	Westside Road	Dry	2002	26	2	25	1
18	White upper	Wet	2001	147	6	123	2
19	White middle	Dry	2001	36	5	32	3
20	White low	Dry	2001	53	9	44	4

3C. Statistics summarizing variation in photo events and species detections among blocks.

		No. photo events (all species combined)	No. of species detected	No. carnivore photo events	No. carnivore species detected
N (no. of blocks studied)	Valid	20	20	20	20
	Missing	0	0	0	0
Mean		65.65	4.20	51.20	2.10
Std. Error of Mean		10.467	.445	8.898	.216
Median		65.00	4.00	47.00	2.00
Mode		3[a]	3	25	2
Std. Deviation		46.808	1.989	39.792	.968
Minimum		3	1	0	0
Maximum		160	9	123	4

a. Multiple modes exist. The smallest value is shown

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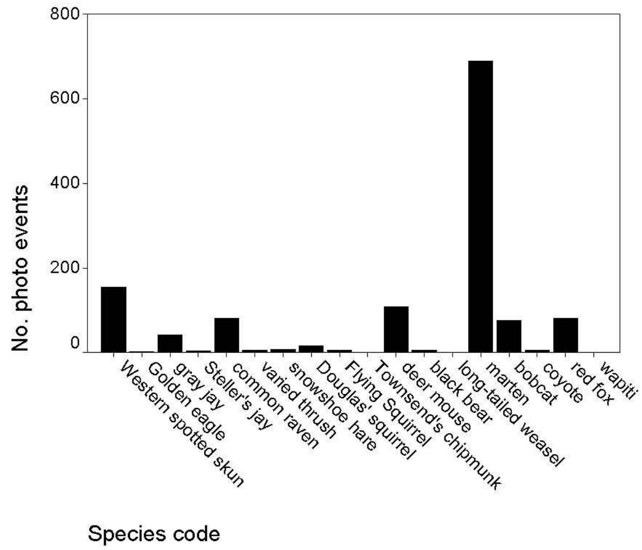
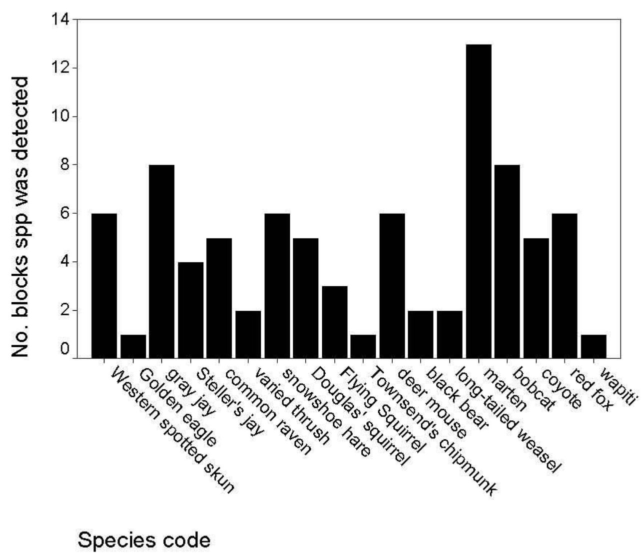
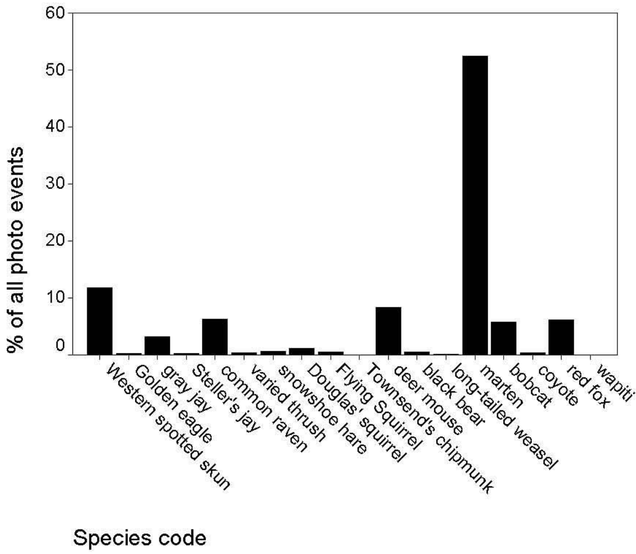
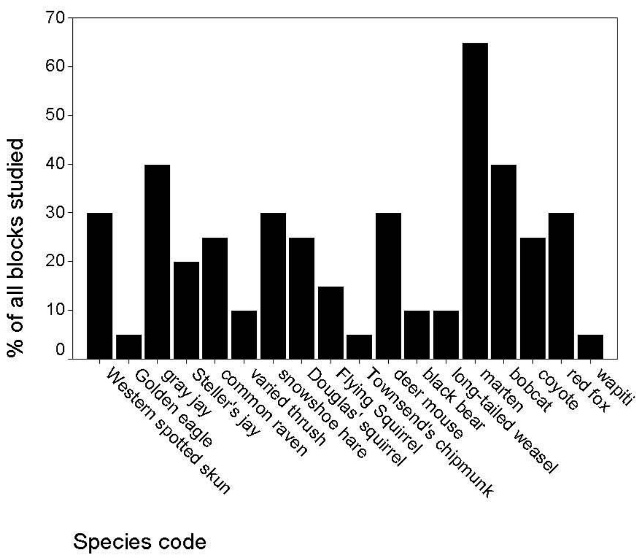
Exhibit 4. How species varied in the number of photo events and the number of blocks in which they were detected.

4A. Graphs illustrating variation in photo events and number of blocks among species









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4B. Tabular summary of photo events and detections by species.

Sum

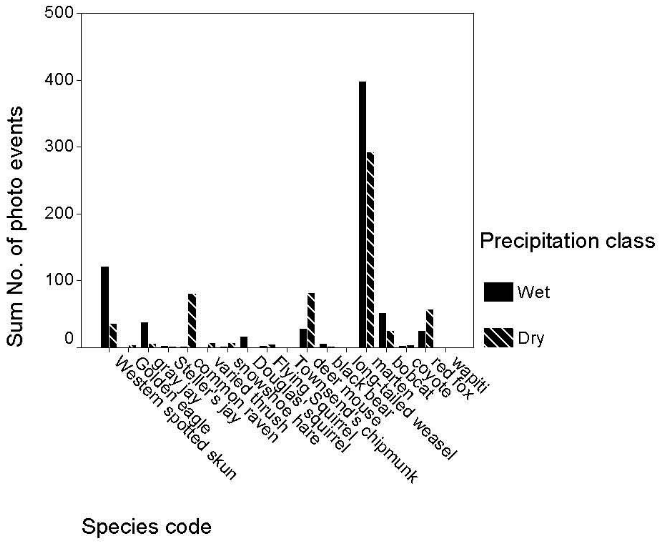
Category	Species code	No. of photo events 2001	No. of photo events 2002	No. of photo events Total	Species detections 2001	Species detections 2002	Species detections Total
		Field season			Field season		
Forest carnivores	Western spotted skunk	63	94	157	3	3	6
	black bear	8	0	8	2	0	2
	long-tailed weasel	1	1	2	1	1	2
	marten	363	328	691	5	8	13
	bobcat	52	25	77	6	2	8
	coyote	4	3	7	3	2	5
	red fox	28	54	82	3	3	6
	Total	519	505	1024	23	19	42
Misc. mammals	snowshoe hare	2	7	9	2	4	6
	Douglas' squirrel	15	2	17	4	1	5
	Flying Squirrel	8	0	8	3	0	3
	Townsend's chipmunk	1	0	1	1	0	1
	deer mouse	110	0	110	6	0	6
	wapiti	1	0	1	1	0	1
	Total	137	9	146	17	5	22
Birds	Golden eagle	4	0	4	1	0	1
	gray jay	18	26	44	4	4	8
	Steller's jay	2	3	5	2	2	4
	common raven	56	27	83	2	3	5
	varied thrush	7	0	7	2	0	2
	Total	87	56	143	11	9	20
Total	Total	743	570	1313	51	33	84

4C. Range among species of photo events and blocks detected

		No. photo events	No. blocks where spp was detected
N (no. of species detected)	Valid	18	18
	Missing	0	0
Mean		72.94	4.67
Std. Error of Mean		37.945	.732
Median		8.50	5.00
Mode		1[a]	6
Std. Deviation		160.985	3.106
Minimum		1	1
Maximum		691	13

a. Multiple modes exist. The smallest value is shown

Exhibit 5. Photo events and species detections compared between precipitation classes



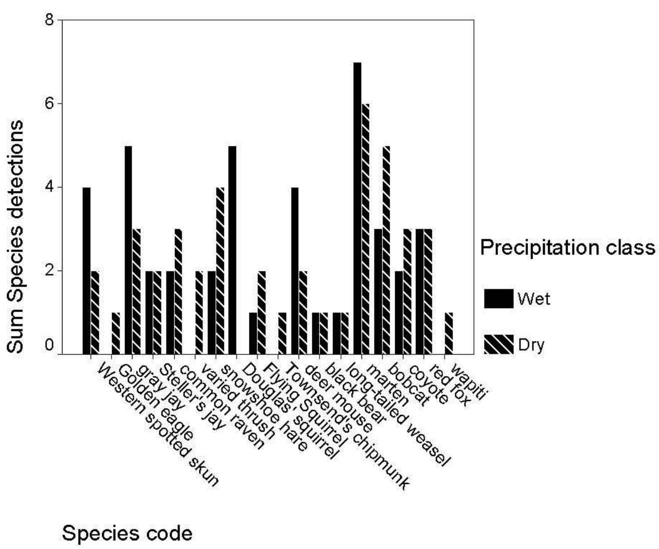


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Exhibit 6. Tabulation and test of species detections vs. precipitation class

6A. Species detections * Precipitation class Crosstabulation

			number of blocks		
			Precipitation class		
Species code			Wet	Dry	Total
Western spotted skunk	Species detected	no	7	7	14
		yes	4	2	6
	Total		11	9	20
Golden eagle	Species detected	no	11	8	19
		yes		1	1
	Total		11	9	20
gray jay	Species detected	no	6	6	12
		yes	5	3	8
	Total		11	9	20
Steller's jay	Species detected	no	9	7	16
		yes	2	2	4
	Total		11	9	20
common raven	Species detected	no	9	6	15
		yes	2	3	5
	Total		11	9	20
varied thrush	Species detected	no	11	7	18
		yes		2	2
	Total		11	9	20
snowshoe hare	Species detected	no	9	5	14
		yes	2	4	6
	Total		11	9	20
Douglas' squirrel	Species detected	no	6	9	15
		yes	5		5
	Total		11	9	20
Flying Squirrel	Species detected	no	10	7	17
		yes	1	2	3
	Total		11	9	20
Townsend's chipmunk	Species detected	no	11	8	19
		yes		1	1
	Total		11	9	20
deer mouse	Species detected	no	7	7	14
		yes	4	2	6
	Total		11	9	20

6A. Species detections * Precipitation class Crosstabulation

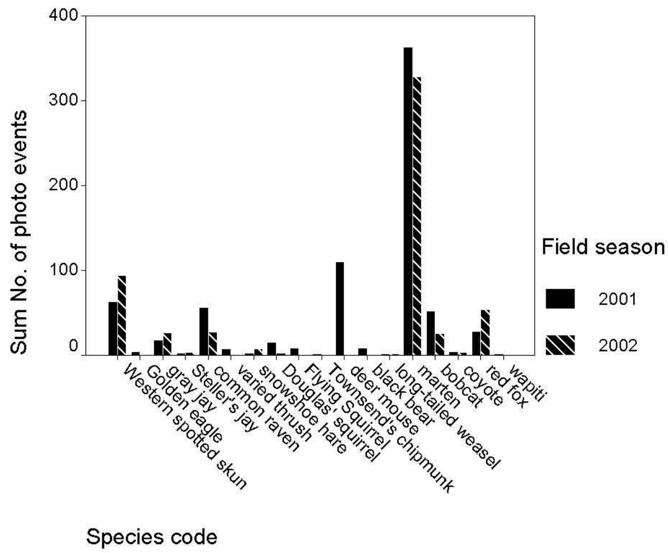
Species code			number of blocks: Precipitation class: Wet	Dry	Total
black bear	Species detected	no	10	8	18
		yes	1	1	2
	Total		11	9	20
long-tailed weasel	Species detected	no	10	8	18
		yes	1	1	2
	Total		11	9	20
marten	Species detected	no	4	3	7
		yes	7	6	13
	Total		11	9	20
bobcat	Species detected	no	8	4	12
		yes	3	5	8
	Total		11	9	20
coyote	Species detected	no	9	6	15
		yes	2	3	5
	Total		11	9	20
red fox	Species detected	no	8	6	14
		yes	3	3	6
	Total		11	9	20
wapiti	Species detected	no	11	8	19
		yes		1	1
	Total		11	9	20

6B. Chi-Square Tests

Fisher's Exact Test

Species code	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Western spotted skunk	.642	.426
Golden eagle	.450	.450
gray jay	.670	.465
Steller's jay	1.000	.625
common raven	.617	.396
varied thrush	.189	.189
snowshoe hare	.336	.217
Douglas' squirrel	.038	.030
Flying Squirrel	.566	.421
Townsend's chipmunk	.450	.450
deer mouse	.642	.426
black bear	1.000	.711
long-tailed weasel	1.000	.711
marten	1.000	.630
bobcat	.362	.205
coyote	.617	.396
red fox	1.000	.574
wapiti	.450	.450

Exhibit 7. Photo events and species detections compared among field seasons



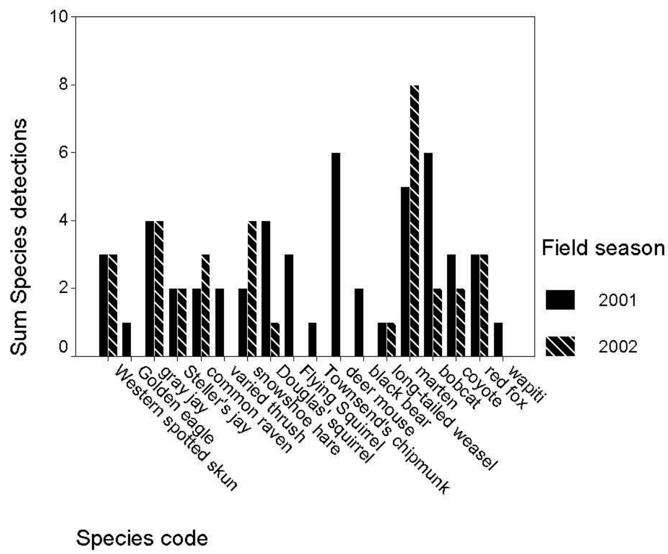


Exhibit 8. Tabulation and test of species detections vs. precipation class

8A. Species detections * Field season Crosstabulation

Species code			number of blocks Field season 2001	2002	Total
Western spotted skunk	Species detected	no	8	6	14
		yes	3	3	6
	Total		11	9	20
Golden eagle	Species detected	no	10	9	19
		yes	1		1
	Total		11	9	20
gray jay	Species detected	no	7	5	12
		yes	4	4	8
	Total		11	9	20
Steller's jay	Species detected	no	9	7	16
		yes	2	2	4
	Total		11	9	20
common raven	Species detected	no	9	6	15
		yes	2	3	5
	Total		11	9	20
varied thrush	Species detected	no	9	9	18
		yes	2		2
	Total		11	9	20
snowshoe hare	Species detected	no	9	5	14
		yes	2	4	6
	Total		11	9	20
Douglas' squirrel	Species detected	no	7	8	15
		yes	4	1	5
	Total		11	9	20
Flying Squirrel	Species detected	no	8	9	17
		yes	3		3
	Total		11	9	20
Townsend's chipmunk	Species detected	no	10	9	19
		yes	1		1
	Total		11	9	20
deer mouse	Species detected	no	5	9	14
		yes	6		6
	Total		11	9	20

8A. Species detections * Field season Crosstabulation

Species code			number of blocks: Field season 2001	2002	Total
black bear	Species detected	no	9	9	18
		yes	2		2
	Total		11	9	20
long-tailed weasel	Species detected	no	10	8	18
		yes	1	1	2
	Total		11	9	20
marten	Species detected	no	6	1	7
		yes	5	8	13
	Total		11	9	20
bobcat	Species detected	no	5	7	12
		yes	6	2	8
	Total		11	9	20
coyote	Species detected	no	8	7	15
		yes	3	2	5
	Total		11	9	20
red fox	Species detected	no	8	6	14
		yes	3	3	6
	Total		11	9	20
wapiti	Species detected	no	10	9	19
		yes	1		1
	Total		11	9	20

8B. Chi-Square Tests

Fisher's Exact Test

Species code	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Western spotted skunk	1.000	.574
Golden eagle	1.000	.550
gray jay	1.000	.535
Steller's jay	1.000	.625
common raven	.617	.396
varied thrush	.479	.289
snowshoe hare	.336	.217
Douglas' squirrel	.319	.221
Flying Squirrel	.218	.145
Townsend's chipmunk	1.000	.550
deer mouse	.014	.012
black bear	.479	.289
long-tailed weasel	1.000	.711
marten	.070	.058
bobcat	.197	.157
coyote	1.000	.604
red fox	1.000	.574
wapiti	1.000	.550

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 105/106298, December 2010

National Park Service
U.S. Department of the Interior

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