National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Mount Rainier National Park and Olympic National Park Elk Monitoring Program Annual Report 2012

Natural Resource Data Series NPS/NCCN/NRDS—2013/456

ON THE COVER
Elk, *Cervus elaphus,* Olympic National Park, August 2012. Inset, view of observer counting same group from inside the helicopter. NPS I&M program.

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March 2013

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on a peer-reviewed protocol, and were analyzed and interpreted within the guidelines of that protocol.

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This report is available from the North Coast and Cascades Network Inventory and Monitoring website (http://science.nature.nps.gov/im/units/nccn/reportpubs.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

Please cite this publication as:

Happe, P. J., M. Reid, D. J. Vales, B. J. Moeller, M. Tirhi, and S. McCorquodale. 2013. Mount Rainier National Park and Olympic National Park elk monitoring program annual report 2012. Natural Resource Data Series NPS/NCCN/NRDS—2013/456. National Park Service, Fort Collins, Colorado.

NPS 105/120115, 149/120115, March 2013

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Executive Summary

Fiscal year 2012 was the second year of implementing an approved elk monitoring protocol (Griffin et al. 2012) in Mount Rainier (MORA) and Olympic (OLYM) National Parks in the North Coast and Cascades Network (NCCN). However, it was the fifth and third year of gathering data according to protocol in MORA and OLYM respectively; data gathered during the protocol development phase followed procedures described in the protocol. Elk monitoring in these large wilderness parks relies on aerial surveys from a helicopter. Summer surveys are intended to provide quantitative estimates of abundance, sex and age composition, and distribution of migratory elk in high elevation trend count areas.

An unknown number of elk is not detected during aerial surveys; however the number of missed elk may be estimated by applying site-specific models that account for detection bias (Griffin et al. 2012). Detection bias for elk surveys in MORA was estimated using a model developed from survey data collected from 2008-2010, making use of elk that were previously equipped with radio collars by cooperating tribes. At the onset of protocol development in OLYM there were no existing radio-collars on elk. Consequently the majority of the effort in the OLYM in the past 5 years has been focused on capturing and radio-collaring elk and conducting sightability trials needed to develop a detection bias model for OLYM. In this annual report we provide estimates of abundance and composition of elk observed in MORA, present raw counts of elk observed in OLYM, and describe sightability trials conducted in OLYM.

At MORA the North trend count unit was surveyed once and the South unit was surveyed twice. We counted 706 and 500 elk during the replicate surveys of the South Rainier trend count area, and 236 elk in the North Rainier trend count area. Using the model to correct for detection bias, we estimated that 810 and 622 elk were in the South area, and 290 elk were in the North trend count area at the time of the respective surveys.

At OLYM, the Core and Elwha trend count areas were completely surveyed, as were portions of the Northwest; we counted 371 elk in the Core and 76 in the Elwha. In addition, we surveyed 16 survey units specifically to get detection bias data. We conducted double-observer sightability trials with 23 collared elk groups for use in developing a detection bias model for OLYM.

Acknowledgments

Elk monitoring in Mount Rainier National Park and Olympic National Park is a component of the North Coast and Cascades Network of National Parks Inventory and Monitoring (I&M) Program (Weber et al. 2009). The program in FY2012 was not scheduled to receive direct NCCN funding. Flights in OLYM were paid for by Washington's National Park Fund and Vectronic Aerospace; in MORA funding was provided from NPS base funds, Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), and Washington Department of Fish and Wildlife (WDFW). In addition staff time and data management support was provided by the NCCN I&M program and MORA, OLYM, and U.S. Geological Survey (USGS). The Lower Elwha K'lallam Tribe (LEKT) provided additional radio collars that were used in OLYM. The National Park Service (NPS) is grateful to the MIT, PTOI, and WDFW for their long-standing support for elk monitoring in Mount Rainier National Park, and for being full partners in the development and implementation of the monitoring protocol. Each of these partners contributed substantial funding and personnel in support of aerial surveys, as well as experience and ideas critical to developing and testing the protocol for elk monitoring in these parks. We would like to thank Paul Griffin and Kurt Jenkins (USGS Forest and Rangeland Ecosystem Science Center) for their role in working with all the partners to develop the elk monitoring protocol for the surveys reported here, and Bruce Lubow (Colorado State University) for his help developing analytical components of the protocol. The authors thank the other crew members who participated in surveys including Kathy Beirne, Bill Baccus, Rebecca Lofgren, Rich Lechleitner (NPS); Mike Middleton, Mike McDaniel, Mike Hilden (MIT); Phillip Dillon, D. Coats (PTOI); Tammy Schmidt, Chris Anderson, Eric Holman, Nicolle Stephens (WDFW). We thank the following pilots for their assistance: Jess Hagerman, Rob Olmstead (Northwest Helicopters). For their support of the elk monitoring program, we thank Muckleshoot Indian Tribe (MIT) Wildlife Committee, Phillip Dillon (PTOI), Kim Sager-Fradkin (LEKT), and Paul Geissler (USGS National Park Monitoring Project). We are grateful to Bill Baccus, Kathy Beirne, John Boetsch, and Kurt Jenkins for reviews of the draft report.

Introduction

Elk populations are key components of lowland and montane ecosystems in MORA and OLYM, and are tightly woven into each park's historical and cultural fabrics. Historical accounts indicate Roosevelt elk (*Cervus elaphus roosevelti*), the Pacific coastal subspecies of elk, were abundant in primeval floodplains and riparian forests along many of the major river systems in western Washington. During summer many herds migrated to subalpine meadows of adjoining mountain chains (Schwartz and Mitchell 1945, Starkey et al. 1982, Taber and Raedeke 1980). Although the ethnographic record clearly indicates that elk were hunted by Native Americans and are indigenous to both the Olympic and Cascades Ranges, early distribution patterns of elk in the Cascades are poorly understood. It is widely acknowledged that elk had become quite rare or absent around Mount Rainier in early historical times for reasons that are not known (Gustafson 1983, Schullery 1983). By the start of the 20th century, unregulated market hunting of elk for meat, antlers, and trophy 'ivory' teeth had widely decimated elk populations throughout the most accessible and settled areas of Oregon and Washington (Graf 1955, Murie 1951). A notable exception was on the Olympic Peninsula where a largely inaccessible wilderness helped to protect a remnant stronghold of native Roosevelt elk.

Elk in Mount Rainier National Park

MORA was created in 1899 to preserve natural wonders of the volcano (Mount Rainier) and its surroundings, and to protect fish and game. Because the park was established largely to protect the mountain, it encompasses mostly montane forests and high elevation subalpine and alpine environments used by elk as summer ranges, but not the majority of low-elevation winter ranges in the adjoining river valleys. Although the native elk had been largely, if not completely eliminated from MORA by 1899, elk populations were reestablished through several translocations of Rocky Mountain elk (*Cervus elaphus nelsoni*) from Yellowstone and Grand Teton National Parks to lands adjacent to the park in 1912-1915 and 1932-1933 (Bradley 1982). Wildlife observation cards maintained at MORA and summarized by Bradley (1982) indicated that by 1915 elk were observed in Grand Park (i.e., the northern part of MORA) just a couple of years following the first releases, and that by the 1930's they had dispersed widely to inhabit the primary summer ranges used by elk today.

From 1950 to the 1970's intensive logging of elk winter ranges adjoining MORA improved winter and spring foraging conditions for elk and stimulated population growth of migratory elk herds that wintered adjacent to the park and summered within (Raedeke and Lehmkuhl 1985, Jenkins and Starkey 1996). In 1962, a U.S. Forest Service biologist counted 466 elk on subalpine meadows within MORA, prompting initial concerns over the potential impacts of elk on subalpine meadows, one of the park's premier natural resources. As elk populations continued to grow during the 1970's and signs of trailing, trampling, and grazing impacts drew greater attention, the following questions assumed primary importance to park managers (Starkey 1984): (1) are the elk native to the park; (2) is the elk population growth a natural ecological process; (3) what changes can be expected into the future; and (4) are the elk having lasting impacts on subalpine vegetation? As a direct response to these growing management concerns, the NPS and several university research cooperators conducted studies of elk history and ethnography in the Mount Rainier ecosystem (Bradley 1982, Gustafson 1983, Schullery 1983), elk distribution and ecology (Bradley 1982, Cooper, 1987), elk taxonomy (Shonewald-Cox 1983), land-use and forest succession on winter range (Jenkins and Starkey 1996), and grazing and trampling impacts

on subalpine summer ranges (Bradley 1982, Ripple et al. 1988, Motazedian and Sharrow 1984, Sharrow and Kuntz 1986). Primary conclusions of this collective work were that elk were native to the area (Gustafson 1983), and that subspecific differences in the Rocky Mountain elk that were reintroduced near the park were not sufficiently distinctive to consider the present population non-native or exotic (Shonewald-Cox 1993, Starkey 1984). It was concluded that elk populations using the park during summer are influenced by logging practices on adjoining winter ranges, but that post-logging forest succession patterns had reduced forage availability on the winter range and ameliorated population growth trends by the late 1980's (Jenkins and Starkey 1996). Although trailing and trampling impacts were locally important (Bradley 1982, Ripple et al. 1988), grazing impacts were not clearly demonstrated (Sharrow and Kuntz 1986). Because elk are such important drivers of ecosystem change, however, it was suggested that long-term monitoring of both subalpine vegetation and elk populations should be sustained indefinitely (Starkey 1984).

Elk in Olympic National Park

OLYM was created first as Mount Olympus National Monument in 1909 by Theodore Roosevelt for the explicit purpose of protecting the last stronghold of Roosevelt elk and its native forested habitat following the large-scale decline in elk populations. Although elk were very abundant throughout the Olympic Peninsula in early historical times, by the turn of the 20th century only 3,000 remained, primarily in the central core of the Peninsula that is currently OLYM (Morganroth 1909). Mount Olympus National Monument was expanded and re-created as OLYM in 1938 to "provide suitable winter range and permanent protection for herds of native Roosevelt elk" (U.S. Congress 1938). Because elk were central to the creation of the park, its boundaries represent as complete an ecological system as was possible when the park was created, including both subalpine summer ranges of elk in the park's mountainous interior, and the many low-elevation river valleys used as winter range. Today the park is internationally recognized by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) as a Biosphere Reserve and a World Heritage Site.

The creation of Mt. Olympus National Monument was just one of several coordinated measures to protect dwindling elk herds throughout Washington in the early 1900s. In addition to the efforts to restock former big game ranges in other areas of the state (i.e., the Mount Rainier ecosystem), elk were protected through a moratorium on hunting, and through an aggressive campaign against predators. A bounty was placed on wolves and cougars, which reduced predation on elk, and ultimately led to the eradication of wolves on the Olympic Peninsula by the late 1920's (Scheffer 1995).

Elk populations responded favorably to multifaceted protection on the Olympic Peninsula. As early as 1915, there were reports of 'overbrowsing' in the western rainforest valleys of the Mt. Olympus National Monument, and large numbers of elk were reported dying during severe winters (Schwartz 1939). During the 1930's, several U.S. Forest Service and NPS biologists examined elk ranges throughout the park and reported concerns about overgrazing in low-elevation winter ranges within the temperate rainforests (Murie 1935*a*, Murie 1935*b*, Sumner 1938, Schwartz 1939). Twenty years later, Newman (1958) noted that the range was not severely over used and that the elk population was stable because of the "rapid and regular seasonal growth of forage plants, even pressure from predators, and natural die-offs".

Elk continue to play an important ecological role in both MORA and OLYM – as architects of plant communities, drivers of ecosystem processes, and sustainers of diverse communities of predators and scavengers. In addition to these important ecological roles in the ecosystem, elk in both parks are significant to hundreds of thousands of visitors annually who travel to these parks with the hope of viewing elk in their natural environment.

Land use, hunting, and predator management programs on lands adjacent to these parks have the potential to influence elk population trends and ecosystem dynamics within the parks. Information on ungulate population trends has important management significance in NCCN parks through its influence on internal park management decisions, and the ability of the NPS to work effectively with land and wildlife managing agencies and local Native American Tribes in establishing common management goals and objectives outside the park's boundaries. Furthermore, interpreting the status, trends, and ecological significance of park resources to an interested public is an important function of the National Park Service.

Monitoring Objectives

There are two specific objectives of the MORA and OLYM elk monitoring protocol.

> **Objective 1**: Monitor trends in elk abundance, distribution, and composition in selected subalpine summer ranges in MORA and OLYM.
>
> **Objective 2**: Monitor trends in elk abundance and distribution in selected low-elevation winter ranges in OLYM.

Survey and Reporting Objectives for 2012

This report and subsequent annual reports for the MORA and OLYM elk monitoring program are for administrative purposes; data are summarized and presented without extensive analysis or interpretation. The elk monitoring protocol (Griffin et al. 2012) calls for providing reports that contain more comprehensive data analysis every four years, including quantified estimates of variance and trends, and interpretation of those data. A four-year report that will examine trends in counts obtained from 2008-2011 is scheduled to be completed in 2013.

The objectives of this report are to summarize results of elk surveys conducted in selected subalpine summer ranges in MORA and OLYM during summer 2012. The 2012 surveys were the second ones conducted since the protocol for aerial surveys in MORA and OLYM was approved for implementation in 2011 and published in 2012 (Griffin et al. 2012). The protocol calls for reporting flight conditions and raw counts of elk obtained from annual surveys in both parks, as well as estimates of elk abundance corrected for detection biases in Mount Rainier.

Based on the monitoring protocol and agreement of all the monitoring partners in MORA, the survey objectives in 2012 were to complete two replicate surveys of the summer range of the South Rainier Herd and a single survey of the North Rainier Herd summer range. Results of the 2012 surveys are reported here, including raw counts and counts adjusted for detection bias.

The 2012 survey objectives for OLYM were to complete surveys of elk within two trend count areas (Cores area and Elwha Unit), while also collecting sightability trial data that will be used to complete development of a double-observer sightability model for OLYM. The double-observer sightability model used to adjust raw counts for detection biases has not been completed for

OLYM. Sightability model development in OLYM lagged behind that of MORA due of the lack of pre-existing radio collars on elk at the onset of the protocol development phase in OLYM (Griffin et al. 2012), as well as the mass failure of GPS collars deployed in OLYM in 2009 (Griffin et al. 2011) and the partial failure of GPS collars deployed in 2010 (Happe et al. 2013).

Due to budgetary constraints, winter range surveys in OLYM were suspended in 2011. Following the monitoring protocol, the winter range surveys in OLYM are treated as a legacy dataset, and additional surveys will be conducted in the future only as funding allows (Griffin et al. 2012).

Study Area

In MORA, the two trend count areas include all of the subalpine habitats in the park that are encompassed by an arc around the volcano from Vernal Park in the north, to Chinook Pass at the east, and south through the Tatoosh Range (Figure 1). These trend count areas include the primary subalpine summer ranges of the North Rainier Herd and South Rainier Herd.

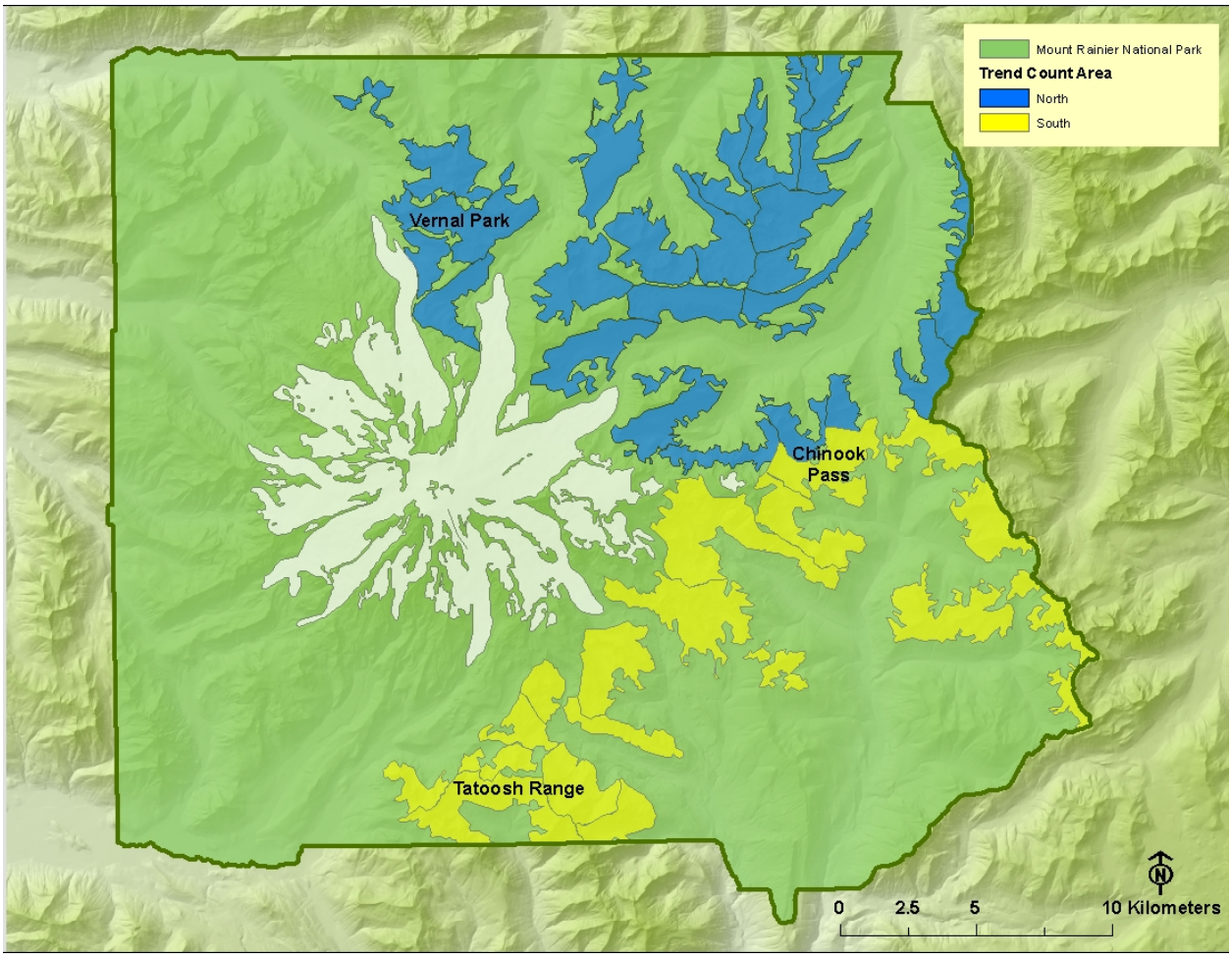


Figure 1. Summer trend count areas within Mount Rainier National Park. The North Rainier trend count area is approximately 103 km^2, and the South Rainier trend count area is approximately 89 km^2.

In OLYM the majority of the summer range for migratory elk is divided into five trend count areas. The Core area corresponds with summer range of migratory herds of elk that winter in the primary low-elevation winter ranges in the Hoh and Queets Valleys (Schwartz and Mitchell 1945, Olympic National Park, unpublished data). The four ancillary summer range trend count areas (Figure 2) encompass the majority of the remaining migratory elk populations in the Park. Elk in the Quinault, Elwha and Northwest trend count areas winter in OLYM, whereas elk in the Southeast trend count area migrate out of OLYM and winter near the Hood Canal.

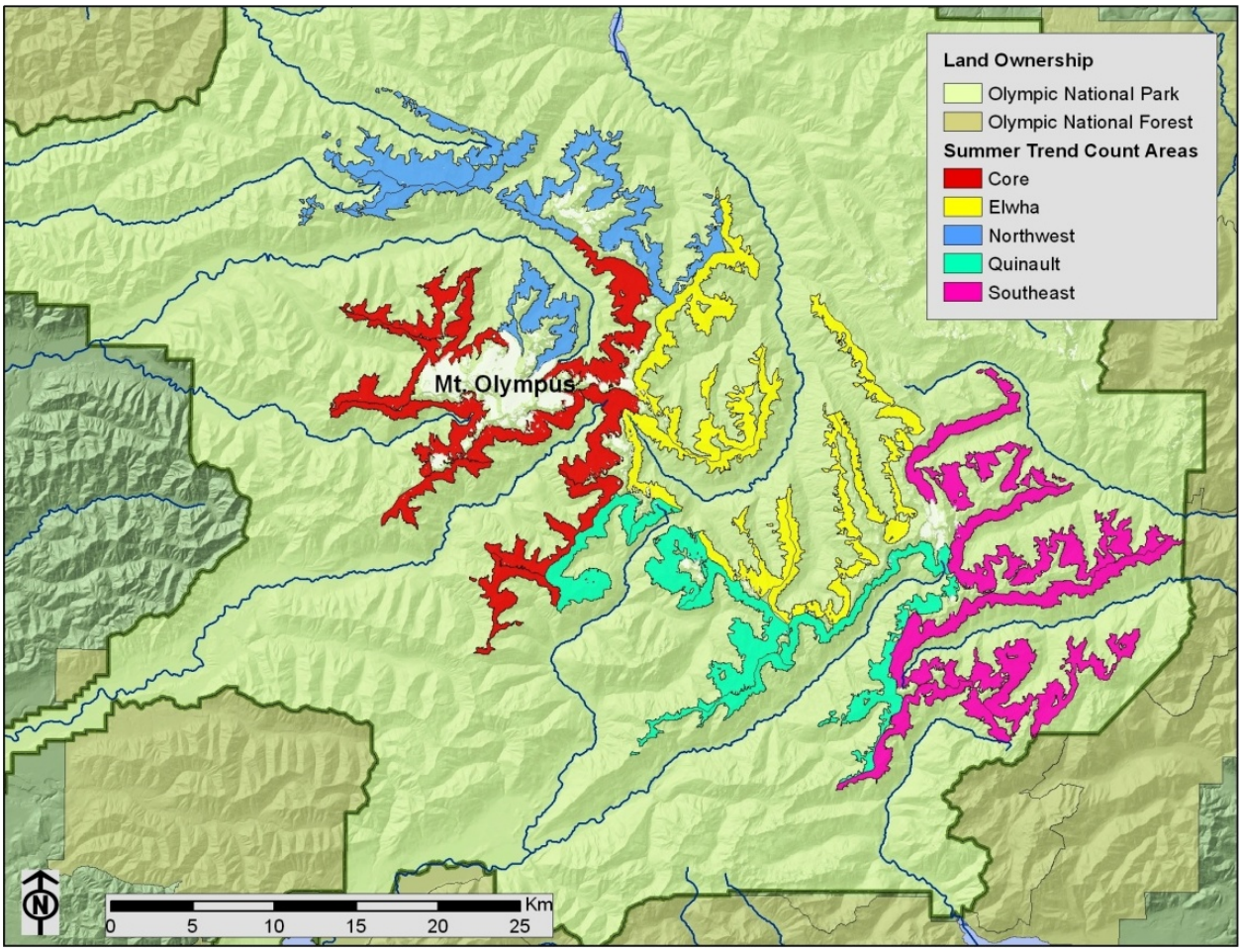


Figure 2. Summer trend count areas within Olympic National Park, including the annually-surveyed, core trend count area, and four ancillary trend count areas surveyed once every four years. The Core and four ancillary trend count areas: Elwha, Northwest, Quinault, and Southeast are approximately 100, 81, 73, 79, and 86 km^2, respectively.

Methods

The sample design, survey methods, and analytical framework for elk monitoring are presented in detail in the elk monitoring protocol for MORA and OLYM (Griffin et al. 2012). Salient features are summarized below.

Safety

All helicopter survey operations strictly followed helicopter use aviation safety plans, prepared specifically for each survey.

Sample Design

The trend count areas established in MORA (Figure 1) and OLYM (Figure 2) comprise most of the subalpine summer ranges used by elk in each park. We defined trend count areas on the basis of elevation and forest canopy cover. Within the elevation boundaries of trend count areas, we used each park's vegetation cover map (Pacific Meridian Resources 1996) and data gathered during earlier surveys to identify and exclude areas of continuous dense forest canopy cover or rock and snow. In MORA, trend count areas were bounded by elevations below 2100 m and above 1500 m for the North trend count area, and by elevations below 2100 m and above 1350 m for the South Rainier trend count area, except that on the SW facing slopes of Stevens Ridge and Shriner Peak we surveyed down to 1200 m. In OLYM, the majority of the summer trend count areas ranged between 1200 m and 1650 m. Following the after-action review of the 2011 surveys, the survey trend count areas in the Core and Northwest were slightly adjusted: some unit designations were reconfigured to facilitate flight patterns; areas which did not fall in the habitat prescriptions were deleted; and habitat patches that met the prescription but were not originally delineated in the survey blocks were added, including areas in the Core where habitat extended down to 1036m. The effects of these modifications to the survey areas will be evaluated in the 4 year synthesis report.

The sampling design calls for completing one replicate survey of both trend count areas in MORA, with an additional replicate of one of the survey areas alternating between years. In 2012 the North was surveyed once and the South twice. Surveys in MORA are conducted in the 4 hours before sunset. In OLYM two trend count areas are surveyed once each year, with the Core area flown each year and one of the other four areas selected on a 4 year rotation. Surveys are flown either 4 hours after sunrise or 4 hours before sunset. All surveys in both parks are to be completed between 15 August and 15 September.

Experience has shown that it is not possible for a single helicopter to effectively survey all of the North Rainier trend count area or all of the South Rainier trend count area in one evening (Griffin et al. 2012). A similar issue exists in OLYM, where it is not always possible to complete a count area in a single morning. Therefore, it has been necessary to either survey a trend count area over two days or to use two helicopters operating simultaneously to complete the surveys. A stated goal of project participants in the MORA surveys is to use two helicopters operating simultaneously, but this is not always possible due to limitations in helicopter availability and crew scheduling. Consequently, the protocol reflects discussions of all the project partners recognizing that surveys may be completed on multiple days as logistics require (Griffin et al. 2012). The complementary halves of the survey areas in MORA have been developed to minimize the movements of elk across boundaries that are counted on different days and to

maximize safety in cases where two helicopters may be operating simultaneously. Any movement of elk across boundaries of areas surveyed on multiple days would increase variance of counts, but would not introduce a systematic bias that would influence trend analysis.

We have also discovered that for a variety of logistical reasons, it has not always been possible to survey elk in all of the subunits that comprise a single trend count area. Among the logistics problems encountered are: high winds or clouds that develop during a survey, mechanical problems with helicopters, and temporal constraints associated with darkness. We will evaluate the effects associated with missed survey units within trend count areas during the 4-year comprehensive analysis scheduled to be completed in 2013.

Survey Methods

A crew of a pilot and three observers counted elk from a type-III helicopter; Bell 206B-3s were used for all flights in 2012. Trend count areas were thoroughly searched in their entirety for elk from approximately 150 m (500 feet) above ground level, with flight lines approximately 250-500 m apart. We recorded the location and group size of all elk groups detected, as well as other covariate data used in estimating aerial survey detection bias. In-flight protocols for the double observer method required all observers to act independently in searching for and detecting elk groups. After reconciling which independent observers detected each observed group of elk, all observers collaborated in determining group size, composition and covariates of detected groups. An elk group was defined as one or more elk in close proximity. Any large group was photographed with a high resolution digital camera (Schoenecker et al. 2006); later, the group size or composition data, or both, were updated if examination of the photo yielded a more complete count.

Double-Observer Sightability Trials in OLYM

Double-observer sightability trials are attempts by aerial survey crews to detect elk groups containing at least one radio-collared elk. These trials are used to model the probability that aerial survey crews detect elk groups of different sizes under different survey conditions. These estimated detection probabilities, in turn, are used to adjust raw counts of elk to better estimate the true number of elk present within a survey area.

In OLYM, we continued to collect double-observer sightability trials in 2012 to contribute data for sightability model development. During the surveys we used radio-telemetry to determine if there were any radio-collared elk within each of the elk groups observed. Following the surveys, we also determined locations and covariate values for any radio-collared elk that were not detected during the survey. The complete set of detailed sampling protocols is provided in Griffin et al. (2012).

In developing the double-observer sightability model, we captured and radio-collared 51 elk from 2008-2012, deploying 38 GPS and 14 VHF collars (one elk was captured twice). Ten elk were captured and collared in 2008, 20 in 2009, 17 in 2010, and 4 in 2012. We had 14 fully or partially functional radio collars available for resights in 2012; 20 GPS radio collars have failed, 13 elk have died, 1 elk's fate is unknown (dead or dead collar), and 4 elk are non-migratory and hence not available for resights during summer range surveys.

Data Management

Following each survey flight the observers immediately reviewed all data forms and corrected any discrepancies. A GIS Specialist downloaded helicopter flight lines to the NCCN project workspace. In MORA, the tribal and WDFW biologists provided copies of their completed data forms, the associated GPS files for the helicopter flight path, and any photographs of large elk groups to the MORA project manager. After the flights the project manager, participating wildlife biologist, or technician examined the photos; if inspection of photos led to a revision for group size or composition, then the pertinent photos were annotated and saved, and changes made to the data forms.

The OLYM and MORA project managers entered survey data into the project database. After data were entered, quality review included verification, which entailed confirming that data in the database were accurate with respect to the field forms. Next, data were checked for consistency, and all data entered were confirmed to be within acceptable bounds (steps that will be automated in the final project database using queries).

Data Analysis

We summarized data according to the template provided in Griffin et al. (2012). Results of surveys are presented here without detailed analysis. Variance estimates, along with more complete analyses of spatial distribution, and trends in abundance and composition, will be part of the four-year analysis.

Results

2012 Climate in Review

Spring and summer conditions in 2012 were colder than normal, but not as extreme as 2011; 2011 set records for the depth and persistence of snow at high elevation areas in the spring and summer (Baccus et al. in press, Lofgren et al. in press). Snow water equivalent (SWE) measured on 1 May, 2012 in OLYM was approximately 145% of the 30-year normal (1971-2000) (NCCN, unpublished data). At Paradise in MORA, May snow-water equivalent measurements were 109% of normal (NCCN, unpublished data). A colder and wetter than normal June and July contributed to a prolonged summer snowpack and delayed phenology of high country vegetation. A shift to warmer and much drier conditions in August, however, helped to accelerate phenology and snow melt by the dates of the 15 August to 15 September elk survey window (NCCN, unpublished data) (Figure 3).

Figure 3. Snowmelt and phenology in 2012 was within prescription, as illustrated by the phenology photo points at a) Swimming Bear Lake (Olympic National Park 8/24/2012) and b) Buck Lake (Mount Rainier National Park 8/27/2012).

Names and Roles of Project Personnel

Patti Happe served as the Project Lead in this study, and also as the project manager for OLYM. Mason Reid served as the project manager for MORA. David Vales was the wildlife biologist for Muckleshoot Indian Tribe (MIT). Barbara Moeller was the wildlife biologist for Puyallup Tribe of Indians (PTOI). Michelle Tirhi and Pat Miller were the wildlife biologists for Washington Department of Fish and Wildlife (WDFW) Region 6 and Region 5, respectively. Other survey personnel that took part in spring and summer surveys are listed in Table 1.

Table 1. Observers that participated in elk surveys in 2012. Personnel are identified by the tribe or agency with which they are affiliated.

Affiliation[1]	Names
NPS	Patti Happe, Mason Reid, Kathy Beirne, Bill Baccus, Rebecca Lofgren (survey crew members); Bill Baccus, Kathy Beirne, Rich Lechleitner (helicopter managers)
MIT	Mike Middleton, Mike Hilden, Mike McDaniel
PTOI	Barbara Moeller, Phillip Dillon, D. Coats
WDFW	Scott McCorquodale, Michelle Tirhi. Tammy Schmidt, Chris Anderson, Eric Holman, Nicolle Stephens
Pilots	Rob Olmstead, Jess Hagerman (Northwest Helicopters)

1: Affiliations: NPS - National Park Service, MIT - Muckleshoot Indian Tribe, PTOI - Puyallup Tribe of Indians, WDFW - Washington Department of Fish and Wildlife.

Flight Statistics

Mount Rainier Summer Surveys

Although the elk surveys at MORA were not funded by the NCCN Inventory and Monitoring Program in 2012, we stuck with the survey schedule listed in the protocol. With semi-annual funding from NCCN, the monitoring partners decided to alternate double-replicate surveys among the two survey areas, with a single replicate of the alternate survey area. For 2012, the group decided to complete two replicate surveys of the South Rainier trend count area and one replicate survey of the North Rainier trend count area (Table 2). In 2011 we conducted two surveys in the north and one survey in the south (Happe et al. 2013).

The first complete survey of the South trend count area was conducted on 14 August 2012, and the second on 28 August 2012. The survey of the North trend count area was conducted on 27 and 30 August and 5 September 2012. The surveyors were not able to complete the 30 August flight due to fog and consequently had to return to the area on 5 September to complete the units.

Table 2. Flight details for summer 2012 surveys at Mount Rainier National Park. Last names of pilots are indicated in bold font.

Flight	Date	Replicate	Survey Units	Total flight time (h:min)	Survey time (h:min)	Sponsor[1]	Crew Members
1	Aug 14	First South	S1, S4, S5, S6, S7, S9, S17, S18, S19, S20	2:54	2:32	NPS	**Olmstead,** Reid, Beirne, Lofgren
2	Aug 14		S8, S10, S11, S13, S14,S15,S16	2:37	2:30	PTOI	**Hagerman,** Coats, Phillip, Moeller
3	Aug 27	North	N4, N5, N6, N7, N8, N11, N12, N13, N14	2:30	2:14	MIT	**Hagerman**, Middleton, McDaniel, Hilden
6	Aug 30		N10, N15, N16, N17,N18	1:56	1:00	WDFW	**Hagerman**, Schmidt, Tirhi, Anderson
7	Sep 5		N1, N2, N3	1:24	0:53	WDFW	**Hagerman**, Schmidt, Tirhi, Anderson
4	Aug 28	Second South	S1, S4, S5, S6, S7, S8, S9, S10, S11, S13	2:46	2:28	NPS	**Olmstead,** Reid, Beirne, Lofgren
5	Aug 28		S14,S15,S16, S17, S18, S19, S20	2:44	2:25	WDFW	**Hagerman**, Holman, McCorquodale, Stephens

[1] Sponsors are the Tribe or agencies responsible for funding the helicopter costs. NPS - National Park Service, Mount Rainier National Park, MIT - Muckleshoot Indian Tribe, PTOI - Puyallup Tribe of Indians, WDFW - Washington Department of Fish and Wildlife.

Olympic National Park Summer surveys

Support for the 2012 flights in OLYM came from Washington's National Park Fund and the GPS radio collar manufacturer (reimbursement for failed collars). We originally planned to conduct 12 flights over 5 consecutive days in OLYM, 8 in the morning and 4 in the evening. Prior to the onset of the surveys, all migratory GPS-collar-equipped elk were detected as consistently using high elevation summer range (NPS, unpublished data). For collecting resight data of migratory elk, we had 6 fully functional GPS collars and 8 additional collars with fully or partially functioning very high frequency (VHF) radio signals that could be located using traditional radio telemetry. Weather unsuitable for conducting surveys developed on 21 August and occurred sporadically both spatially and temporally throughout the week. At the end of the survey period we were able to conduct 11 flights over 6 days: 9 during the morning hours and 2 in the evening. We conducted a complete survey of the Core and the Elwha trend count areas, although we had to spread the flights out over 3 days to complete the Elwha and 4 days to complete the Core (some areas were persistently clouded over until 24 August). In addition 16 survey units in the Core, Elwha and Northwest were flown one or more times solely to get resight data.

Table 3. Flight details for 2012 surveys at Olympic National Park. Last names of pilots are indicated in bold font. Costs of all these flights were paid by Washington's National Park Fund and Vectronic Aerospace.

Flight	Date	Replicate[1]	Survey Units	Total flight time (h:min)	Survey time[2] (h:min)	Crew Members
1	Aug 20	1	E1, E2a	2:06	1:33	**Olmstead,** Happe, Beirne, Baccus
2,3	Aug 21	1	C6c, C7, E2c, E3	4:04	2:37	**Olmstead,** Happe, Beirne, Baccus
4, 5, 6	Aug 22	1,0	C1, C2, C3, C4, E2b,E2c, E3, NW1	5:40	4:36	**Olmstead,** Happe, Beirne, Baccus
7	Aug 23	1,0	C1, C5	2:01	1:18	**Olmstead,** Happe, Beirne, Baccus
8,9	Aug 24	1,0	C2, C3, C6, C7, E2c, NW5a	4:20	3:15	**Olmstead,** Happe, Beirne, Baccus
10,11	Aug 25	0	C1, C2, C3, C6d, C7, E2c, E3, NW4	3:44	3:15	**Olmstead,** Happe, Beirne, Baccus

[1] Replicate = 0 are flights just flown for gathering resight data, and are often not complete counts of units.

[2] Excludes time spent on telemetry.

Elk Observations

Mount Rainier National Park Summer Surveys

Figures 4 through 6 show the survey paths (flight lines) flown during the summer surveys in MORA. Observed counts of elk groups in MORA are summarized in Table 4. We saw 706 elk in 61 groups in the first of the South trend count area replicate counts, and 500 elk in 96 groups on the second replicate. The mean group size was greater in the first count (11.57) with the largest group being 104 elk. In the North trend count area 263 elk in 33 groups were observed; the average groups size was 7.15 elk, and the largest group seen contained 56 elk.

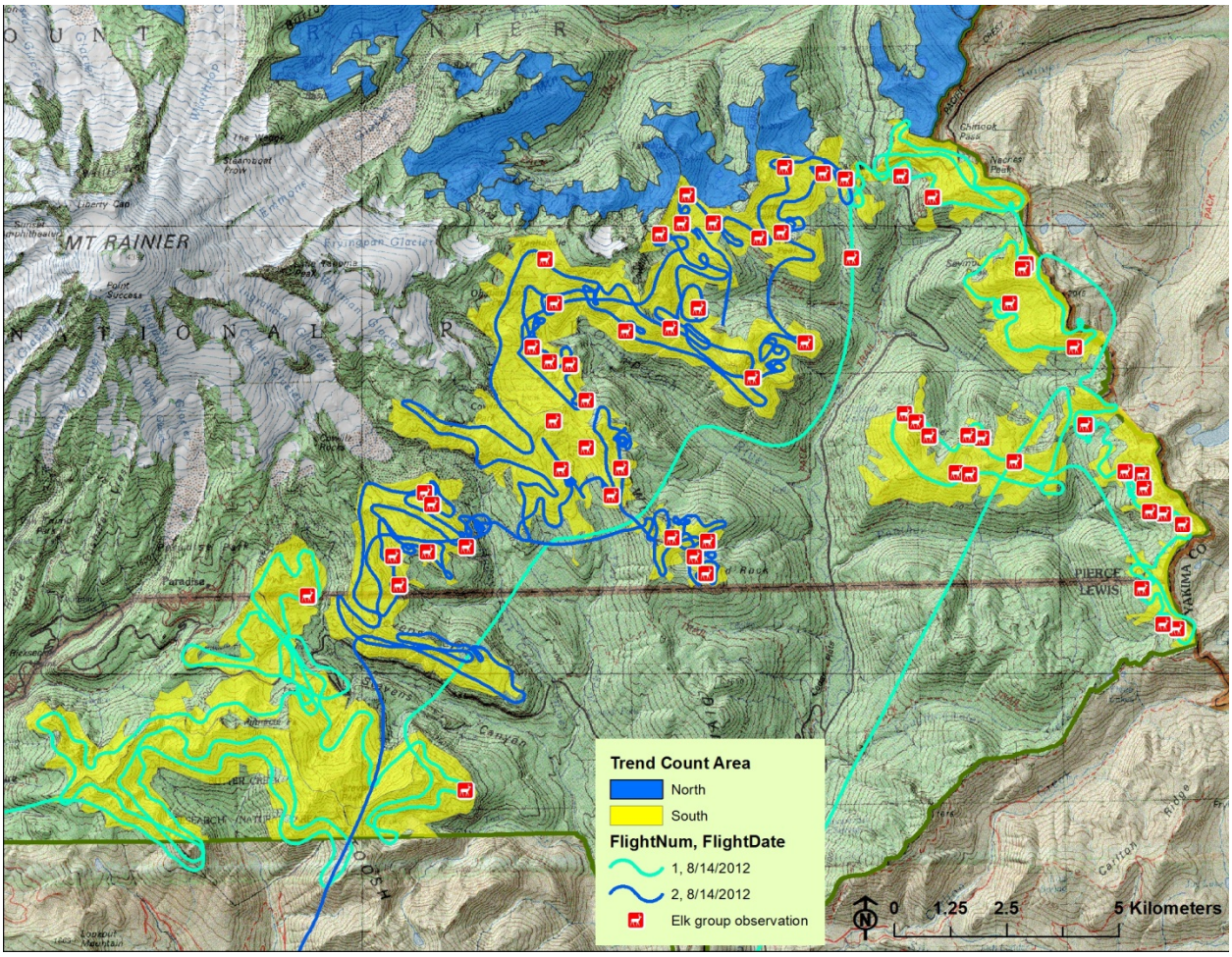


Figure 4. Flight lines for the first replicate survey in the South Rainier trend count area, conducted 14 August 2012. Approximate locations of observed elk groups are indicated with the red icon.

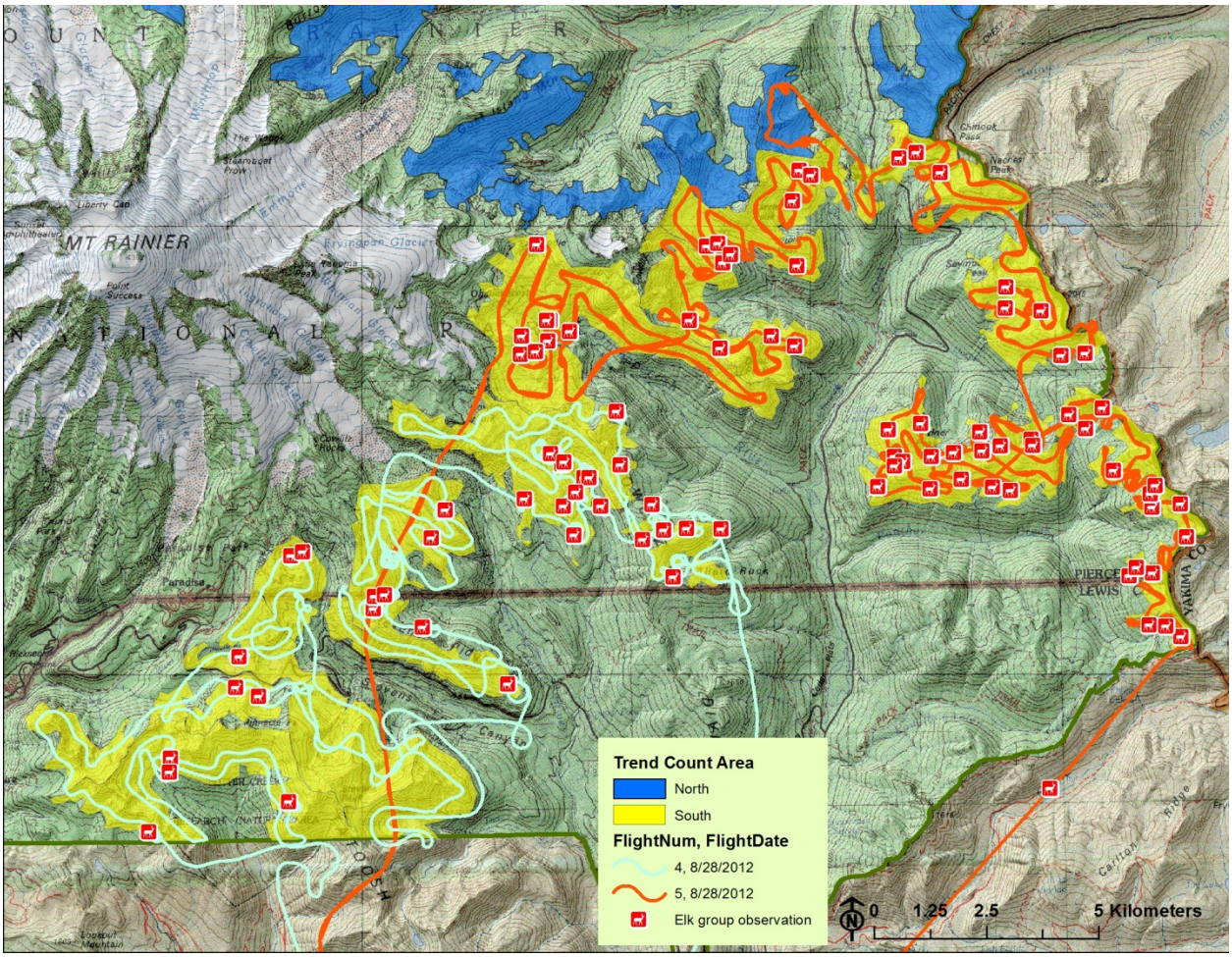


Figure 5. Flight lines for the second replicate survey in the South Rainier trend count area, conducted 28 August 2012. Approximate locations of observed elk groups are indicated with the red icon.

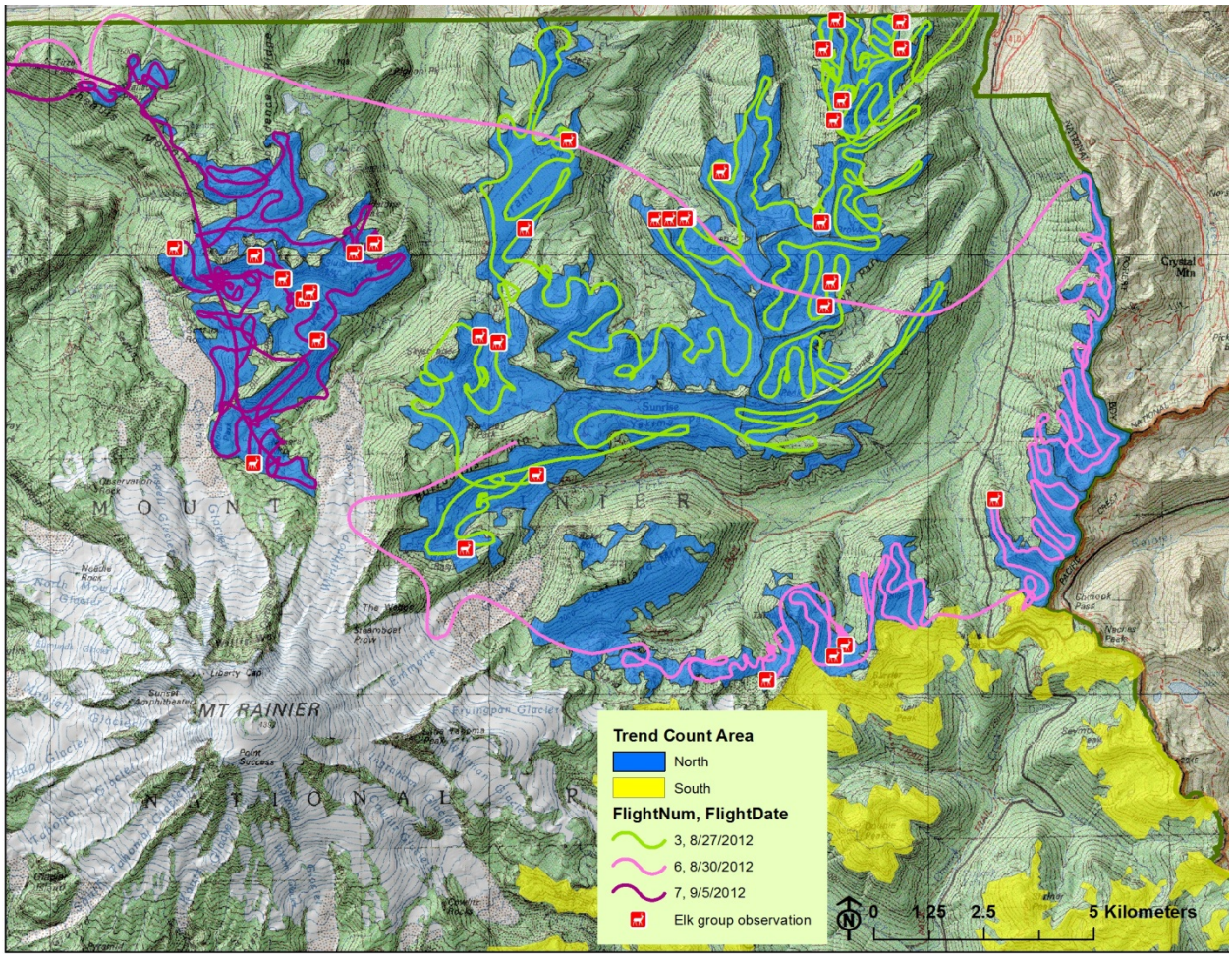


Figure 6. Flight lines for the survey in the North Rainier trend count area, conducted 27 August, 30 August, and 5 September 2012. Observed elk groups are indicated with the red icons.

Table 4. Summarized elk observations from two replicate surveys of the South Rainier trend count area, and one survey of the North Rainier trend count area. Counts include elk seen in the counts of each survey unit and a 300m buffer around each unit.

Trend Count Area	Groups	Total Elk	Cows	Calves	Bulls			Calves per 100 Cows	Bulls per 100 Cows	Mean Group Size	Max. Group Size
					Spike	Sub-adult	Mature				
North Rainier	33	236	123	61	14	18	20	49.59	42.28	7.15	56
South Rainier (Rep. 1)	61	706	391	142	19	42	88	36.32	38.11	11.57	104
South Rainier (Rep. 2)	96	500	261	110	26	44	36	42.15	40.61	5.21	53

Olympic National Park Summer Surveys

Figure 7 shows the flight paths and location of elk groups observed during the summer in OLYM. Counts and composition of elk groups seen in OLYM surveys are summarized in Table 5. We counted 371 elk in the Core and 76 in the Elwha. During the 2012 flights mean group size ranged from 28.6 to 6.3; we encountered several large groups in 2012, including a group of 88 in the Northwest count area (see cover photo).

In addition, we completed 23 resighting trials (i.e., aerial surveys conducted over groups with radio-collared elk). Of 23 opportunities to see collared groups during these surveys, we detected 17 groups and missed 6. We now have a total of 39 resighting trials, and anticipate finishing gathering resight data in 2013 and developing a model for OLYM in 2014.

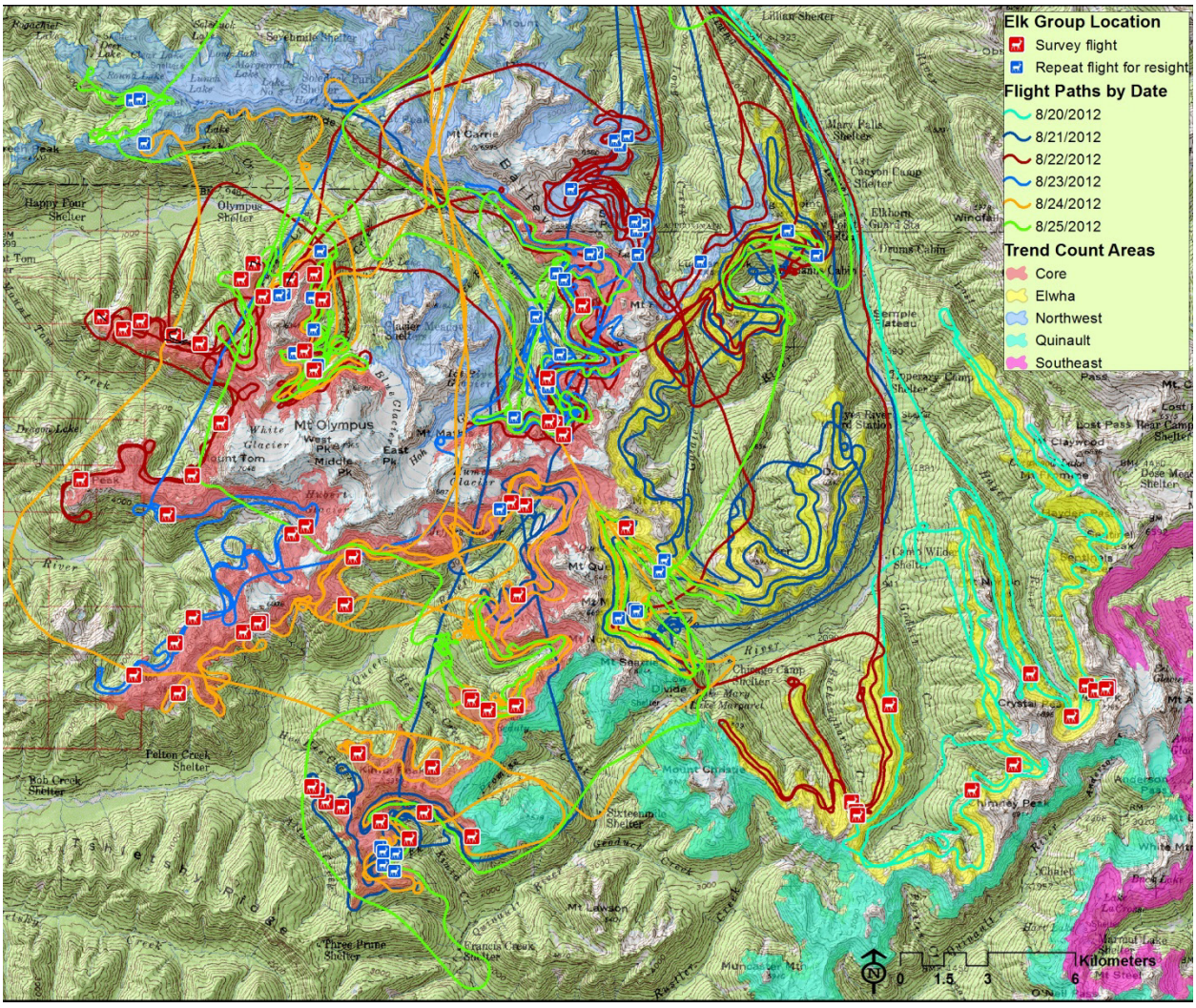


Figure 7. Flight lines in the summer trend count areas of Olympic National Park, conducted 20-25 August 2012. Approximate locations of observed elk groups are indicated with the icons (red= elk groups seen during the survey flight, blue= elk groups seen during additional flights conducted to collect resight data). The first flights in the Core and Elwha trend count areas were used for survey data. All other flights were to collect resight data.

Table 5. Summarized elk observations from summer surveys in Olympic National Park. Surveys are complete for the Core and Elwha; surveys in the Northwest are incomplete and only reported here for convenience. Counts include elk seen in the first complete count of each survey unit and a 300m buffer around each unit.

Trend Count Area	Groups	Total Elk	Cows	Calves	Bulls			Calves per 100 Cows	Bulls per 100 Cows	Mean Group Size	Max. Group Size
					Spike	Sub-adult	Mature				
Core	48	371	183	62	11	8	91	33.88	60.11	7.73	55
Elwha	12	76	29	7	4	5	20	24.14	100.00	6.33	20
North-west (partial)	5	142	85	44	1	1	11	51.76	15.29	28.40	88

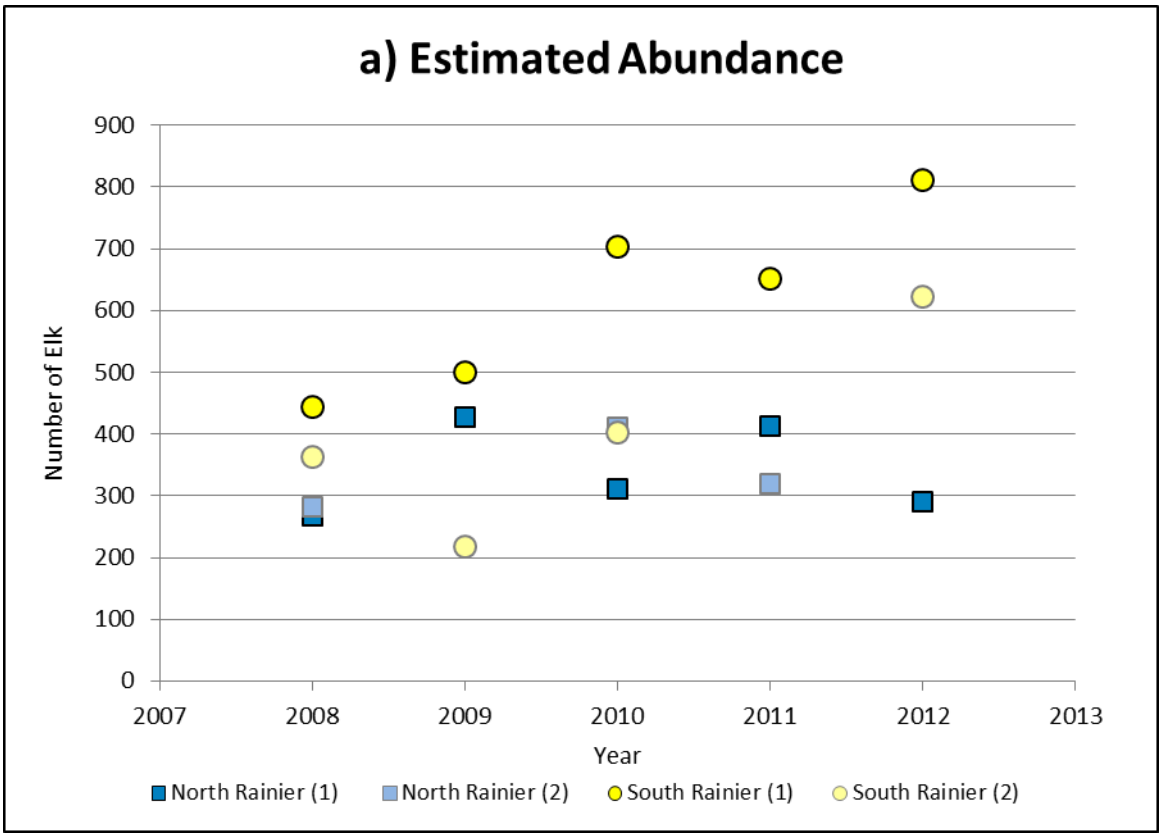
Elk Abundance and Composition Estimates

We applied the double observer sightability model to the 2012 MORA survey data (Table 6). After using the model to adjust for sightability, the estimated abundance and bulls per 100 cows increased over the raw numbers, however there was little change in the calves per 100 cows.

Table 6. Raw and estimated numbers of elk and herd composition in the 2012 Mount Rainier National Park summer surveys.

Trend Count Area	Total Elk Seen	Estimated Abundance	Raw Calves per 100 Cows	Estimated Calf:100 Cow	Raw Bulls per 100 Cows	Estimated Bull:100 Cow
North Rainier	236	**289.87**	49.59	**49.40**	42.28	**48.72**
South Rainier (Replicate 1)	706	**810.49**	36.32	**36.34**	38.11	**42.70**
South Rainier (Replicate 2)	500	**621.77**	42.15	**40.42**	40.61	**47.15**

The double observer sightability model has been applied to the MORA survey data from 2008 through 2012 (Figure 8). Trend analyses of the 2008-2011 survey data will be presented in the 4-year synthesis report, due to be completed in 2013. Data from the 2012 MORA surveys will be analyzed in the subsequent 4-year synthesis report.



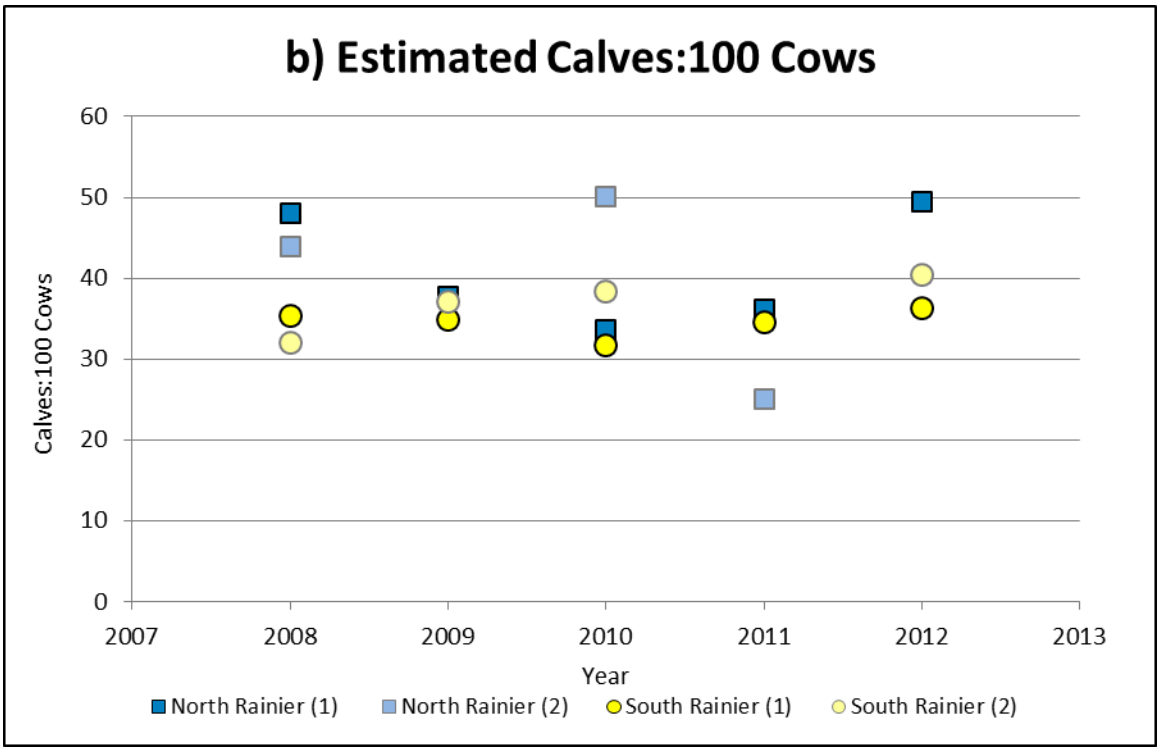


Figure 8. Estimated a) abundance, b) calves:100 cows, and c) bulls:100 cows in the North and South Rainier herd surveys, 2008-2012.

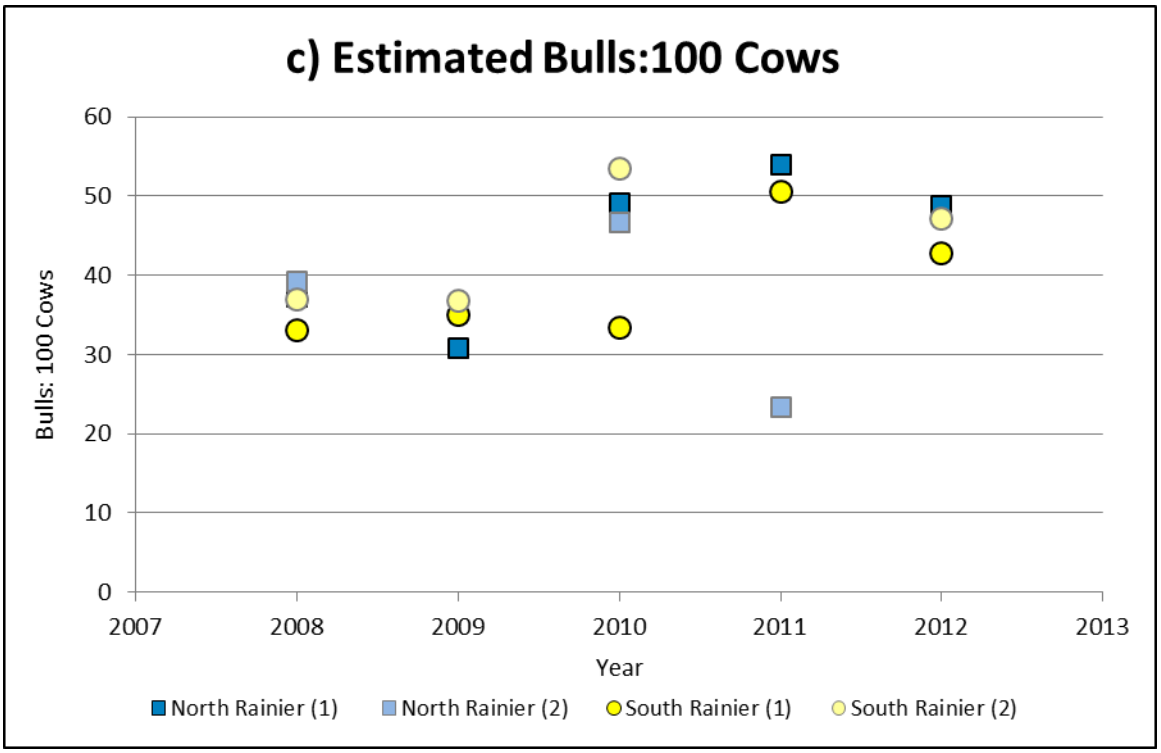


Figure 8. Estimated a) abundance, b) calves:100 cows, and c) bulls:100 cows in the North and South Rainier herd surveys, 2008-2012 (continued).

It is not yet possible to present estimated abundance or composition values for OLYM summer surveys; this will be done retroactively for the 2008 - 2012 data from OLYM once the OLYM model is completed.

Literature Cited

Baccus, W. D., M. Larrabee, R. Lofgren, and M. Huff. In press. North Coast and Cascades Network climate monitoring report: Olympic National Park; water year 2011. Natural Resource Data Series NPS/NCCN/NRDS—2013/XXX. National Park Service, Fort Collins, Colorado.

Bradley, W. 1982. History, ecology, and management in an introduced Wapiti population in Mount Rainier National Park, Washington. Ph.D. Dissertation. University of Washington, Seattle, Washington.

Cooper, K. C. 1987. Seasonal movements and habitat use of migratory elk in Mount Rainier National Park. MS Thesis. Oregon State University, Corvallis, Oregon.

Graf, W. 1955. The Roosevelt elk. Port Angeles Evening News. Port Angeles, Washington.

Griffin, P. C., P. J. Happe, K. J. Jenkins, M. Reid, D. Vales, B. J. Moeller, M. Tirhi, S. McCorquodale, and P. Miller. 2011. Mount Rainier National Park and Olympic National Park elk monitoring program annual report 2010. Natural Resource Data Series NPS/NCCN/NRDS—2011/289. National Park Service, Fort Collins, Colorado.

Griffin, P. C., K. Jenkins, P. J. Happe, M. Reid, D. Vales, B. J. Moeller, S. McCorquodale, M. Tirhi, J. Boetsch, K. Beirne, and J. Schaberl. 2012. Elk monitoring protocol for Mount Rainier National Park and Olympic National Park: January 11, 2012. Natural Resource Report. NPS/NCCN/NRR—2012/485. National Park Service, Fort Collins, Colorado.

Gustafson, C. E. 1983. Wapiti populations in and adjacent to Mount Rainier National Park: Archeological and ethnographic evidence. Unpublished report on file at Mount Rainier National Park, Ashford, Washington.

Happe, P. J., M. Reid, P. C. Griffin, K. J. Jenkins, D. J. Vales, B. J. Moeller, M. Tirhi, and S. McCorquodale. 2013. Mount Rainier National Park and Olympic National Park elk monitoring program annual report 2011. Natural Resource Data Series NPS/NCCN/NRDS—2013/437. National Park Service, Fort Collins, Colorado.

Jenkins, K. J., and E. E. Starkey. 1984. Habitat use by Roosevelt elk in unmanaged forests of the Hoh valley, Washington. Journal of Wildlife Management 48:642-646.

Jenkins, K. J., and E. E. Starkey. 1996. Simulating secondary succession of elk forage values in a managed forest landscape, western Washington. Environmental Management 20:715-724.

Lofgren, R. A., B. Baccus, M. Larrabee, and M. Huff, M. In press. North Coast and Cascades Network climate monitoring report: Mount Rainier National Park; water year 2011. Natural Resource Data Series NPS/NCCN/NRDS—2013/XXX. National Park Service, Fort Collins, Colorado.

Morganroth, C. 1909. Roosevelt elk in the Olympic Mountains. U.S. Forest Service unpublished report on file at Olympic National Park, Port Angeles, Washington.

Motazedian, I., and S. H. Sharrow. 1984. Elk and vegetation monitoring, Mount Rainier National Park. Part II: Plant monitoring and analysis. Final progress report. Department of Rangeland Resources, Oregon State University, Corvallis.

Murie, A. 1935*a*. Special report of senior naturalist technician Adolph Murie on wildlife of the Olympics. National Park Service unpublished report on file at Olympic National Park, Port Angeles, Washington.

Murie, O. J. 1935*b*. Report on the Elk of the Olympic Peninsula. U.S. Biological Survey. Unpublished report on file at Olympic National Park, Port Angeles, Washington.

Murie, O. J. 1951. The elk of North America. Stackpole Co., Harrisburg, Pennsylvania.

Newman, C. C. 1958. Final report on Roosevelt elk in Olympic National Park. National Park Service unpublished report on file at Olympic National Park, Port Angeles, Washington.

Pacific Meridian Resources. 1996. Vegetation and Landform Database Development – Final Report. Unpublished report on file at Olympic National Park, Port Angeles, Washington.

Raedeke, K. J., and J. F. Lemkuhl. 1985. A simulation procedure for modeling the relationships between wildlife and forest management. Pages 377-382 *in* J. Verner, M. Morrison, and C. J. Ralph (editors), Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin.

Ripple, W. J., E. E. Starkey, and B. J. Schrumpf. 1988. Assessing elk trail and wallow impacts in Mount Rainier National Park. National Park Service unpublished report on file at Mount Rainier National Park, Ashford, Washington.

Scheffer, V. B. 1995. Mammals of the Olympic National Park and vicinity (1949). Northwest Fauna Occasional Monographs on Vertebrate Natural History 2.

Schoenecker, K., B. Lubow, L. Ziegenfuss, and J. Mao. 2006. 2005 Annual progress report: elk and bison grazing ecology in the Great Sand Dunes Complex of Lands. U.S. Geological Survey Open-File Report 2006-1267.

Schonewald-Cox, C. 1983. Are elk in Mount Rainier National Park exotic? National Park Service unpublished report on file at Mount Rainier National Park, Ashford, Washington.

Schullery, P. 1983. A history of native elk in Mount Rainier National Park. Unpublished report on file at Mount Rainier National Park, Ashford, Washington.

Schwartz, J. E. 1939. The Olympic elk study. U.S. Forest Service unpublished report on file at Olympic National Park, Port Angeles, Washington. Schwartz, J. E. and G. E. Mitchell. 1945. The Roosevelt elk on the Olympic Peninsula, Washington. Journal of Wildlife Management 9:295-319.

Sharrow, S.H., and D. E. Kuntz. 1986. Plant response to elk grazing in subalpine dry meadow communities of Mount Rainier National Park. Final Report. Department of Rangeland Resources, Oregon State University, Corvallis, Oregon.

Starkey, E. E. 1984. Elk of Mount Rainier National Park: A review of existing information. National Park Service , Cooperative Park Studies Unit Report CPSU/OSU 85-6. Unpublished report on file at Mount Rainier National Park, Ashford, Washington.

Starkey E. E., D. S. deCalesta, and G. W. Witmer. 1982. Management of Roosevelt elk habitat and harvest. Transactions of the North American Wildlife and Natural Resources Conference 47:353-362.

Sumner, L. 1938. Special report on elk in Olympic National Park. National Park Service Unpublished report on file at Olympic National Park, Port Angeles, Washington.

Taber, R. D., and K. J. Raedeke. 1980. Roosevelt elk of the Olympic National Forest. College of Forest Resources. University of Washington, Unpublished final report on file at Olympic National Park, Port Angeles, Washington.

U.S. Congress. 1938. Establishing the Olympic National Park in the state of Washington. Report 2247 to accompany H. R. 10024, 75th Congress.