North Coast and Cascades Network

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Supplemental Forest Carnivore Surveys in North Cascades National Park Service Complex, Washington

National Park Service
North Coast and Cascades Network




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North Cascades National Park Service Complex, comprising North Cascades National Park, Ross Lake National Recreation Area, and Lake Chelan National Recreation Area, was established in October, 1968 and is located in northwestern Washington. North Cascades National Park was established to preserve certain majestic mountain scenery, snow fields, glaciers, alpine meadows, and other unique natural features in the North Cascades mountains for the benefit, use, and inspiration of present and future generations. Ross Lake and Lake Chelan National Recreation Areas were established to provide for outdoor recreation use and enjoyment and to conserve scenic, scientific, historic, and other values contributing to public enjoyment of these lands and waters.

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EXECUTIVE SUMMARY

Forest carnivore surveys using remotely triggered cameras were conducted in North Cascades National Park Service Complex (NOCA) from mid-May through mid-August 2005. Sampling units consisted of 4 mi^2 blocks with two camera stations per block, with each camera separated by a minimum of one mile. Surveys focused on three target species; fisher (*Martes pennanti*), wolverine (*Gulo gulo*) and Canada lynx (*Lynx canadensis*) which were not previously detected in NOCA using the remote camera method. American marten (*Martes americana*) were also a species of interest, although they had previously been detected in NOCA using the camera method. A total of 11 blocks (22 sub-blocks) were sampled, however only 17 sub-blocks were sampled to the full 28-night protocol standard. Five sub-blocks fell short of the 28-night sampling standard due to equipment malfunctions and the remoteness of these stations which precluded regularly scheduled visits. From this effort we obtained 129 identifiable animal photos of 12 mammal species including five carnivore species. American black bear (*Ursus americanus*) were the most frequently detected carnivore species with detections at 81.8% of the sampling blocks. American marten were the second most frequently detected species occurring at 45.5% of the sampling blocks. Other carnivore species detected included coyote (*Canis latrans*), northern raccoon (*Procyon lotor*) and an unidentified felid, found at 18.2%, 9.1%, and 9.1% of sampling blocks respectively. Cameras also documented mule deer (*Odocoileus hemionus*), Douglas squirrel (*Tamiasciurus douglasii*), field mouse (*Peromyscus sp.*), northern flying squirrel (*Glaucomys sabrinus*), Townsend's chipmunk (*Tamias townsendii*), snowshoe hare (*Lepus americanus*) and hoary marmot (*Marmota caligata*). No detections were made of fisher, wolverine or lynx. It appears these species are indeed very rare and elusive in NOCA.

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INTRODUCTION

Reported declines throughout western North America in abundances and distributions of mid-sized forest carnivores such as marten (*Martes americana*), fisher (*Martes pennanti*), wolverine (*Gulo gulo*) and Canada lynx (*Lynx canadensis*) have prompted conservation concerns (Maj and Garton 1994). Information gaps that preclude the development of effective management strategies for these species include limited knowledge of forest carnivore habitat relationships at the landscape scale (Ruggiero et al. 1994) and the relative importance of habitat characteristics at various scales, such as stand vs. landscape (Bissonette and Broekhuizen 1995). Determining current geographic distributions of these species and evaluating differences in current and historical ranges is a first step in addressing these concerns (Buskirk and Zielinski 2003). Initial survey work was completed in the mid-1990's throughout much of the suitable forest carnivore habitat in Washington (Lewis and Stinson 1998). However, a substantial amount of unsurveyed land still remained within the three large parks of Washington; Mount Rainier National Park (MORA), Olympic National Park (OLYM), and North Cascades National Park Service Complex (NOCA).

In 2000 the National Park Service Natural Resource Challenge was developed to improve management of natural resources in national parks with an increased emphasis on scientific knowledge. This initiative was designed to provide funding for vertebrate species inventories. Pursuant to this plan, the North Coast and Cascades Network (NCCN) Inventory and Monitoring Technical Committee identified forest carnivores as among the highest priority taxa requiring more information to effectively protect these rare species (NCCN 2001). Subsequently each NCCN large park conducted a 2-year inventory of forest carnivores; MORA in the winters of 2001 and 2002, OLYM in 2002 and 2003, and NOCA in 2003 and 2004.

From these surveys no fisher, wolverine or lynx were documented in any of the three parks (Christophersen et al. 2005; Happe et al. 2005; J. Schaberl unpublished data). The NOCA sampling scheme may have been biased towards winter safety concerns which prohibited access to the more remote and perhaps more suitable forest carnivore habitat areas. With that in mind, the program recommended augmenting the completed 2003 and 2004 survey with additional sampling to be completed during the summer of 2005 when access to remote areas would be more reasonable. This report summarizes the results of that survey. The objectives were to survey new drainages that could not be accessed during the winter months in order to:

1. Document forest carnivore species presence in NOCA, targeting species that were not previously detected during the 2003 and 2004 survey, primarily wolverine, fisher and lynx.
2. Further describe the distribution of other forest carnivore species detected in NOCA.

STUDY AREA

NOCA is located in northwestern Washington and includes North Cascades National Park, Lake Chelan National Recreation Area, and Ross Lake National Recreation Area (Figure 1). NOCA, also referred to as the 'park complex', lies within two very different biogeographic zones: the temperate marine on the west side of the Cascade crest and the semi-arid continental east of the crest (Franklin and Dyrness 1973). Elevation gradients are extreme and range from 119 m in the low elevation forested valleys to 2,806 m at high elevation glaciated mountain peaks. Total land area of this extensive mountainous terrain encompasses 276,815 ha, of which approximately 93% is designated wilderness.

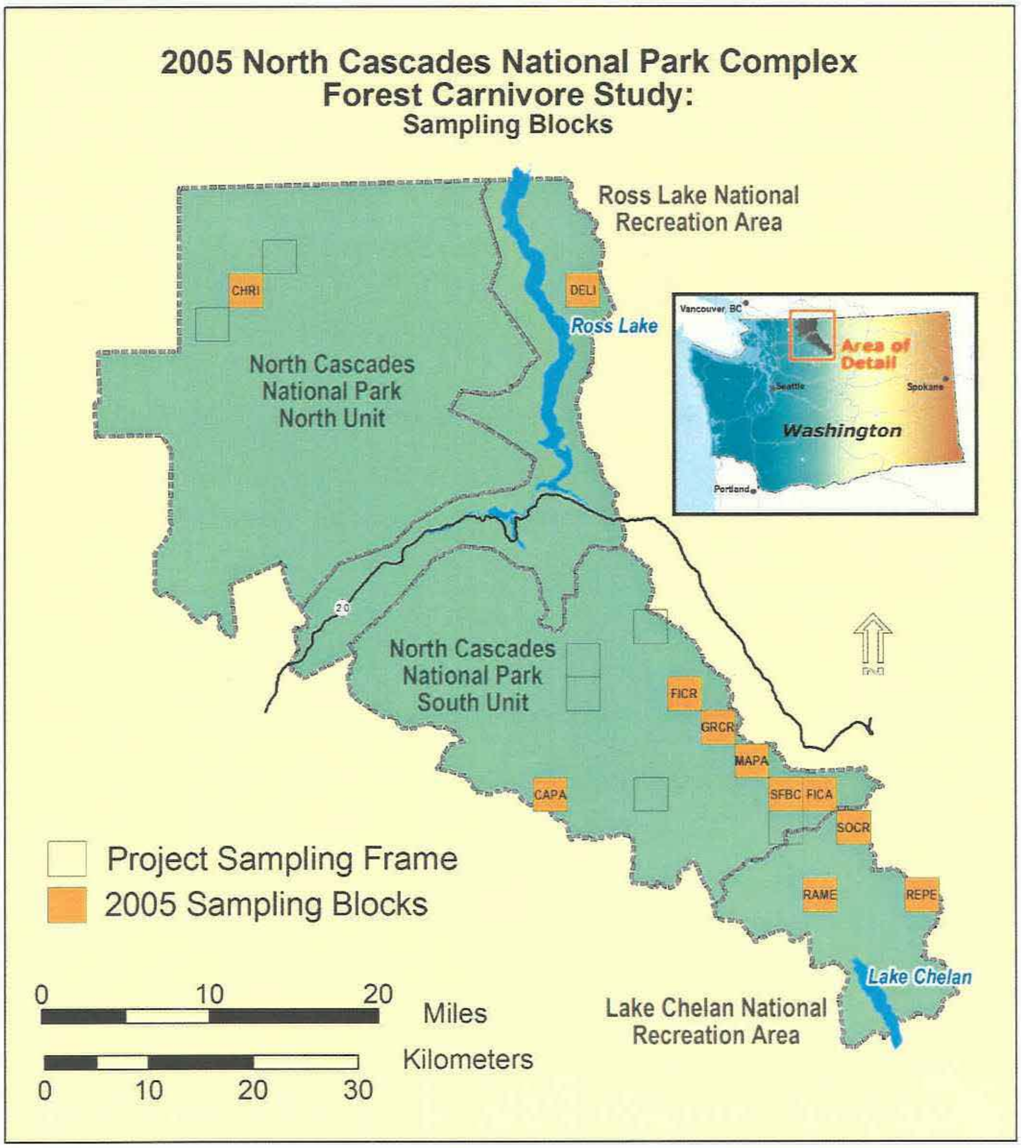

Figure 1. Study area and location of forest carnivore sampling blocks, NOCA 2005.

A seasonally wet maritime climate is representative of the region west of the Cascade crest. Here, summers are relatively dry and typically cool with the majority of precipitation falling during the mild wet winters. Average annual precipitation on the west-slope ranges from 203-897 cm (Sumioka et al. 1998). As characterized by Agee and Kertis (1986), the Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) cover types dominate west-side forested habitat below 1,220 m. Above 1,220 m, forested habitat west of the crest is dominated by Pacific silver fir (*Abies amabilis*), interspersed with mountain hemlock (*Tsuga mertensiana*) and Alaska yellowcedar (*Chamaecyparis nootkantensis*) cover types (Agee and Kertis 1986).

The Cascade crest creates a rain shadow effect to the east and a climate that is much more influenced by continental air masses. As a result, east-slope conditions consist of cold winters and warm dry summers, with average annual precipitation measuring from 76 cm in the lower Stehekin Valley to 897 cm along the Cascade crest (Sumioka et al. 1998). Forested habitat below 1, 220 m is dominated by the Douglas-fir cover type with lodgepole pine (*Pinus contorta*) and ponderosa pine (*Pinus ponderosa*) commonly found as significant components, while forests above 1,220 m are dominated by subalpine fir (*Abies lasiocarpa*), interspersed with mountain hemolock and Englemann spruce (*Picea engelmannii*) cover types (Agee and Kertis 1986).

METHODS

Sampling Scheme

Field surveys were conducted from mid-May through mid-August 2005. We followed standard forest carnivore survey techniques and protocols that utilize remotely triggered cameras (Zielinski and Kucera 1995). These techniques have been successfully implemented by other researchers throughout the western states. We did, however, deviate slightly from the standard protocol in that we did not use bait (eg. whole feather chickens). We therefore limited ourselves to using only commercial scent lures as an attractant to the camera stations. Our main objective in this decision was to minimize encounters with bears.

Layout of sampling blocks and site selection was similar to that developed for the NOCA 2003 and 2004 winter carnivore surveys (Christophersen et al. 2005). Initially a Geographical Information Systems (GIS) grid overlay of 4mi^2 blocks was used across the entire park complex. Actual block selection differed somewhat from the 2003 and 2004 surveys in that the 2005 sampling blocks were not selected randomly. We narrowed our sampling universe considerably by identifying habitat broadly described as suitable for lynx, wolverine and fisher (Buskirk and Powel 1994; Powel and Zielinski 1994). We also mapped anecdotal occurrence records of the three target carnivore species from our NOCA wildlife database. Priority selection was given to those blocks that had suitable habitat overlap between the species and where anecdotal sightings of the three target species were displayed on the GIS overlay map. Slopes greater than 35 degrees were eliminated for safety reasons. We set no limit on distances from a trailhead or road, therefore many sites were a 2-day hike from the trailhead and required overnight camping. Given these factors and habitat criteria selected for each target species it turned out that an overwhelming amount of the selected blocks (8 out of 11) were located either on the east side of Ross Lake or east of the Cascade crest. The remaining three sites were located in the Cascade and Chilliwack River drainages west of the crest.

Detection Method

We used a dual-sensor remote camera system consisting of an automatic 35-mm camera connected to a Trailmaster 550® infrared trail monitor. Commercial scent lures including marten essence, skunk oil mixed with lanolin, Spots o' Plenty® (for felids) and anise oil were used for attractants. We also suspended a large bird feather from a nearby branch as an additional visual attractant. Camera stations were left installed for a minimum 28-night sampling period per protocol procedures (Kucera et al. 1995). To account for occasional equipment malfunctions it became necessary to keep some camera stations installed beyond the 28-night sampling period in order to meet the minimum required sampling effort. Camera stations were installed and maintained by a 3-person crew with an occasional fourth-person volunteer. Various combinations of teams were arranged according to how many people were available and the logistics involved getting to the particular sampling site. Every attempt was made to check each camera station on an approximate 14-day interval. Providing there were no technical problems that would require additional visits, each station was visited three times (installation, check and removal). The exception involved two blocks that were in such remote areas that in the essence of time we decided to forgo the normal 14-day check visit.

Habitat Sampling

We broadly characterized the vegetation composition and structure of the forest stand at each camera station following the methods used in Christophersen et al. (2005). Examples of field forms and procedures for filling them out are also provided in the aforementioned document. Universal Transverse Mercator (UTM) coordinates and topographic variables, such as relative slope position and elevation, were also recorded for each station (Appendix F).

Data Management

For the purposes of this document we used the term 'block' when referencing the 4 mi^2 grid cell containing the two cameras. When referencing individual stations we used the term 'sub-block' or 'camera station'. We considered a block sampled if at least one of the two cameras was operational for the full 28-night period. To maintain consistency and equal sampling effort, every attempt was made to insure both camera stations within a block were operational for the protocol standard of 28 nights.

We initially used 36-exposure, 400 ASA-slide film. Development occurred locally within 24 hours from the time it was dropped off at the photo shop. We later changed to 24 exposure film for cost saving purposes, since there were so few photos taken on many of the film rolls. After development, each slide was examined for species identification and labeled with site name acronym, species, event number, frame number and date and time the photo was taken according to the sensor data. Photos that had no animal present due to a sensor malfunction or the animal escaping before the camera shutter fired were classified as 'no animal observed'. Photos that contained an unidentifiable animal due to poor quality of the picture were classified as 'unknown animal'. Photos that were taken to check the cameras operational status were counted as 'test photos'. Those photos that fell into any of these three categories were not included in the 'total identifiable animal photos' count or subsequent categorization (Appendix A & B). To maintain quality control we randomly selected one half of the total sub-blocks and rechecked all photos from this subset for accuracy.

StatPack software Version 2000.1212.8 was used to download and organize the Trailmaster event data (Goodson and Associates, Inc. 2000). Field data were entered into a relational MS Access database Version 2002. Queries for detection frequency, number of photos for each species by block and sub-block, and vegetation characteristics were extracted from the database and then imported into a MS Excel spreadsheet Version 2002 for chart development and descriptive summaries.

RESULTS

Survey Effort

We sampled to protocol 11 blocks during the months of mid-May to mid-August 2005 (Appendix A). Two additional cameras stations, each in separate blocks, were strategically installed while enroute to other planned destinations. These two camera stations were considered incidental stations with results reported separately. Of the 11 blocks (22 sub-blocks), 17 sub-blocks were sampled the minimum 28 camera nights, while five camera stations fell short of the required 28 night period due to technical malfunctions. These five sites with site acronyms of FICA-1, SFBC-2, CHRI-1 GRCR-2 and REPE-2 (Appendix B) were each sampled 20, 15, 10, 21 and 26 nights respectively. This represents a sampling effort of 568 operable camera nights. From this effort we recorded 129 identifiable animal photos (Table 1) of 12 mammal species including five carnivore species (Table 2). The number of total animal species detected in each block ranged from 1-7 with a mean of 3.3 while the number of carnivore species detected per block ranged from 1-3 with a mean of 1.6 (Table 1). Two sub-blocks (DELI-1 and CAPA-1) had no animal detections whatsoever (Appendix D).

Camera Operation

Seven of the 22 sub-blocks experienced some sort of technical difficulty that rendered the site non-operational for a period of time. Five of these seven sub-blocks did not meet the full 28-night sampling protocol (Appendix B), due to camera and or sensor damage induced by bear activity. These five camera stations were in such remote areas that time and budget constraints did not allow for an extension of sampling time and hence a fourth visit to these sites. The two remaining sub-blocks experienced film depletion which we think was most likely a technical problem related to direct sunlight on the sensor, which in turn created sufficient heat combined with some motion triggering object such as vegetation that inadvertently tripped the camera. These two camera stations required extended sampling of 14 and 17 camera nights respectively in order to satisfy the protocol requirements. Since these two camera stations were not as remote as the others it was more feasible to extend the sampling period and visit the sites a fourth time.

Table 1. Counts of pictures taken, frequency of detections and number of total species and carnivore species detected, NOCA 2005.

Year of Survey	**2005**
Number of Sample Blocks	**(n=11)**
Number of Pictures (excludes test photos)	352
Number of Animal Pictures	129
Number of No Animal Pictures (includes unknowns)	223
% Animal Pictures	36.6
Frequency of Species Detected[1] [mean (range)]	3.3 (1-7)
Frequency of Carnivore Detected[2] [mean (range)]	1.6 (1-3)
Total Number of Species Detected	12
Number of Forest Carnivore Species Detected	5

[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).

Table 2. Animal species detected and percent of sample blocks and sub-blocks at which species were detected using remotely triggered cameras, NOCA 2005.

Species Common Name	Sample blocks (n=11) Number (% of blocks)	Sample sub-blocks (n=22)[1] Number (% of sub-blocks)
Forest Carnivores		
American black bear	9 (81.8)	14 (63.6)
American marten	5 (45.5)	6 (27.3)
Coyote	2 (18.2)	2 (9.1)
Raccoon	1 (9.1)	1 (4.5)
Felid[1]	1 (9.1)	1 (4.5)
Misc. Mammals		
Mule deer	8 (72.7)	14 (63.6)
Douglas squirrel	3 (27.3)	3 (13.6)
Field Mouse[2]	2 (18.2)	2 (9.1)
Northern flying squirrel	2 (18.2)	3 (13.6)
Townsend's chipmunk	2 (18.2)	2 (9.1)
Snowshoe hare	2 (18.2)	2 (9.1)
Hoary Marmot	2 (18.2)	2 (9.1)

[1]Five sub-blocks not sampled to full 28 night protocol.
[2]Unable to identify to species level from photo.

Forest Carnivores Detected

Though not a target species, American black bear (*Ursus americanus*) was the most frequently detected carnivore species (see Appendix C for black bear distribution map). They were detected at 81.8% (9 of 11) of sample blocks and comprised 28.7% (37 of 129) of the total animal photos (Figure 2). They were found both east and west of the

Cascades crest. Elevation of black bear detections ranged from 792 m to 1,897 m with a mean of 1,330 m. This compares to an elevation range of 728 m to 1,897 m and a mean of 1,380 m for all sampling stations. The number of bear photos taken per individual camera station ranged from 1-6 photos with a mean of 2.6.

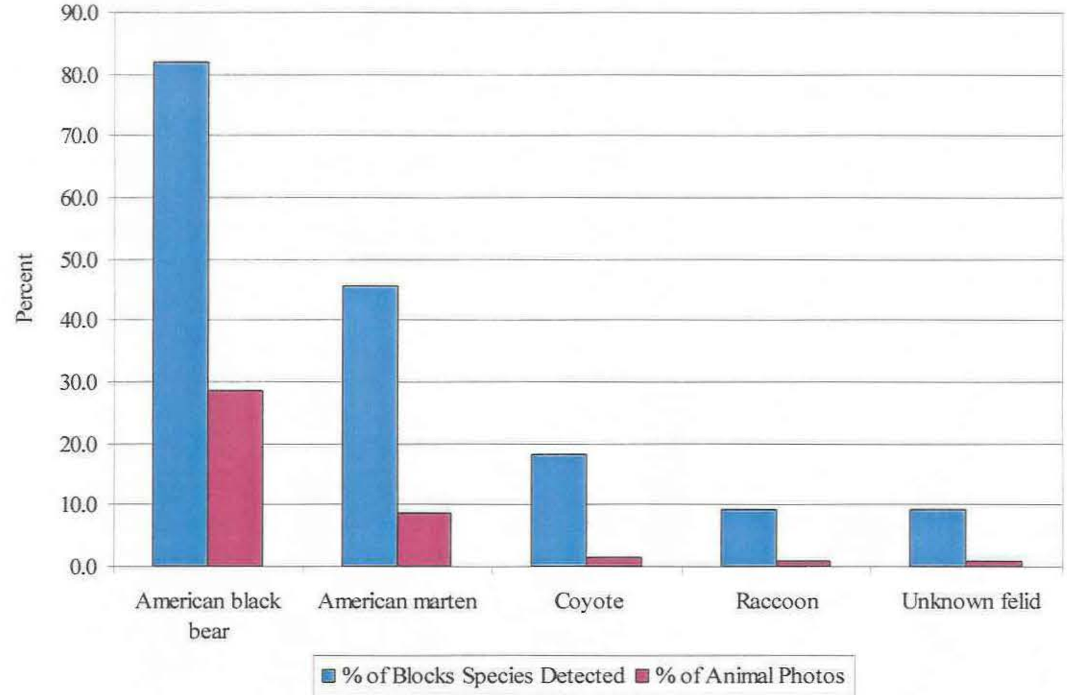

Figure 2. Species of carnivores detected shown as percent of sampling blocks with detections and percent of total animal photos for each species.

American marten were the second most frequently detected carnivore species (see Appendix C for distribution map). They were found at 45.5% (5 of 11) of the sampling blocks and comprised 8.5% (11 of 129) of the total animal photos taken (Figure 2). Four of the five blocks where they were detected were located east of the Cascade crest. Martens occurred at elevations ranging from 1,067 m to 1,848 m with a mean of 1,521 m. The number of nights that martens visited individual camera stations within the 28-night sampling period ranged from 1-5 nights with a mean of 1.8. The number of photos taken at camera stations where marten were present was few, again ranging from 1-5 with a mean of 1.8 photos per occupied station.

The frequency of detections for the three remaining carnivore species was quite low (Figure 2). Coyote (*Canis latrans*) were detected at 18.2% (2 of 11) of sampling blocks and comprised 1.6% (2 of 129) of the total photos. Both blocks in which they were detected are located in remote drainages east of the crest (Appendix C). Raccoon (*Procyon lotor*) and an unknown felid (*Lynx sp.*) were both detected at 9.1% (1 of 11) of the sampling blocks (Appendix C), with each representing 0.8% (1 of 129) of the total photos. The unknown felid was difficult to positively identify to species level due to poor photo quality. It was presumably either a bobcat (*Lynx rufus*) or lynx. This was the first time raccoon was detected in NOCA using the remotely triggered camera system. It was detected in a riparian area in the extreme northwest section of the park complex.

Other Animal Detections
Aside from forest carnivores, seven other animal species were detected (Figure 3). These included mule deer (*Odocoileus hemionus*), Douglas squirrel (*Tamiasciurus douglasii*), hoary marmot (*Marmota caligata*), northern flying squirrel (*Glaucomys sabrinus*), Townsend's chipmunk (*Tamias townsendii*), snowshoe hare (*Lepus americanus*) and field mouse (*Peromyscus sp.*). It was not possible to identify the field mouse to species level due to the small size relationship and insufficient details in the photo.

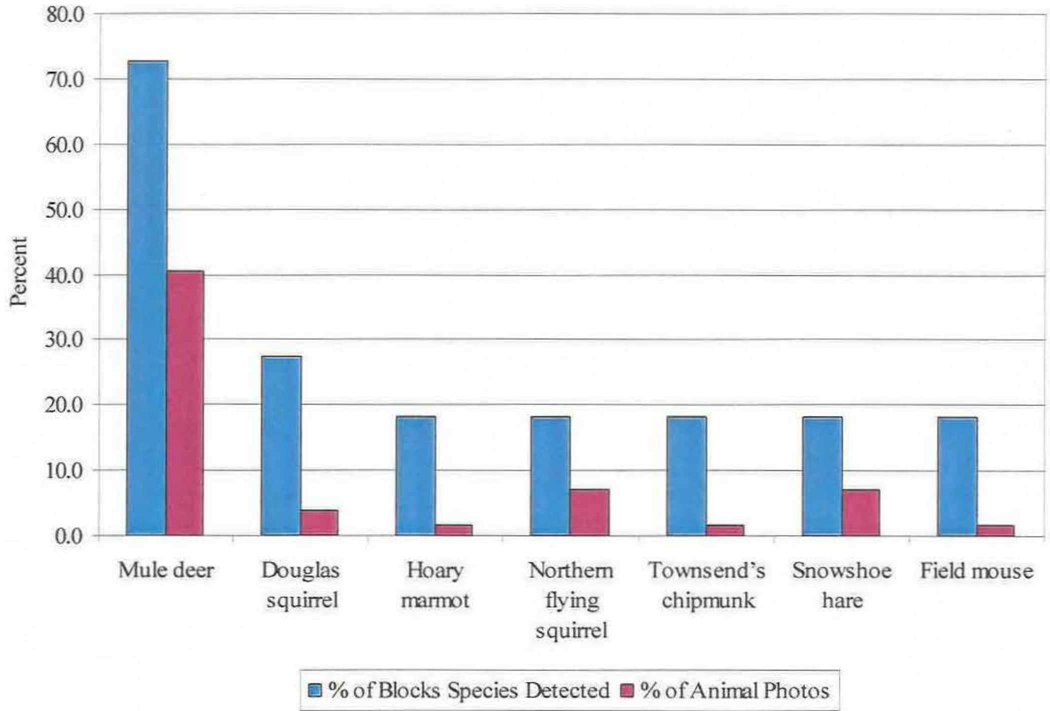

Figure 3. Species of other mammals detected shown as percent of sampling blocks with detections and percent of total animal photos for each species.

Incidental Camera Stations
Two cameras, each in separate blocks, were added as incidental sampling stations. They were added because of their unique geographic location. Each site was situated just below a prominent mountain pass separating two major drainages. We felt these areas would have favorable wolverine potential. These two camera stations included Rainbow Pass-1 (RAPA-1) and Woody Basin-1 (WOBA-1) with results reported independent of other sub-blocks (Appendix B). Each of these two sites recorded black bear as the only carnivore species detected. Other mammals detected at these two sites included mule deer, northern flying squirrel and Townsend's chipmunk.

Vegetation Assessment
Vegetation characteristics for sampling stations that had marten detections were compiled and reported (Appendix E). Habitat data were also collected at stations containing other

species, but were not reported in this same format due to the low number of detections. We did not attempt any further analyses of the habitat data since small sample sizes make it difficult to draw meaningful conclusions.

DISCUSSION

Of the forest carnivore species targeted in this inventory, only marten were detected. No detections were made of wolverine, fisher or lynx. This is similar to the results of previous forest carnivore surveys conducted in NOCA during the winters of 2003 and 2004 (Christophersen et al. 2005). The results of this survey further strengthen the notion that lynx, wolverine and fisher are very rare and difficult to define in NOCA.

We demonstrated that forest carnivore surveys can be conducted in the summer months with operational and logistical success. However, we experienced little achievement in detecting the targeted species. When compared to the previous winter surveys of 2003 and 2004 there were notable differences in the diversity of animal species detected, number of carnivore species detected, frequency of species detection per block, total number of animal photos and number of camera nights visited by each species. Although there were slightly fewer sample sites in 2005 than either of the 2003 or 2004 survey years, in all cases there were markedly fewer numbers resulting from the summer survey than the winter surveys (Christophersen et al. 2005). For example, in 2005 there were 129 total animal photos recorded, a substantial difference from the 2003 and 2004 surveys where there were 803 and 931photos recorded respectively. Also, 12 animal species including five carnivore species were detected during the summer 2005 survey, whereas a total of 18 animal species including seven species of carnivores were detected during each of the 2003 and 2004 winter surveys. Marten detections from the 2005 survey ranged from 1-5 photos with a mean of 1.8 photos per camera station compared to detections ranging from 1-158 photos with a mean of 31.8 photos per camera station from the combined 2003 and 2004 surveys. The number of nights martens visited a camera station within the 28-night sampling period was also quite different between the sampling seasons. During the 2005 summer surveys marten visits ranged from 1-5 nights with a mean of 1.8 camera nights per station during the 28-night sampling period. By comparison, during the combined 2003 and 2004 winter surveys, marten visits ranged from 1-17 nights during the 28-night sampling period with mean visits of 5.3 camera nights per station.

The relatively low number of visits, total animal photos and species diversity recorded is likely a reflection of factors associated with summer-time surveys. The biggest factor may be related to the fact that we did not use bait as a lure, which in turn seems plausible that it would be more difficult to attract an animal to the camera station. Also, even when an animal was drawn in, they were not inclined to stay long since there was no bait available for them to forage from for numerous days, hence fewer photos taken. This actually helped in alleviating the winter problem of having reoccurring photos of presumably the same animal exposing an entire roll of film prematurely. Moreover, home range size of some forest carnivores has been shown to vary as a function of prey availability (Thompson and Colgan 1987) and habitat type (Soutiere 1979; Thompson and Colgan 1987). These factors may cause a change in seasonal distribution of species that may have made our camera stations less evident or attractive to some of the target species. Other factors such as differences in lure effectiveness due to weather, and timing of breeding season around winter for some species may also have an influence on detection success. These concerns may also help explain why no summer detections were made of spotted skunk (*Spilogale gracilis*), short-tailed weasel (*Mustela erminea*), cougar (*Puma concolor*) and bobcat, which were all detected during both the 2003 and 2004 winter surveys (Christophersen et al. 2005).

In addition, through GIS mapping of what is currently known about suitable habitat for some of the carnivores species in question, particularly lynx, we found that NOCA lies on the very fringe of good quality lynx habitat. More suitable areas lie to the east of the park boundary along the eastern edge of the Pasayten Wilderness where there exists one of the greatest lynx population centers in the lower 48 states (Koehler 1990). Habitat that does exist in the park complex is very limited, generally occurring east of the Cascade crest where it is very patchily distributed and limited in terms of connectivity between suitable forest stands. However, the anecdotal occurrence records of lynx in NOCA over the years are compelling, given the relative close proximity to a known breeding population. The one photo recorded as 'unknown felid' (used on cover page of this document) during this summer survey could have actually been a lynx, especially when considering it was detected in what was mapped as suitable lynx habitat east of Ross Lake. Unfortunately the clarity in the photo was insufficient to make a positive confirmation. Applying the information available thus far, it appears lynx do use habitat within the administrative boundaries of NOCA, but it remains uncertain whether a resident population is present.

The presence of historical fisher populations in and adjacent to the park complex combined with substantial suitable habitat available for fisher in NOCA, and yet no confirmed documentation from our extensive efforts, is cause for concern. Our results further strengthen the veracity that populations have dramatically declined and have probably been extirpated throughout Washington (Lewis and Stinson 1998). Their historic low densities and slow reproductive rates have not allowed them to recover from fragmentation of habitat and decades of over-trapping during the early 1900's (Powell and Zielinski 1994; Lewis and Stinson 1998). The occasional sighting reports of fisher in NOCA suggest there may be a few individuals remaining, but it seems unlikely there is an extant breeding population. This is consistent with other findings and the consensus that there are no known breeding populations of fisher in Washington (Aubry and Lewis 2003). Further, since there are also no known fisher populations near enough to re-establish a population in the state it appears a reintroduction program is the only route of recovery for this species (Lewis and Stinson 1998).

Our data show that marten remain relatively common in NOCA. This is similar to previous surveys in NOCA (Christophersen et al. 2005) and MORA (J. Schaberl unpublished data). However, this is contrary to survey results at OLYM where there was a lack of marten detections using the same sampling methods (Happe et al. 2005). Nonetheless, much remains to be learned about their current distribution and habitat requirements at various scales in order to develop sound conservation strategies for the protection of this species.

To no surprise, black bear were quite active during the summer survey period and were the most frequent visitor to our camera stations. Fortunately they caused minimal permanent damage to our camera equipment. This could be attributable to not using bait as a lure, so in a sense their curiosity was satisfied more quickly and they would leave the site shortly after investigating and getting their picture taken. We were also diligent in avoiding leaving scent on the camera equipment by keeping the camera installation duties separate from the duties of the individual applying the commercial scents. We also tried to be consistent in swiping the camera and sensor equipment with rubbing alcohol to avoid leaving our own scent behind.

RECOMMENDATIONS

The 2005 summer survey enabled us to sample an additional 6,938 ha of suitable habitat (approximately 5% of the suitable lynx, wolverine, fisher habitat in the park) that had not been previously sampled for forest carnivores. Combined with the winter surveys of 2003 and 2004, the total sampled area measures 29,630 ha (roughly 21.5 % of the suitable habitat in the park complex). Obviously there still are large portions of habitat that have not yet been sampled. Typically this includes the most remote areas that are difficult to access even under the best conditions. This survey did, however, produce additional detections of marten, one of the four target species upon inception of this inventory, and has given us a more accurate description of their distribution in NOCA. Point in case, the more area we can survey the more information is gained. Although funding will limit future systematic carnivore surveys such as these, we do recommend being proactive and continue our focus on high priority areas to place cameras, especially if field crews are already working in an area of potential habitat. We also recommend being attentive to future anecdotal reports of wolverine, lynx or fisher in the park complex. Depending on the score of credibility these incidental sightings should be followed-up on immediately. Careful observations by a trained field biologist can be made from possible tracks or a camera could be installed near the sighting in an attempt to confirm the animal's presence. Documenting these observations will also provide information on potential presence and help to guide future camera survey efforts designed to determine verifiable evidence of species presence.

It remains open to discussion whether we are using the best method to detect the more wide-ranging and elusive carnivore species, particularly wolverine. Although wolverine and lynx were detected east of the Cascades crest on the Okanagon National Forest using this same method during the summer months (H. Dodd, Conservation Northwest, pers. comm. 2005), the probability of detection is presumably quite low. The low abundance and large home ranges of wolverines, for example, linked with the increased mobility they would have in the summer certainly limits the chances of actually drawing one in to an individual camera station. It seems there is a need to have several cameras installed in a given region or perhaps they need to be left installed for a greater duration and to increase our success they would need to be baited. Herein lies a paradox in that it is logistically difficult to access and saturate remote areas with cameras in the winter, whereas it might be more feasible in the summer, but yet the use of bait would be more advisable in the winter versus the summer.

One alternative to bridge this gap is to utilize additional sampling techniques such as helicopter track surveys during the winter months. This method has been used along the eastern boundary of the park on U.S. Forest Service land with successful confirmation of wolverine tracks that led to a possible natal den site (S. Fitkin, Washington Department of Fish and Wildlife, pers. comm. 2005). However, the expense of this endeavor may be prohibitive, but there may be opportunities to share the operational costs among the two agencies and this collaboration should be pursued. We also recommend developing relationships with other non-profit organizations, such as The Nature Conservancy (J. Floberg pers. comm. 2005), Conservation Northwest (H. Dodd pers. comm. 2005) and The Mountaineers (B. Kandiko pers. comm. 2005), that have expressed interest in contributing resources to investigate forest carnivore presence and distribution in the North Cascades eco-region to include remote habitat within the park complex.

The information gained thus far on forest carnivore presence and distribution in NOCA has useful application for local management. It also has value at a larger scale when making regional assessments of species distribution and monitoring changes in distribution over time. A valuable tool in making data accessible to interested biologists is now being developed by means of an Internet website containing an archive of standardized survey data and an interactive mapping application (Aubry and Jagger 2005). We have since added our winter survey data to this centralized database with the recommendation of archiving additional forest carnivore data as it is collected.

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APPENDICES

Appendix A. Animal species detected and number of visits from each species by block, NOCA 2005.

Block No.	Station Name	Site Acronym	Total Photos Taken	No Animal Observed	Unknown	Black Bear	American Marten	Coyote	Raccoon	Unknown Felid	Mule Deer	N. Flying Squirre	Townsend's Chipmunk	Douglas Squirrel	Snowshoe Hare	Hoary Marmot	Mouse	Total Identifiable Animal Photos
94	Deer Lick	DELI	2	1						1								1
491	Fireweed Camp	FICA	22	9	3	4					6							10
490	South Fork Bridge Creek	SFBC	25	4	10	4	2				5							11
518	Sollek Creek	SOCR	95	79			6				7			2		1		16
483	Cascade Pass	CAPA	4	1		2	1											3
572	Reynolds Peak	REPE	81	60		4		1			10				6			21
409	Fisher Creek	FICR	15	4	2	4					2				3			9
436	Grizzly Creek	GRCR	52	34		4	1	1			10			1		1		18
569	Rainbow Meadows	RAME	21	7		1	1				5	3	1	2			1	14
463	Maple Pass	MAPA	28	7	1	6					3	6	1				1	17
84	Chilliwack River	CHRI	10	1		8			1									9
	Totals	**11 blocks**	**355**	**207**	**16**	**37**	**11**	**2**	**1**	**1**	**48**	**9**	**2**	**3**	**9**	**1**	**2**	**129**

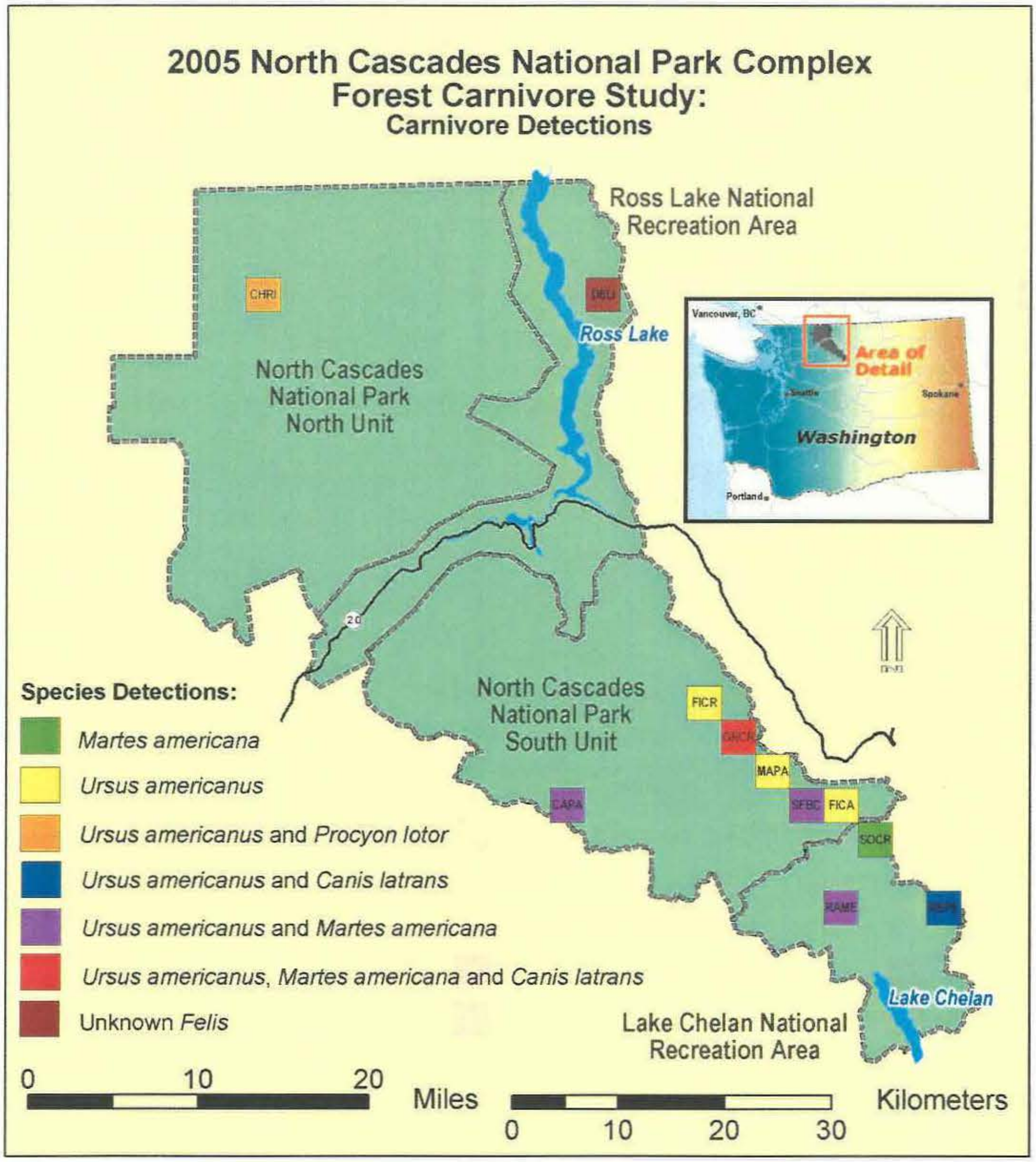
Appendix B. Animal species detected and number of visits from each species by sub-block, NOCA 2005.

Block No.	Station Name	Site Acronym	Total Photos Taken	No Animal Observed	Unknown	Black Bear	American Marten	Coyote	Raccoon	Unknown Felid	Mule Deer	N. Flying Squirrel	Townsend's Chipmunk	Douglas Squirrel	Snowshoe Hare	Hoary Marmot	Mouse	Total Identifiable Animal Photos
94	Deer Lick-1	DELI-1	0															0
94	Deer Lick-2	DELI-2	2	1						1								1
491	Fireweed Camp-1[1]	FICA-1	11	7	3						1							1
491	Fireweed Camp-2	FICA-2	11	2		4					5							9
490	South Fork Bridge Creek-1	SFBC-1	8	3		1	2				2							5
490	South Fork Bridge Creek-2[1]	SFBC-2	17	1	10	3					3							6
518	Sollek Creek-1	SOCR-1	7	1			5				1							6
518	Sollek Creek-2	SOCR-2	88	78			1				6			2		1		10
483	Cascade Pass-1	CAPA-1	0															0
483	Cascade Pass-2	CAPA-2	4	1		2	1											3
572	Reynolds Peak-1	REPE-1	11	3		1					7							8
572	Reynolds Peak-2[1]	REPE-2	70	57		3		1			3				6			13
409	Fisher Creek-1	FICR-1	4	1	2	1												1
409	Fisher Creek-2	FICR-2	11	3		3					2				3			8
436	Grizzly Creek-1	GRCR-1	16	2		3	1	1			9							14
436	Grizzly Creek-2[1]	GRCR-2	36	32		1					1			1		1		4
569	Rainbow Meadows-1	RAME-1	12	6			1				3			2				6
569	Rainbow Meadows-2	RAME-2	9	1		1					2	3	1				1	8
463	Maple Pass-1	MAPA-1	9	3								2	1					3
463	Maple Pass-2	MAPA-2	19	4	1	6					3	4					1	14
84	Chilliwack River-1[1]	CHRI-1	4			4												4
84	Chilliwack River-2	CHRI-2	6	1		4			1									5
Totals	**11 blocks**		**355**	**207**	**16**	**37**	**11**	**2**	**1**	**1**	**48**	**9**	**2**	**5**	**9**	**2**	**2**	**129**
516	Rainbow Pass-1[2]	RAPA-1	7			1					5	1						6
4621	Woody Basin-1[2]	WOBA-1	26	14		1						10	1					11
Totals	**2 sub-blocks**		**33**	**14**		**2**					**5**	**11**	**1**					**17**

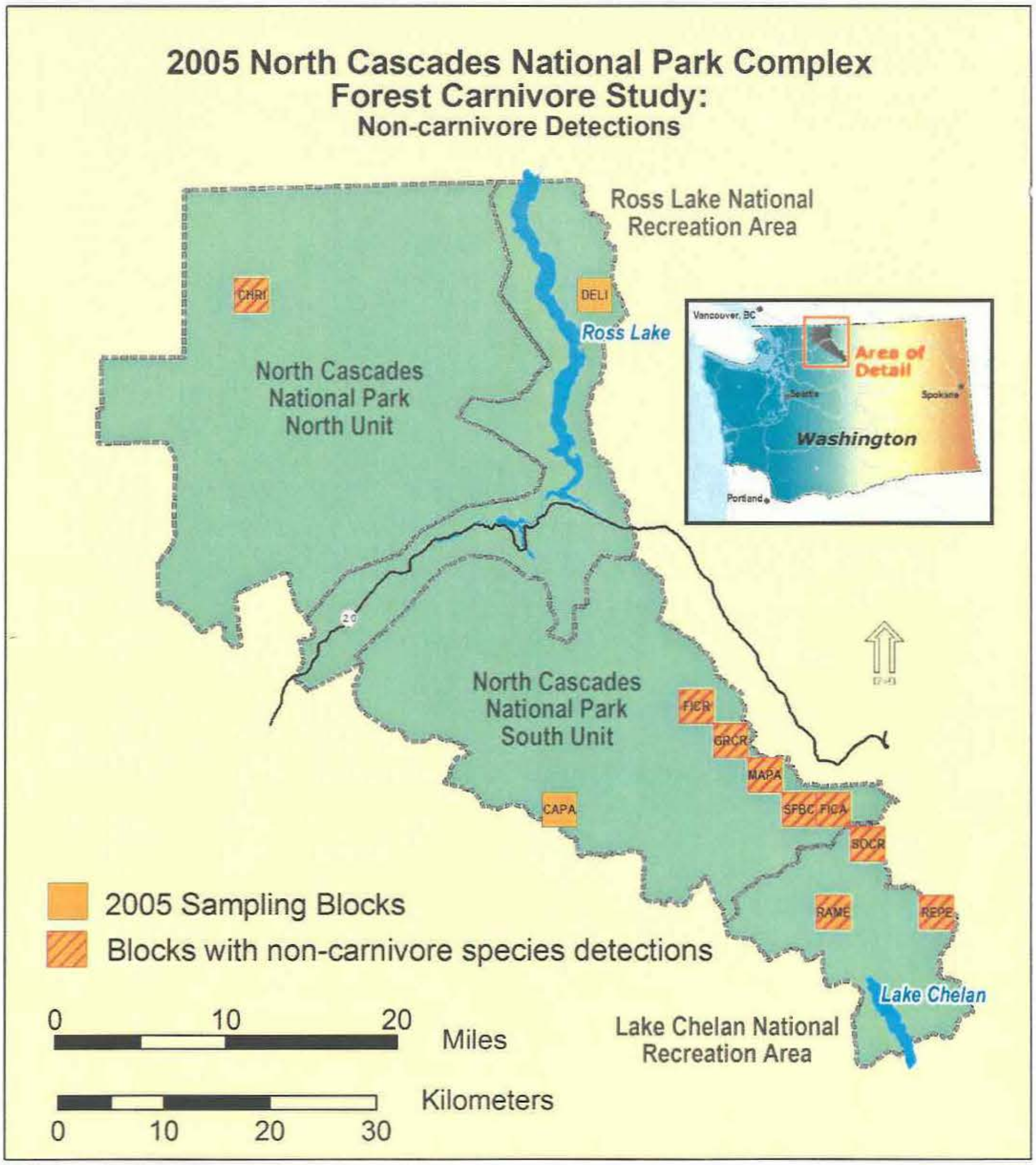
[1]These five sub-blocks fell short of the 28-night sampling protocol.

[2]These two sub-blocks were installed as incidentals, but were sampled to protocol otherwise. Results were recorded separately.

Appendix C. Sample blocks with carnivore detections, NOCA 2005.



Appendix D. Sample blocks with 'other than carnivore' detections, NOCA 2005.



Appendix E. Vegetation characteristics of sample stations with marten detections, NOCA 2005.

Block No.	Site Acronym	Common Canopy Tree1	Common Canopy Tree2	Common Canopy Tree3	Pct Canopy Cover	DBH Live Trees (inches)	Average Spacing Live Trees (feet)	Dead Trees >10% of Stand	Average DBH Dead Trees (inches)	DBH Woody Debris (inches)	Fuel Load
490	SFBC-1	*Abies amabilis*	*Pseudotsuga menziesii*	*Picea engelmannii*	40-70%	>20	8-12	Yes	12-20	12-20	M
518	SOCR-1	*Abies amabilis*	*Picea engelmannii*	*Tsuga mertensiana*	>70	12-20	8-12	No		12-20	M
518	SOCR-2	*Tsuga mertensiana*	*Abies amabilis*	*Larix occidentalis*	40-70	6-12	4-8	No		<6	L
483	CAPA-2	*Abies amabilis*	*Tsuga mertensiana*	*Abies lasiocarpa*	>70	6-12	<4	No		<6	L
436	GRCR-1	*Abies amabilis*	*Tsuga mertensiana*	*Abies lasiocarpa*	>70	12-20	4-8	No		6-12	M
569	RAME-1	*Tsuga heterophylla*	*Abies amabilis*	*Larix occidentalis*	<40	12-20	8-12	No		6-12	L

Appendix F. Topographic Data and NAD 27 Universal Transverse Mercator (UTM) coordinates of NOCA 2005 sampling stations.

Block No.	Site Name	Site Acronym	UTM Easting	UTM Northing	Topographic Position	Elevation (m)
94	Deer Lick-1	DELI-1	5418524	647666	lower 1/3 slope	728
94	Deer Lick-2	DELI-2	5417325	647942	lower 1/3 slope	754
491	Fireweed Camp-1	FICA-1	5370786	668902	riparian	1122
491	Fireweed Camp-2	FICA-2	5368822	670336	lower 1/3 slope	1319
490	South Fork Bridge Creek-1	SFBC-1	5370283	667309	riparian	1067
490	South Fork Bridge Creek-2	SFBC-2	5370026	665198	riparian	977
518	Sollek Creek-1	SOCR-1	5366369	671088	mid 1/3 slope	1506
518	Sollek Creek-2	SOCR-2	5365634	673001	ridge top	1848
483	Cascade Pass-1	CAPA-1	5371132	643173	mid 1/3 slope	1613
483	Cascade Pass-2	CAPA-2	5369145	645107	lower 1/3 slope	1439
572	Reynolds Peak-1	REPE-1	5360566	678141	riparian	1897
572	Reynolds Peak-2	REPE-2	5359171	678964	lower 1/3 slope	1728
409	Fisher Creek-1	FICR-1	5381268	657247	riparian	1502
409	Fisher Creek-2	FICR-2	5380828	654868	lower 1/3 slope	1271
436	Grizzly Creek-1	GRCR-1	5377568	659503	lower 1/3 slope	1512
436	Grizzly Creek-2	GRCR-2	5375286	659233	riparian	1345
569	Rainbow Meadows-1	RAME-1	5363197	667118	mid 1/3 slope	1759
569	Rainbow Meadows-2	RAME-2	5361319	669480	riparian	1444
463	Maple Pass-1	MAPA-1	5374340	664308	valley bottom	1788
463	Maple Pass-2	MAPA-2	5372821	663826	lower 1/3 slope	1491
84	Chilliwack River-1	CHRI-1	5418073	615668	riparian	830
84	Chilliwack River-2	CHRI-2	5417728	614290	riparian	792
462	Woody Basin-1[1]	WOBA-1	5374726	661763	riparian	1799
516	Rainbow Pass-1[1]	RAPA-1	5364691	667310	riparian	1594

[1] Indicates two sampling stations that were added as incidentals.

NATIONAL PARK SERVICE

As the nation's principal conservation agency, the Department of Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interest of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

(NPS D-280) January 2006