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 2011

Natural Resource Data Series NPS/NCCN/NRDS—2013/437

USGS science for a changing world

Muckleshoot Indian Tribe

Puyallup Tribe of Indians

Washington Department of Fish and Wildlife

ON THE COVER
Top: Elk, *Cervus elaphus,* Mount Rainier, August 2011; bottom left and right: Elk, Olympic National Park, September 2011.
Photo: Top, Washington Department of Fish and Wildlife; bottom left and right, NPS I&M program.

Mount Rainier National Park and Olympic National Park Elk Monitoring Program Annual Report 2011

Natural Resource Data Series NPS/NCCN/NRDS—2013/437

Patricia J. Happe

National Park Service
Olympic National Park
600 East Park Avenue
Port Angeles, WA 98362

Mason Reid

National Park Service
Mount Rainier National Park
55210 238th Ave E
Ashford, WA 98304

Paul C. Griffin, Kurt J. Jenkins

US Geological Survey
FRESC – Olympic Field Station
600 East Park Avenue
Port Angeles, WA 98362

David J. Vales

Muckleshoot Indian Tribe
39015 172 Ave SE
Auburn, WA 98092

Barbara J. Moeller

Puyallup Tribe of Indians
5722 66th Ave E
Puyallup, WA 98371

Michelle Tirhi

Washington Department of Fish and Wildlife
7801 Philips Rd. SW
Lakewood, WA 98498

Scott McCorquodale

Washington Department of Fish and Wildlife
1701 S. 24th Ave
Yakima, WA 98902

January 2013

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

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.

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, 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.

NPS 105/119621, 149/119621, January 2013

Contents

Contents (continued)

Page

Figures

Page

Tables

Page

Executive Summary

Fiscal year 2011 was the first year of implementing an approved elk monitoring protocol in Mount Rainier (MORA) and Olympic (OLYM) National Parks in the North Coast and Cascades Network (NCCN) (Griffin et al. 2012). However, it was the fourth and second year of gathering data according to protocol in MORA and OLYM respectively; data gathered during the protocol development phase followed procedures that are laid out 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 surveys; however the protocol estimates the number of missed elk by applying a model that accounts for detection bias. Detection bias in elk surveys in MORA is estimated using a double-observer sightability model that was developed using survey data from 2008-2010 (Griffin et al. 2012). That model was developed using 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 OLYM in the past 4 years has been focused on capturing and radio-collaring elk and conducting sightability trials needed to develop a double-observer sightability model in OLYM. In this annual report we provide estimates of abundance and composition for MORA elk, raw counts of elk made in OLYM, and describe sightability trials conducted in OLYM.

At MORA the North trend count area was surveyed twice and the South once (North Rainier herd, and South Rainier herd). We counted 373 and 267 elk during two replicate surveys of the North Rainier herd, and 535 elk in the South Rainier herd. Using the model, we estimated that 413 and 320 elk were in the North and 652 elk were in the South trend count areas during the time of the respective surveys.

At OLYM, the Core and Northwest trend count areas were completely surveyed, as were portions of the Quinault. In addition, we surveyed 10 survey units specifically to get resight data. Two-hundred and forty eight elk were counted in the Core, 19 in the Northwest, and 169 in the Quinault. We conducted double-observer sightability trials associated with 14 collared elk groups for use in developing the double-observer sightability 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 FY2011 was supported by the NCCN I&M program and was also supported by Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), Washington Department of Fish and Wildlife (WDFW), MORA, OLYM, U.S. Geological Survey (USGS), and Washington's National Parks Fund. The Lower Elwha K'lallam Tribe (LEKT) provided some of the radio collars used in OLYM. The National Park Service (NPS) is grateful to the MIT, PTOI, and WDFW, who have long supported elk monitoring in Mount Rainier National Park, and have been 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. The authors thank the other crew members who participated in surveys including Kathy Beirne, Bill Baccus, Ellen Myers, Sarah Yates, Rich Lechleitner, Glenn Kessler (NPS); Mike Middleton, Mike McDaniel, Paul Rodarte (MIT); Phillip Dillon, Jason Wrolson (PTOI); Tammy Schmidt, Delbert Shoop, Brian Calkins, Eric Holman (WDFW). We thank the following pilots for their assistance: Jess Hagerman, Trevor Walker, Mike Everett (Northwest Helicopters). For their support of the elk monitoring program, we thank Muckleshoot Indian Tribe Wildlife Committee (MIT), Phillip Dillon (PTOI), Kim Sager-Fradkin (LEKT), and Paul Geissler (USGS National Park Monitoring Project). We are grateful to Bill Baccus, Kathy Beirne and Bob Kuntz 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 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 at the turn of the last century. 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 2011

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. Every four years we will provide reports that contain more comprehensive analysis of the data, including quantified estimates of variance and trends, and interpretation of those data. We are in the process of developing a four-year report that will examine trends in counts obtained from 2008-2011; it is expected to be completed in 2013.

Due to budgetary constraints, no winter range surveys were conducted in OLYM in 2011. Following the protocol, the winter range surveys in OLYM are treated as a legacy dataset, and will be conducted in the future only as funding allows (Griffin et al. 2012). Therefore, the objectives of this report are to summarize results of elk surveys conducted in selected subalpine summer ranges in MORA and OLYM during summer 2011.

Surveys conducted in 2011 were the first since completion of the approved protocol for aerial surveys in MORA and OLYM (Griffin et al. 2012; note: the protocol was approved for publication in 2011). The approved protocol calls for reporting flight conditions and raw counts of elk obtained from surveys in both parks annually, 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 2011 were to complete two replicate surveys of the North Rainier Herd and a single survey of the South Rainier Herd. Results of the 2011 surveys, both the raw counts and counts adjusted for detection biases, are reported here.

As outlined in the monitoring protocol (Griffin et al. 2012), the double-observer sightability model used to adjust raw counts for detection biases has been completed for MORA (Griffin et al. 2012), but not for OLYM. Sightability model development in OLYM lagged behind that of MORA because of the lack of pre-existing radio-collars on elk at the onset of the protocol development phase in OLYM (Griffin et al. 2012) and the mass failure of collars deployed in OLYM in 2009 (Griffin et al. 2011). Therefore 2011 survey objectives for OLYM were to complete surveys of elk within the Core, Northwest, and Quinault trend count areas (described below), while also collecting sightability trial data that will be used to complete development of a double-observer sightability model for application in OLYM. Once a model is developed for OLYM, the 2008-2011 data will be retroactively analyzed to correct raw counts for detection biases. Consequently, reporting objectives for 2011 in OLYM were to report flight conditions, raw counts of elk, and to summarize sightability trials completed in 2011.

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.

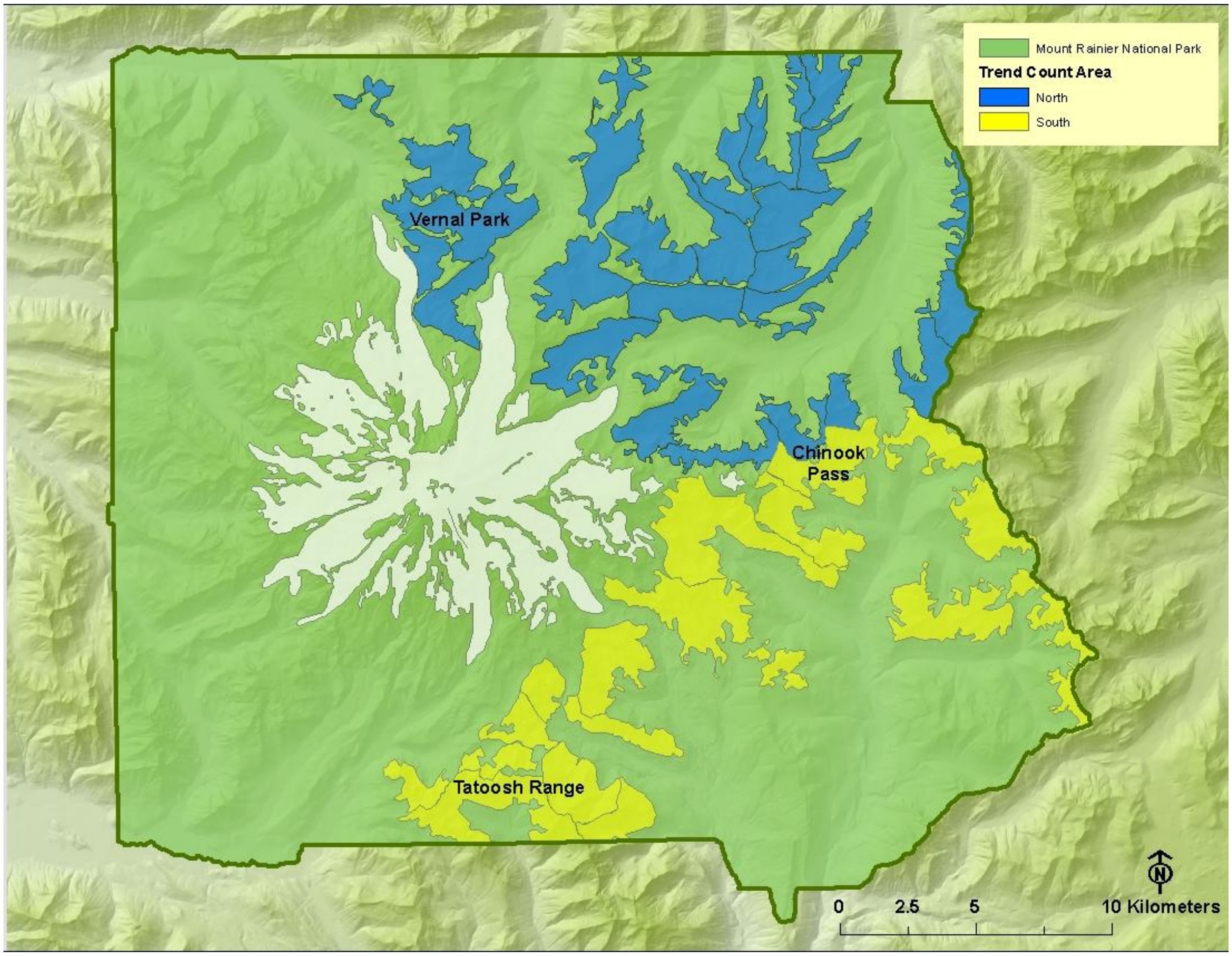

Figure 1. Summer trend count areas within MORA. The North Rainier trend count area is approximately 103 km^2, and the South Rainier trend count area is approximately 89 km^2.

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 migrate out of OLYM and winter near the Hood Canal.

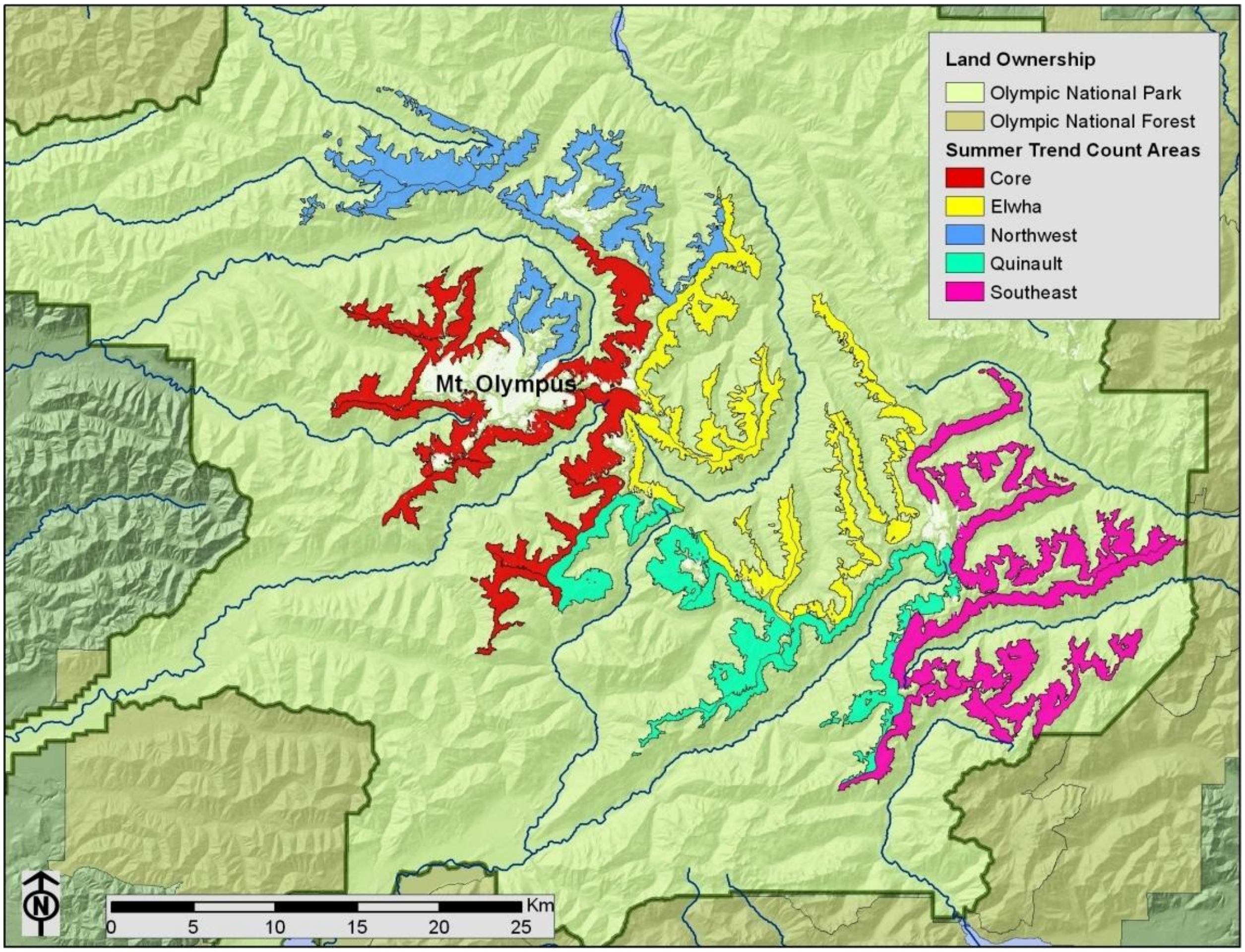

Figure 2. Summer trend count areas within OLYM, including the core trend count area that will be surveyed annually, and four ancillary trend count areas that will be surveyed once per four years. The Core, Elwha, Northwest, Quinault, and Southeast trend count areas are approximately 93, 82, 74, 80, and 85 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 specific 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. In MORA, trend count areas were bounded by elevations below 2100 m and above 1500 m in the North herd range, and by elevations below 2100 m and above 1350 m in 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, summer trend count areas ranged between 1200 m and 1650 m. Within the elevation boundaries of trend count areas, we used each park's vegetation cover map (Pacific Meridian Resources 1996) to identify and exclude areas of continuous dense forest canopy cover or rock and snow.

The sampling design calls for completing one replicate survey of both trend count areas in MORA, and an additional replicate of one of the survey areas. Which area will be surveyed twice alternates between years. In 2011 the North was surveyed twice and the South once. Surveys in MORA are conducted in the 4 hours before sunset. In OLYM two trend count areas are surveyed each year, with the Core flown each year and the other four 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 of two helicopters 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 problems associated with missed survey units within trend count areas during the 4 year comprehensive analysis 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 2011. 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 2011 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 2010 we radio-collared 18 additional elk for use in conducting sightability trials during 2011 (Griffin et al. 2011). Going into 2011 we had 31 functional radio collars for these sightability trials. However, mid-way through 2011 we experienced a second round of GPS collar failures. Although not as severe as the total failure of GPS collars deployed in 2009, greater than 50% of the new collars deployed in 2010 were not working and several were in the process of failing. Only 22 collars were fully or partially functional by September 2011.

Data Management

Following each survey flight the observers immediately reviewed all data forms and noted and corrected any discrepancies. The GIS Specialist downloaded helicopter flight lines to the NCCN computer server. 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. There were also checks for data consistency, and confirmation that all data entered were within acceptable bounds; those steps of quality assurance will be achieved by automated queries in the final project database. After data quality review was complete, data were shared with project participants from MIT, PTOI, and WDFW.

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

2011 was a wet and cold year that set records for the depth and persistence of snow at high elevation areas in the spring and summer. During 2011, snow water equivalent (SWE) measured on 1 April in OLYM was approximately 167% of the 30-year normal (1971-2000). Late-season snows continued to augment the snowpack in April, resulting in a snowpack approximately 225% of normal on 1 May. Delayed phenology of vegetation and persistent snow continued into the elk survey window (15 August to 15 September) (Figure 3). At Paradise in MORA, the record for the maximum snow depth was broken for eight consecutive days beginning on August 7th and ending on August 24th. July snow-water equivalent measurements at Paradise were over 260% of normal.

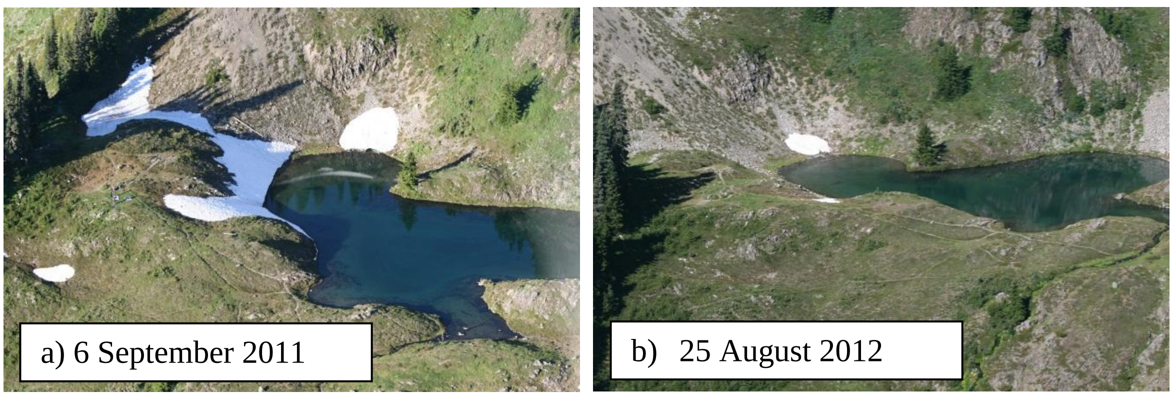

Figure 3. Late snowmelt and delayed phenology in 2011, as illustrated by the OLYM phenology photopoint at Swimming Bear Lake. Note the picture from 2011 was obtained 12 days later in the calendar year than the picture in 2012, but has significantly more snow near the lake.

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 the 2011 surveys are listed in Table 1.

Table 1. Observers that participated in elk surveys in 2011. 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, Ellen Myers, Dave Manson, Sarah Yates (survey crew members); Bill Baccus, Kathy Beirne, Ellen Myers, Rich Lechleitner, Glenn Kessler (helicopter managers)
MIT	Mike Middleton, Mike McDaniel, Paul Rodarte
PTOI	Barbara Moeller, Phillip Dillon, Jason Wrolson
WDFW	Scott McCorquodale, Michelle Tirhi. Tammy Schmidt, Brian Calkins, Eric Holman.
Pilots	Trevor Walker, Jess Hagerman, Mike Everett Delbert Shoop (observer, fuel truck driver) (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

Weather for MORA surveys in 2011 was good, with clear, calm days with average temperatures. Flights at MORA included two complete surveys of the North trend count area and one complete survey of the South (Table 2). Cold temperatures and above normal precipitation during spring and early summer months resulted in above normal snowpack that persisted notably late in the season. Radio-marked elk monitored by the Muckleshoot Tribe delayed their migration from winter range to MORA summer range until late July. The first complete survey of the North Rainier herd trend count area was conducted on 17 August 2011; however the second North herd count and the survey of the South Rainier herd were delayed until later in the survey window to allow for more snow melt. The second North herd count was conducted on 12 September 2011 and the South Rainier herd trend count area was conducted on 1 September and 13 September 2011.

Table 2. Flight details for summer 2011 survey flights at Mount Rainier National Park. Pilots' last names are in bold font.

Flight	Date	Replicate	Survey Units	Total flight time (h:min)	Survey time (h:min)	Sponsor[1]	Crew Members
1, 2	Aug 17	First North	N1, N2, N3a, N3b, N3c, N5a, N6, N9, N10, N15, N16a	2:35	2:16	NCCN	**Walker,** Reid, Beirne, Meyers
3	Aug 17		N4, N5b, N7, N8a, N8b, N11a, N11b, N12a, N12b, N13a, N13b, N14, N17, N18	3:01	2:47	MIT	**Hagerman,** Middleton, Rodarte, McDaniel
4	Sep 01	South	S8, S10, S11, S13, S14, S15, S16	2:56	2:27	PTOI	**Hagerman**, Moeller, Phillip, Wrolson
7	Sep13		S1, S4, S5a, S6, S7, S9, S17, S18, S19	2:58	2:22	WDFW	**Hagerman**, McCorquodale, Holman, Colkins
5	Sep 12	Second North	N1, N2, N3a, N3b, N3c, N4, N11a, N12a, N12b, N13a, N13b, N14	2:34	2:17	NCCN	**Everett**, Reid, Beirne, Yates
6	Sep12		N5a, N5b, N6, N7, N8a, N8b, N9, N10, N15, N16a, N16b, N17, N18	2:35	2:58	WDFW	**Hagerman**, Tirhi, Shoop, Schmidt

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

Olympic National Park Summer surveys

Flights at OLYM were conducted for 5 consecutive days in early September. Flights were initially planned for August 22 – 26, but were delayed for two weeks due to the lingering snowpack, and the consequent lack of consistent use of high elevation summer range by elk, as indicated by the data from the elk with GPS-equipped radio collars (NPS, unpublished data). The OLYM surveys included a complete count of the Core and the Northwest trend count areas, and a partial count of the Quinault area. In addition, 10 survey units were flown one or more times to get resight data for use in developing a double-observer sightability model for OLYM. We had planned to conduct a complete count of the Quinault unit, however those plans were curtailed by a chip light coming on in the helicopter, requiring the early termination of flight 7. The change in flight schedule necessitated a shifting of priorities for flights 8 through 10.

Table 3. Flight details for 2011 survey flights at Olympic National Park. Pilots' last names are in bold font. Costs of these flights were paid by North Coast and Cascades Network, National Park Service, and Washington's National Park Fund.

Flight	**Date**	**Replicate**[1]	**Survey Units**	**Total flight time** (h:min)	**Survey time**[2] (h:min)	**Crew Members**
1, 2	Sep 6	1	NW1, NW2, NW3a, NW3b, NW4, NW5a, NW5b, NW5c	3:56	3:03	**Walker**, Happe, Beirne, Baccus
3,4	Sep 7	1, 0	C1, C2, C6b, C6c, C6d, C7	3:59	2:33	**Walker**, Happe, Beirne, Baccus
5,6	Sep 8	1,0	C1, C3, C4, C5, C6a, E3	4:13	2:22	**Walker**, Happe, Beirne, Baccus
7,8	Sep 9	1,0	Q1c,Q2d, Q3, E3,	3:52	2:30	**Walker**, Happe, Beirne, Manson
9,10	Sep 10	0	C1, C2, C5, C7, NW2, NW5a, Q1c	3:53	2:25	**Walker**, Happe, Beirne, Manson

[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 flight survey paths (flight lines) flown during the summer surveys in MORA. Observed counts of elk groups in MORA are summarized in Table 4. On the first replicate survey (Aug 17) of the northern area, there was a large discrepancy in the number of elk seen by the different flights. Flights 1 and 2 (single helicopter with a refuel) observed only 30 elk in their allotted survey units, whereas the paired helicopter (Flight 3) observed 343. Unit N16b was not flown due to time constraints, however it did not contain elk during the second replicate.

A single replicate of the south area was flown. Due to scheduling conflicts, the entire area could not be flown in one day; one half of the area was flown on Sept. 1, and the other half was flown on Sept. 13. Unit S20 was not flown due to time constraints, and Unit S5b was not surveyed due to a planning mix up.

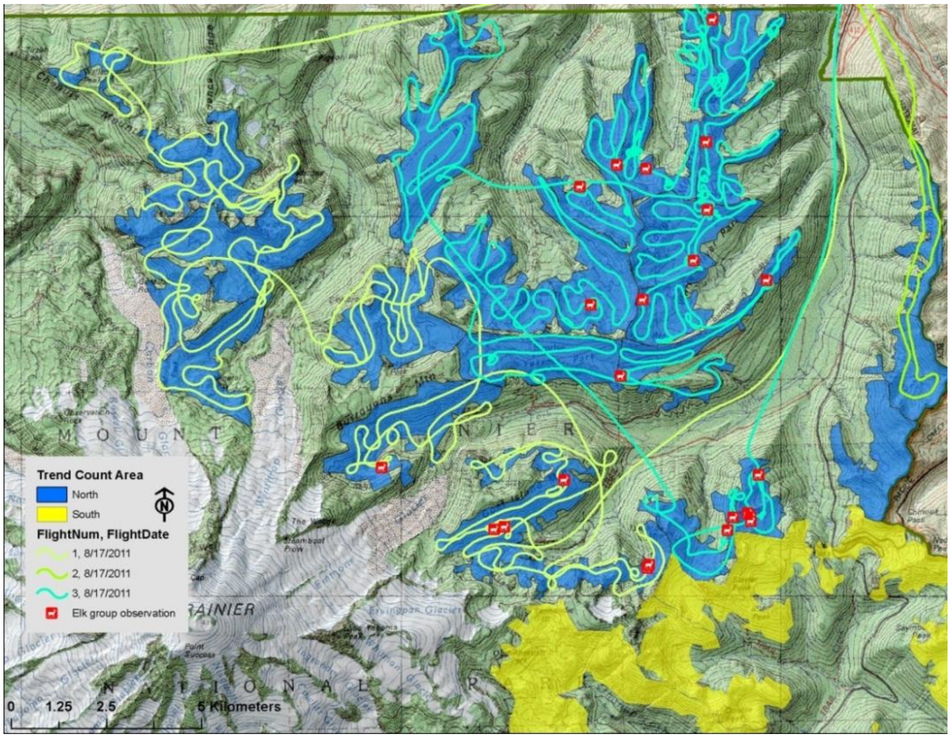

Figure 4. Flight lines for the first replicate survey in the North Rainier trend count area, conducted August 17, 2011. Approximate locations of observed elk groups are indicated with the red icon.

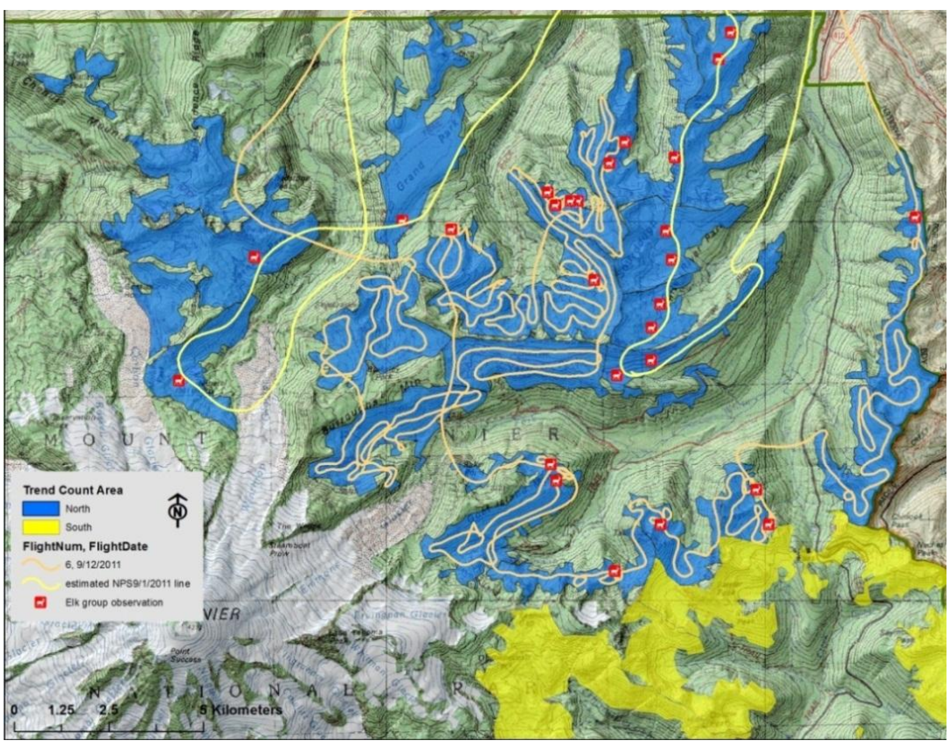

Figure 5. Flight lines for the second replicate survey in the North Rainier trend count area, conducted September 12. 2011. The line for flight 5 was lost soon after the flight started. Approximate locations of observed elk groups are indicated with the red icon.

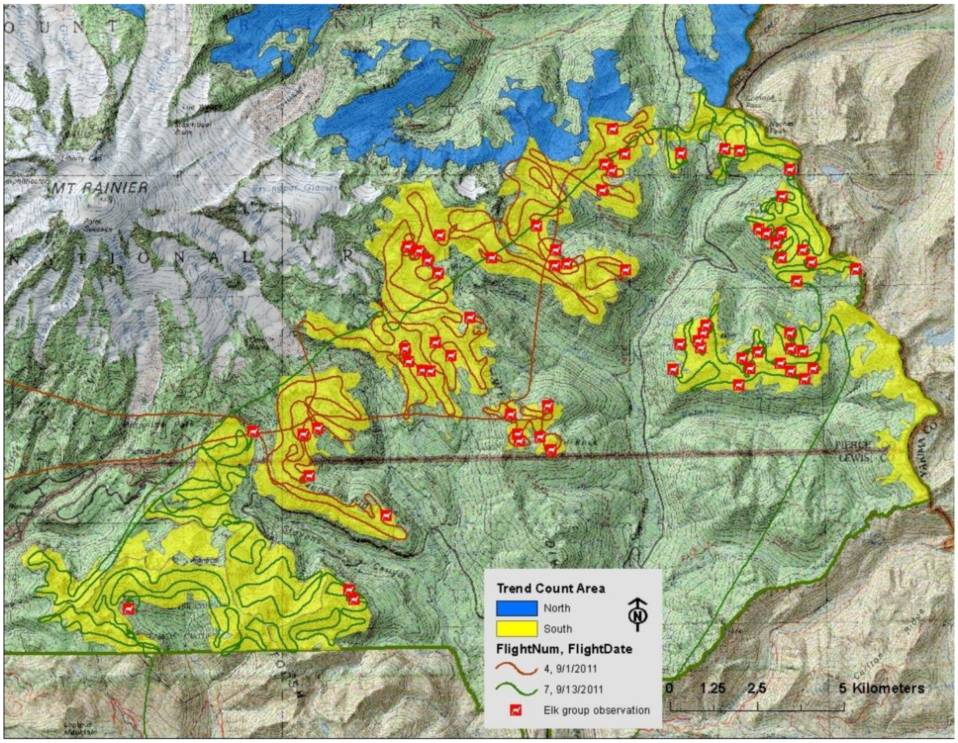

Figure 6. Flight lines for the survey in the South Rainier trend count area, conducted September 1 and 13, 2011. Observed elk groups are indicated with the red icons.

Table 4. Summarized elk observations from two replicate surveys of the North Rainier herd trend count area, and one survey of the South Rainier herd trend count area.

Trend Count Area	Groups	Total Elk	Cows	Calves	Bulls	Calves per 100 Cows	Bulls per 100 Cows	Mean Group Size	Max. Group Size
1st North Rainier	23	373	200	73	100	36.5	50.0	16.2	130
2nd North Rainier	26	267	175	44	32	25.1	18.3	10.3	72
1st South Rainier	68	535	297	101	135	34.0	45.5	7.9	75

Olympic National Park Summer Surveys

Figure 7 shows the flight paths flown during the summer in OLYM. Observed counts of elk groups seen in OLYM summer surveys are summarized in Table 5. In addition we completed 14 resighting trials; i.e. aerial surveys conducted over groups with radio-collared elk. Of 14 opportunities to see collared groups during these surveys, we detected 10 groups and missed 4.

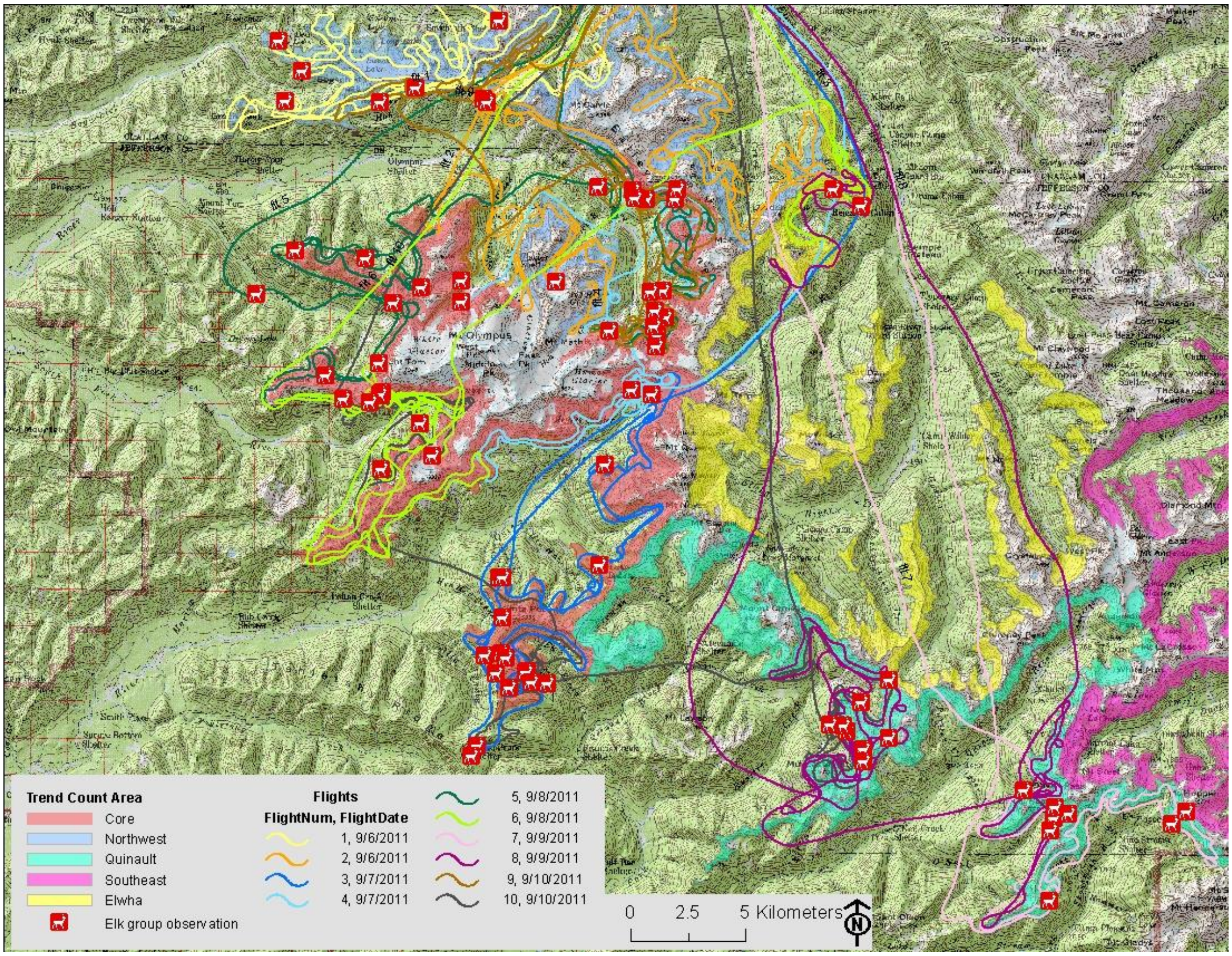

Figure 7. Flight lines in the summer trend count areas of OLYM, conducted September 6-10, 2011. Approximate locations of observed elk groups are indicated with the red icons.

Table 5. Summarized elk observations from summer surveys in OLYM. Surveys are complete for the Core and Northwest, and partial for the Quinault. Counts include elk seen in the survey units 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
Core	26	248	133	39	75	29.3	56.4	9.5	52
Northwest	6	19	8	1	8	12.5	100.0	3.2	18
Quinault (partial)	13	169	98	28	43	28.6	43.9	13.0	64

Elk Abundance and Composition Estimates

We applied the double observer sightability model to the 2011 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 2011 MORA 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
1st North Rainier	373	**412.8**	36.5	**36.1**	50.0	**53.9**
2nd North Rainier	267	**319.9**	25.1	**25.1**	18.3	**23.4**
South Rainier	535	**651.8**	34.0	**34.5**	45.5	**50.5**

It is not yet possible to present estimated abundance or composition values for OLYM summer surveys; this will be done retroactively to the OLYM 2011 data once the OLYM model is completed.

Literature Cited

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., 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

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.

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.

Weber, S., A. Woodward, and J. Freilich. 2009. North Coast and Cascades Network vital signs monitoring report (2005). Natural Resource Report NPS/NCCN/NRR—2009/098. National Park Service, Natural Resource Program Center, Fort Collins, Colorado.