



Mount Rainier National Park and Olympic National Park Elk Monitoring Program Annual Report 2014

Natural Resource Data Series NPS/NCCN/NRDS—2015/779





ON THIS PAGE

Elk in the upper Queets, Olympic National Park, WA.
Photography by: Patti Happe, Olympic National Park.

ON THE COVER

Elk in the upper Skokomish, Olympic National Park, WA.
Photograph by: Patti Happe, Olympic National Park.

Mount Rainier National Park and Olympic National Park Elk Monitoring Program Annual Report 2014

Natural Resource Data Series NPS/NCCN/NRDS—2015/779

Patricia J. Happe

National Park Service
Olympic National Park
600 E. Park Ave
Port Angeles, WA 98362

Michelle Tirhi

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

David J. Vales

Muckleshoot Indian Tribe
39015 172 Ave SE
Auburn, WA 98092

Eric Holman

Washington Department of Fish and Wildlife
2108 Grand Blvd.
Vancouver, WA 98661

Barbara J. Moeller

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

Katherine Beirne

National Park Service
Olympic National Park
600 E. Park Ave
Port Angeles, WA 98362

April 2015

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 established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government. Furthermore, views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the Muckleshoot Indian Tribe, Puyallup Tribe of Indians, or Washington Department of Fish and Wildlife.

This report is available in digital format 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/>). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Happe, P. J., D. J. Vales, B. J. Moeller, M. Tirhi, E. Holman, and K. Beirne. 2015. Mount Rainier National Park and Olympic National Park elk monitoring program annual report 2014. Natural Resource Data Series NPS/NCCN/NRDS—2015/779. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	v
Tables.....	vi
Executive Summary	vii
Acknowledgments.....	ix
Introduction.....	1
Elk in Mount Rainier National Park.....	1
Elk in Olympic National Park	2
Monitoring Objectives.....	3
Survey and Reporting Objectives for 2014	3
Study Area	5
Methods.....	7
Safety.....	7
Sample Design.....	7
Survey Methods.....	8
Data Management.....	8
Data Analysis.....	8
Results.....	9
2014 Climate in Review	9
Names and Roles of Project Personnel.....	9
Flight Statistics	10
Mount Rainier Summer Surveys	10
Olympic National Park Summer Surveys.....	11
Elk Observations	11
Mount Rainier Summer Surveys	11
Olympic National Park Summer Surveys.....	15

Contents (continued)

	Page
Elk Abundance and Composition Estimates	17
Mount Rainier Summer Surveys	17
Olympic Summer Surveys.....	19
Literature Cited	21
Appendix A: Other wildlife recorded during elk surveys in Mount Rainier National Park, 2014.....	25
Appendix B: Other wildlife recorded on elk surveys in Olympic National Park, 2014.	27

Figures

	Page
Figure 1. Elk in the upper Quinault, Olympic National Park, Washington.	viii
Figure 2. Bull elk, north Rainier count area, 2014. Photo by Muckleshoot Indian Tribe.....	x
Figure 3. Summer elk trend count areas within Mount Rainier National Park.....	5
Figure 4. Summer elk 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..	6
Figure 5. Snowmelt and phenology in 2014 was within prescription, as illustrated by the phenology photo points at Fan Lake (Mount Rainier National Park 8/21/2014) and Lake Billye Everett (Olympic National Park 8/18/201).	9
Figure 6. Flight lines for the first survey in the South Rainier elk trend count area, conducted 21 August 2014.....	12
Figure 7. Flight lines for the second replicate survey in the South Rainier elk trend count area, conducted 27 August 2014.	13
Figure 8. Flight lines for the survey in the North Rainier elk trend count area, conducted 25 August 2014.	14
Figure 9. Flight lines in the Core elk trend count area of Olympic National Park conducted 18-19 August 2014.	15
Figure 10. Flight lines in Elwha and a portion of the Northwest elk trend count areas of Olympic National Park conducted 19 August 2014.....	16
Figure 11. Flight lines in the Quinault elk trend count area of Olympic National Park conducted 17-18 August 2014.	17
Figure 12. Estimated elk abundance in the North Rainier and South Rainier herd surveys, 2008-2014.	18
Figure 13. Estimated elk calves: 100 cows in the North Rainier and South Rainier herd surveys, 2008-2014.	18
Figure 14. Estimated elk bulls: 100 cows in the North Rainier and South Rainier herd surveys, 2008-2013.	19
Figure 15. Estimated elk abundance, calves:100 cows and bulls:100 cows in the Core, Elwha, Northwest, Quinault and Southeast trend count areas of Olympic National Park, 2008-2014.	20

Tables

	Page
Table 1. Observers that participated in elk surveys in 2014.	10
Table 2. Flight details for summer 2014 elk surveys at Mount Rainier National Park.	10
Table 3. Flight details for summer 2014 elk surveys at Olympic National Park.	11
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.	14
Table 5. Summarized elk observations from summer surveys in Olympic National Park.	17
Table 6. Raw and estimated numbers of elk and herd composition in the 2014 Mount Rainier National Park summer surveys in the trend count area.	18
Table 7. Raw and estimated numbers of elk and herd composition in the 2014 Olympic National Park summer surveys in the trend count area.	19

Executive Summary

Fiscal year 2014 was the fourth 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 seventh and fifth 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 (Figure 1). 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.

The number of missed elk during aerial surveys may be estimated by applying site-specific models that account for detection bias (Griffin et al. 2012). Detection bias for elk surveys in MORA and OLYM was estimated using a model developed from survey data collected from 2008-2010 in MORA and 2009-2013 in OLYM (Lubow et al. 2015). In MORA we developed the model based on observations of elk that were previously equipped with radio collars by cooperating tribes. At the onset of protocol development in OLYM there were no radio-collars on elk. Consequently the majority of the effort in OLYM from 2008-2011 was focused on capturing and radio-collaring elk and conducting sightability trials needed to develop a detection bias model for OLYM. Data collection for the model was completed in 2013, and a new model that integrates data for both parks was developed in 2014 and is used in this report (Lubow et al. 2015).

At MORA the South trend count unit was surveyed twice and the North unit was surveyed once. We counted 339 and 399 elk during the replicate surveys of the South Rainier trend count area, and 468 elk in the North Rainier trend count area. Using the model to correct for detection bias, we estimated that 512 and 545 elk were in the South trend count area, and 672 elk were in the North trend count area at the time of the respective surveys.

Three trend count areas at OLYM - the Core, Quinault, and Elwha - were surveyed completely. We counted 116 elk in the Core, 43 in the Elwha and 207 in the Quinault. Using the model to correct for detection bias, we estimated that 174 elk were in the Core, 143 in the Elwha, and 246 in the Quinault trend count areas at the time of the respective surveys.



Figure 1. Elk in the upper Quinault, Olympic National Park, Washington. Photography by: Patti Happe, Olympic National Park.

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). Due to ongoing reduced budgets, the program in FY2014 received little direct funding from the NCCN I&M program. Flights in OLYM were paid for by the Washington's National Park Fund; in MORA funding was provided by the Washington's National Park Fund, Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), and Washington Department of Fish and Wildlife (WDFW), and the NCCN. Additional staff time and data management support was provided by the NCCN I&M program, MORA, OLYM, and U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center (USGS-FRESC). 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 P. Griffin and K. Jenkins (USGS-FRESC) for their role in working with all the partners to develop the elk monitoring protocol for the surveys reported here, and B. Lubow (Colorado State University) for developing the double-observer sightability model. The authors thank the other crew members who participated in surveys including B. Baccus, R. Lofgren, R. Lechleitner, (NPS); M. Middleton, M. McDaniel, P. Rodarte (MIT); D. Coats, P. Dillon (PTOI); M. Smith, T. Schmidt, N. Stephen, S. Bergh (WDFW); K. Jenkins (USGS-FRESC). We thank the following pilots for their assistance and safe flying: R. Olmstead, J. Hagerman (Northwest Helicopters). For their support of the elk monitoring program, we thank Muckleshoot Indian Tribe (MIT) Wildlife Committee, P. Dillon (PTOI), P. Geissler (USGS National Park Monitoring Project). We are grateful to B. Baccus, K. Jenkins and R. Lofgren for reviews of the draft report.

We also wish to thank and say goodbye to two members of the elk monitoring team –Scott McCorquodale and Mason Reid. Scott served as the deer and elk specialist with WDFW and was instrumental in the program development phase of this project; in 2014 Scott moved on to another position with WDFW. Mason was the elk monitoring lead for MORA since 2008 and retired in July 2014. Mason was instrumental in keeping the program on track and in the air, and will be sorely missed – we wish him well in his retirement.



Figure 2. Bull elk, north Rainier count area, 2014. Photo by Muckleshoot Indian Tribe.

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 (Schonewald-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 (Schonewald-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 monitoring in MORA has continued from 1974 to present day.

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 1935a, Murie 1935b, 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 2014

This annual report for the MORA and OLYM elk monitoring program is 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 4-year report that examined trends in counts obtained from 2008-2011 was completed in 2014 (Jenkins et al. 2015). The next comprehensive report is scheduled to commence after the completion of the surveys scheduled for 2015.

The objectives of this report are to summarize results of elk surveys conducted in selected subalpine summer ranges in MORA and OLYM during summer 2014. The 2014 surveys were the fourth 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.

Based on the monitoring protocol and agreement of all the monitoring partners in MORA, the survey objectives in 2014 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 2014 surveys are reported here, including raw counts and counts adjusted for detection bias.

Although the protocol calls for collecting data in OLYM in two trend count areas per year – the Core and one of the ancillary areas, in past years our emphasis in OLYM has been to collect sightability trial data needed to complete development of a double-observer sightability model for OLYM. Sightability model development in OLYM lagged behind that of MORA due to 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). We completed collection of sightability data in 2013, but were behind schedule in collecting data in the ancillary areas. Consequently, the 2014 survey objectives for OLYM were to complete surveys of elk within three trend count areas (Core, Quinault, and Elwha) to make up for missed surveys in previous years.

Support for the 2014 flights in MORA came from Washington’s National Park Fund, WDFW, MIT, PTOI, and the NCCN, and in OLYM, support came from the Washington’s National Park Fund. 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 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 3). These trend count areas include the primary subalpine summer ranges of the North Rainier Herd and South Rainier Herd.

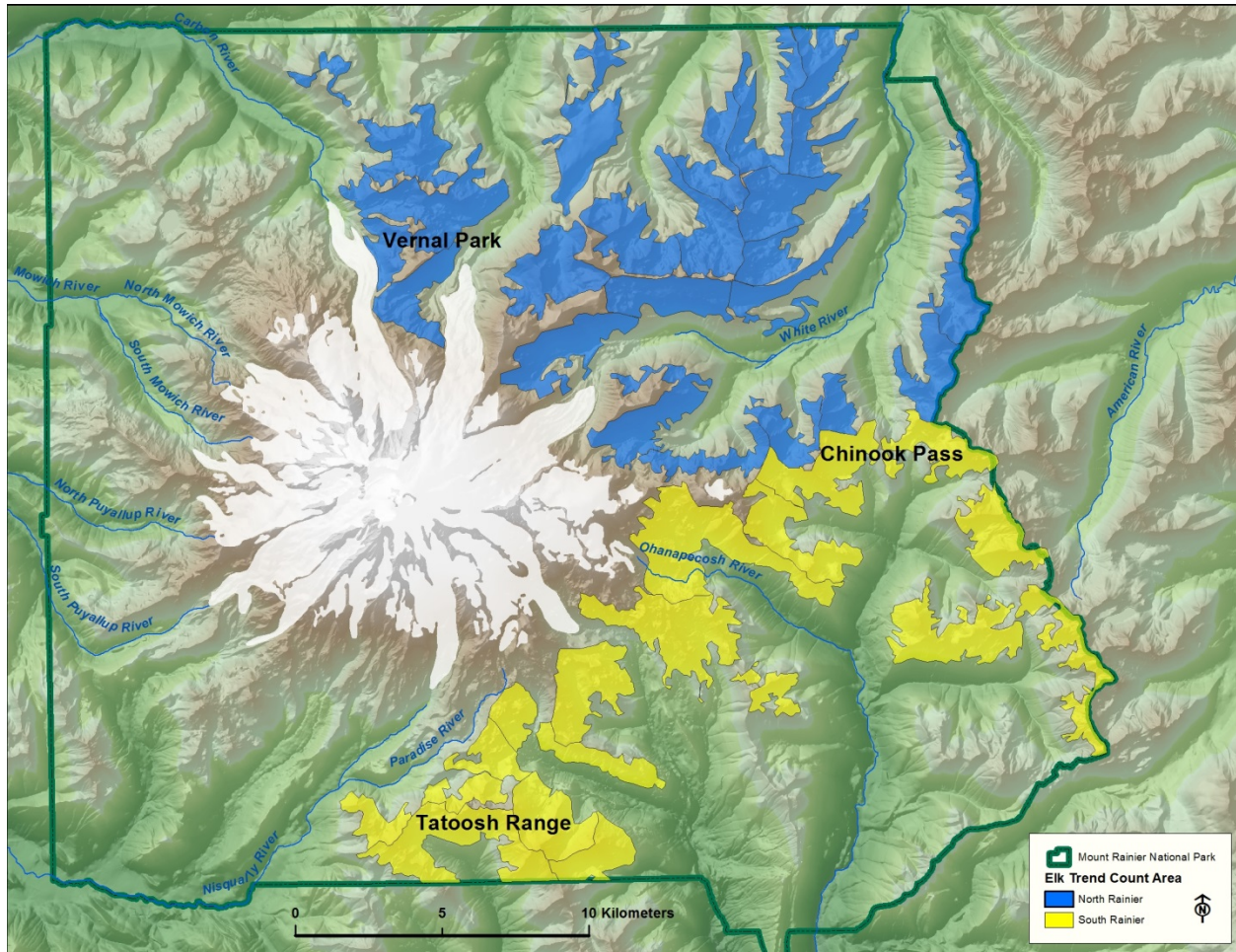


Figure 3. Summer elk trend count areas within Mount Rainier National Park. The North Rainier trend count area is approximately 103 km², and the South Rainier trend count area is approximately 89 km².

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 4) 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.

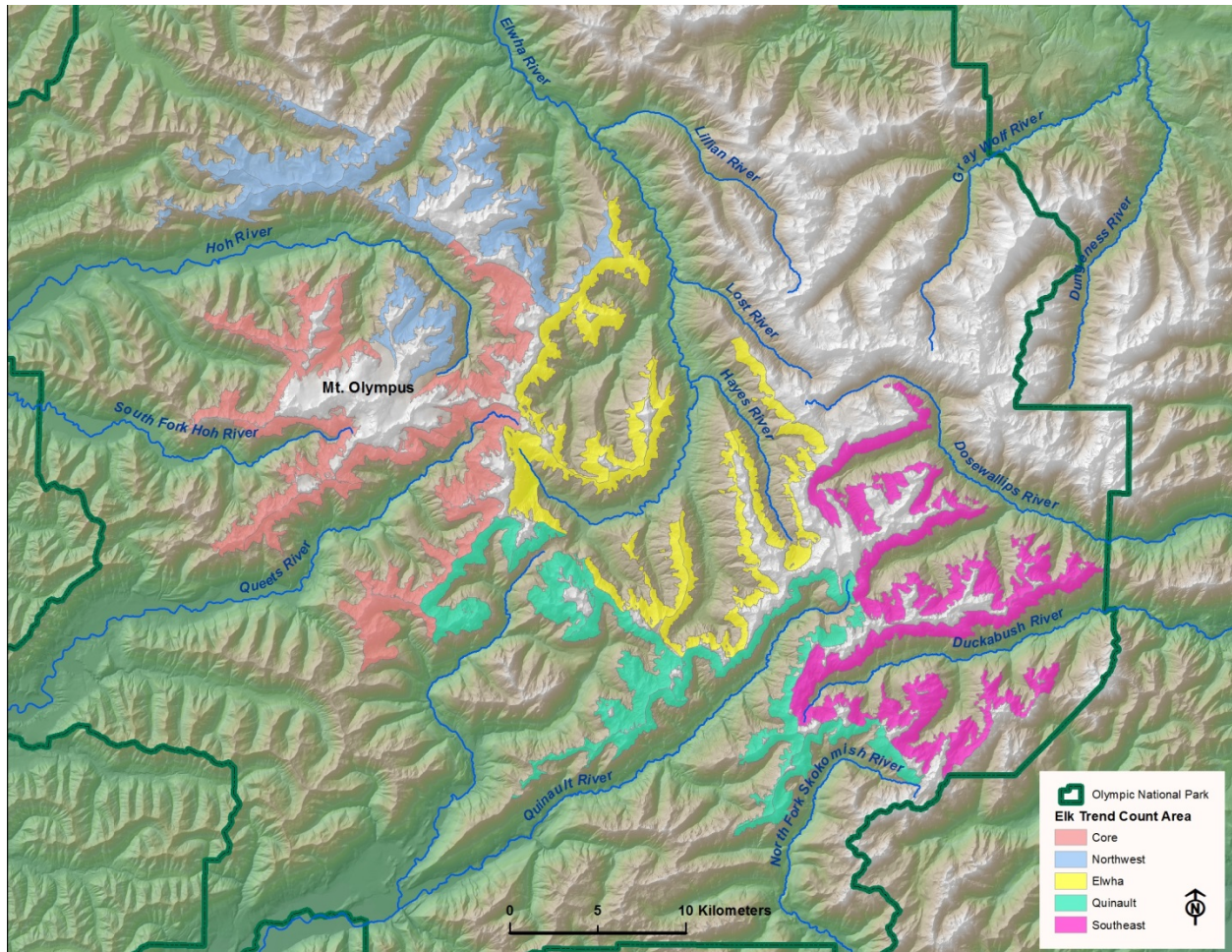


Figure 4. Summer elk trend count areas within Olympic National Park, including the annually-surveyed, Core trend count area, and four ancillary trend count areas surveyed once every four years. The Core and four ancillary trend count areas: Elwha, Northwest, Quinault, and Southeast are approximately 100, 81, 73, 79, and 86 km², 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 summer trend count areas established in MORA (Figure 3) and OLYM (Figure 4) 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.

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. For example, in 2013 the South was surveyed once and the North twice. In 2014 the South was surveyed twice and the North once. 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.

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, clouds or fog that develops during a survey, mechanical problems with helicopters, and temporal constraints associated with darkness. In addition, in years or areas where we were gathering resight data for model development, time spent on radio-telemetry locating missed elk negatively impacted our ability to completely survey all units. For the 4-year

synthesis report, missing survey data were imputed (Jenkins et al 2015) for detailed trend analysis, but for these annual survey reports, the missing data are not corrected for. In annual reports reported results where survey units are missing are interpreted as minimum estimates with missing units noted.

Survey Methods

A crew of a pilot and three observers counted elk from a type-III helicopter; helicopters used in 2014 were Bell 206B-3s. Trend count areas were thoroughly searched 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 to each other. When possible, large groups were photographed with a high resolution digital camera (Schoenecker et al. 2006) or GoPro video recorder. In addition, all other wildlife species seen on the flights were recorded (Appendix 1, Appendix 2).

Data Management

Following each survey flight the observers immediately reviewed all data forms and corrected any discrepancies. A GIS Specialist downloaded GPS data of helicopter flight lines to the NCCN project workspace on an OLYM 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 project lead. After the flights the project manager, participating wildlife biologist, or technician examined the photos and videos; if inspection of photos led to a revision for group size, composition, location or covariates, then the pertinent photos were annotated and saved, and changes were made to the data forms.

The OLYM and MORA project managers or NCCN staff entered survey data into the elk 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 of temporal trends or other environmental variables that influence estimates (which are covered in the 4-year synthesis reports). Counts of elk in MORA were adjusted for aerial detection biases. In prior reports this step was not undertaken with OLYM count data because sufficient sightability data had not been collected to develop a sightability model for application in OLYM (Jenkins et al. 2015). In 2014, however, we revised the double-observer sightability model based on the combined set of detection trial data collected in MORA and OLYM since 2008 that corrects raw counts of elk for aerial sightability biases in both parks (Lubow et al. 2015).

Results

2014 Climate in Review

Spring and summer conditions in 2014 were warmer and drier than in the previous years. A warmer than normal June and July helped accelerate the melting of the snow-pack. Snow cleared from reference sites at OLYM and MORA 2.5 and 1.8 days earlier than normal, which is in sharp contrast to the last few years when snowmelt averaged almost 20 days later (NPS, unpublished data). Climate conditions during the summer differed slightly between OLYM and MORA. High elevation areas in OLYM experienced unusually dry conditions from July through September, where precipitation was 61% of normal, and most of August, mountain temperatures remained above normal. However in MORA July through September precipitation was 118% of normal. Although plant phenology appeared within prescription during the survey period (Figure 5), conditions appeared drier than in prior years in OLYM. Grasses and sedges remained green with little indications of senescence (yellowing). However, heath, huckleberry and willow shrubs started showing indication of fall color change in mid-August.

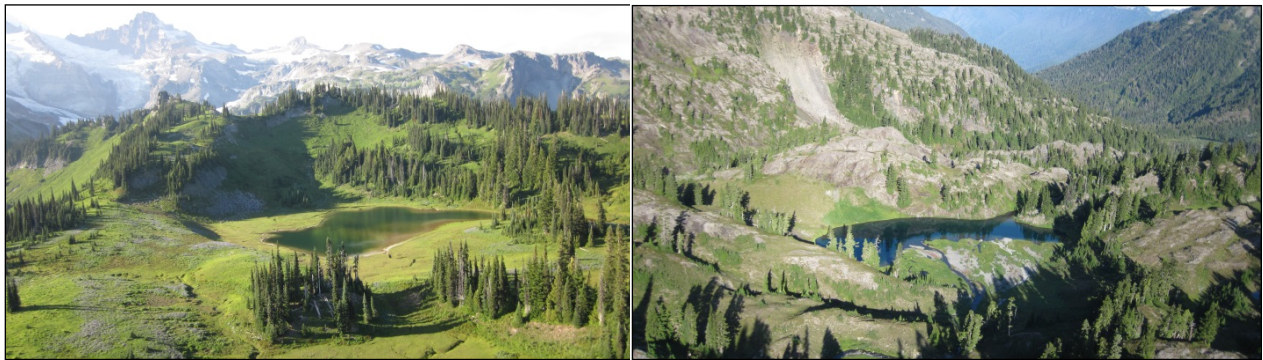


Figure 5. Snowmelt and phenology in 2014 was within prescription, as illustrated by the phenology photo points at a) Fan Lake (Mount Rainier National Park 8/21/2014) and b) Lake Billey Everett (Olympic National Park 8/18/201).

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 until his retirement in July. David Vales, lead wildlife biologist for Muckleshoot Indian Tribe (MIT), coordinated the survey conducted by MIT. Barbara Moeller, wildlife biologist for Puyallup Tribe of Indians (PTOI), coordinated the survey conducted by PTOI, whereas Michelle Tirhi and Eric Holman, wildlife biologists for Washington Department of Fish and Wildlife (WDFW) Region 6 and Region 5, respectively supervised two WDFW surveys. 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 2014. Personnel are identified by the tribe or agency with which they are affiliated.

Affiliation	Names
National Park Service	Patti Happe, Kathy Beirne, Bill Baccus, Rebecca Lofgren (survey crew members); Bill Baccus, Katherine Beirne, Rich Lechleitner (helicopter managers)
Muckleshoot Indian Tribe	Mike Middleton, Mike McDaniel, Paul Rodarte
Puyallup Tribe of Indians	Barbara Moeller, D. Coats, Phillip Dillon
Washington Department of Fish and Wildlife	Tammy Schmidt, Michelle Tirhi, Stephanie Bergh, Mike Smith, Nicolle Stephen, Eric Holman.
U.S. Geological Survey	Kurt Jenkins
Pilots	Rob Olmstead, Jess Hagerman

Flight Statistics

Mount Rainier Summer Surveys

During 2014, project partners completed two replicate surveys of the South Rainier trend count area and one replicate survey of the North Rainier trend count area (Table 2).

For all surveys in 2014, we were able to complete the replicate counts of each trend count area on the same day, using 2 helicopters (Table 2). The first replicate survey for the South Rainier trend count area was conducted on 21 August, and the second a week later on 27 August. The survey for the North Rainier trend count area was conducted on 25 August. Survey conditions were fair to good for all flights, however challenges with glare were encountered in late evenings on some surveys.

Table 2. Flight details for summer 2014 elk 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 21	First South	S1,S4,S5,S6,S7,S9, S17,S18, S19,S20	3:02	2:36	NPS	Beirne, Lofgren, Jenkins, Olmstead
2	Aug 21		S8,S10,S11,S13,S14, S15, S16	2:58	2:46	PTOI	Moeller, Dillon, Coats, Hagerman
3	Aug 25	First North	N4, N5b,N7,N8,N11, N12,N13,N14	2:52	2:44	MIT	Middleton, McDaniel, Rodarte,
4	Aug 25		N2,N3,N5a,N5b,N6,N9, N10, N15, N16, N17, N18,	2:55	2:31	WDFW	Tirhi, Schmidt, Smith, Olmstead
5	Aug 27	Second South	S1,S4,S5,S6,S7,S8,S9, S10,S11,S13	3:05	2:43	WDFW	Bergh, Holman, Stephens, Hagerman
6	Aug 27		S14,S15,S16,S17,S18 S19, S20	2:45	2:22	NPS	Beirne, Lofgren, Jenkins, Olmstead

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

We conducted flights over 2 ½ days in the Core, Quinault and Elwha trend count areas. Due to challenges with contracting, not all funds available for surveys in 2014 were able to be obligated in time, and hence the flight budget was extremely tight. In order to work within the budget the crew drove to Olympia and conducted a survey during the ferry to OLYM on the evening of 17 August. We also conducted a survey on the return ferry to Olympia in the evening of 19 August. Despite these efforts, concerns about remaining funds in the agreement forced us to curtail surveys in a portion of the Elwha count unit; during flight 7 we did not count 38% of survey area in E1, E2a and E2b.

We had acceptable flying weather throughout the duration of the surveys in OLYM. During all of the morning flights, the sky was clear and visibility partially impaired by glare and high contrast, especially for elk groups that were in forested cover. Counting conditions were much better in the evening flights, when skies were overcast.

Table 3. Flight details for summer 2014 elk surveys at Olympic National Park. Last names of pilots are indicated in bold font.

Flight	Date	Survey Start Time	Survey Units	Total flight time (h:min)	Survey time (h:min)	Crew Members
1	Aug 17	16:14	Q2c, Q2d, Q3	2:23	1:34	Baccus, Beirne, Happe, Olmstead
2	Aug 18	06:08	Q2a, Q2b, Q1 (part)	2:06	1:25	Baccus, Beirne, Happe, Olmstead
3	Aug 18	08:36	Q1 (part), C7, C6d (part)	2:04	1:27	Baccus, Beirne, Happe, Olmstead
4	Aug 18	16:28	C6d (part), C6c, C6b, C6a, C5 (part)	2:19	1:42	Baccus, Beirne, Happe, Olmstead
5	Aug 19	06:13	C5 (part), C4, C3, C2, C1	2:25	1:59	Baccus, Beirne, Happe, Olmstead
6	Aug 19	09:01	E2c, E3, NW1 (part)	2:34	2:02	Baccus, Beirne, Happe, Olmstead
7	Aug 19	16:48	E1 (most), E2a, E2b	2:00	1:01	Baccus, Beirne, Jenkins, Olmstead

Elk Observations

Mount Rainier Summer Surveys

Figures 6 through 8 show the survey paths (flight lines) flown during the summer surveys in MORA. During flight 6 only ½ of the last survey unit was surveyed due to time constraints (Figure 7). In the North herd count, unit N1 was not counted, and unit N5 was counted twice (Figure 8).

Observed counts of elk groups in MORA are summarized in Table 4. We saw 360 elk in 83 groups in the first South trend count area replicate count, and 402 elk in 76 groups on the second replicate. The mean group size was slightly greater in the second count, by 1.1 elk, with the largest group being 57

elk. In the North trend count area, 491 elk were observed in 58 groups; the average groups size was 8.5 elk, and the largest group seen contained 73 elk.

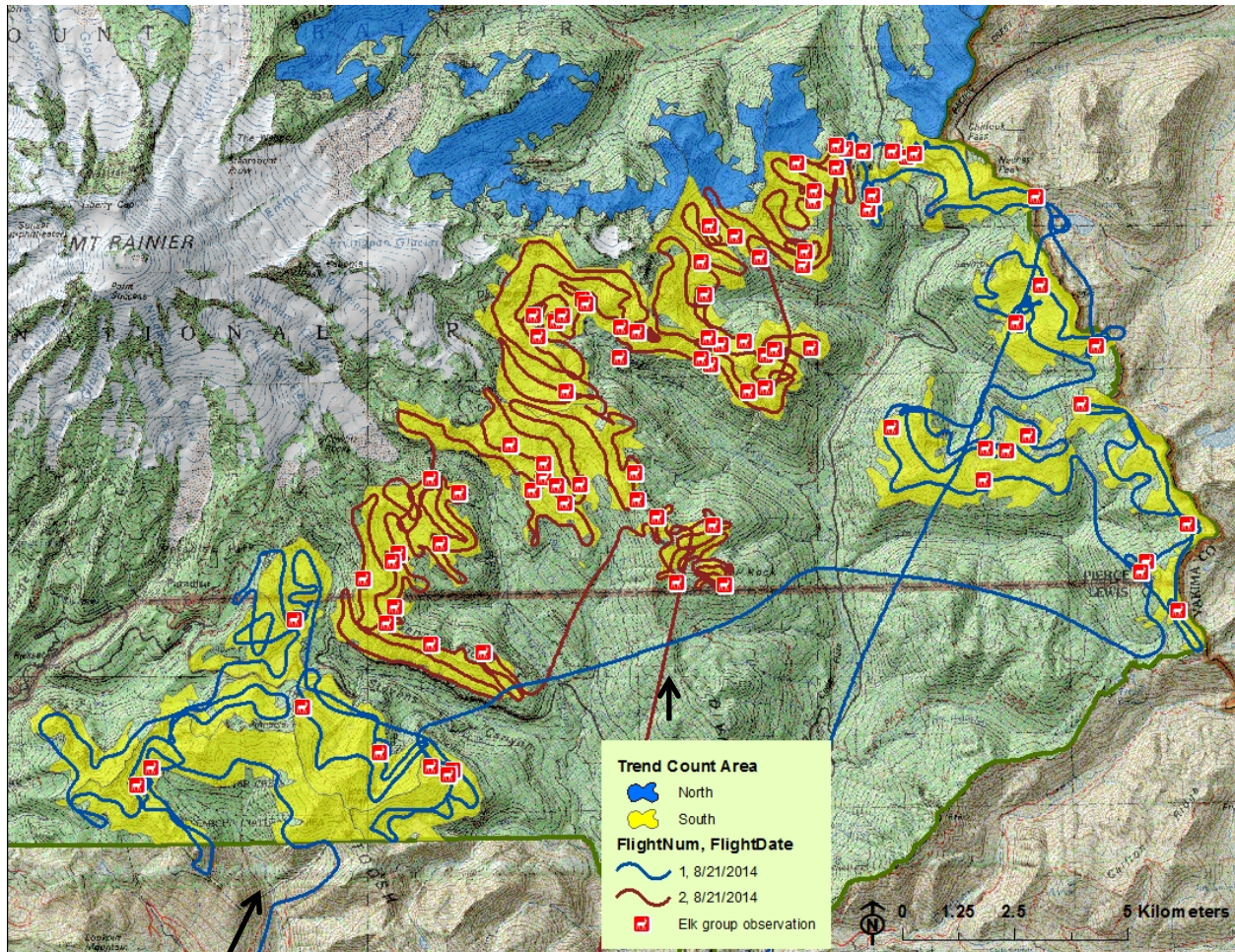


Figure 6. Flight lines (blue=flight 1, brown=flight 2) for the first survey in the South Rainier elk trend count area, conducted 21 August 2014. Both flights originated and ended south of the survey area; black arrows indicate the start point and the flight path direction for each flight line. Approximate locations of observed elk groups are indicated with the red icon.

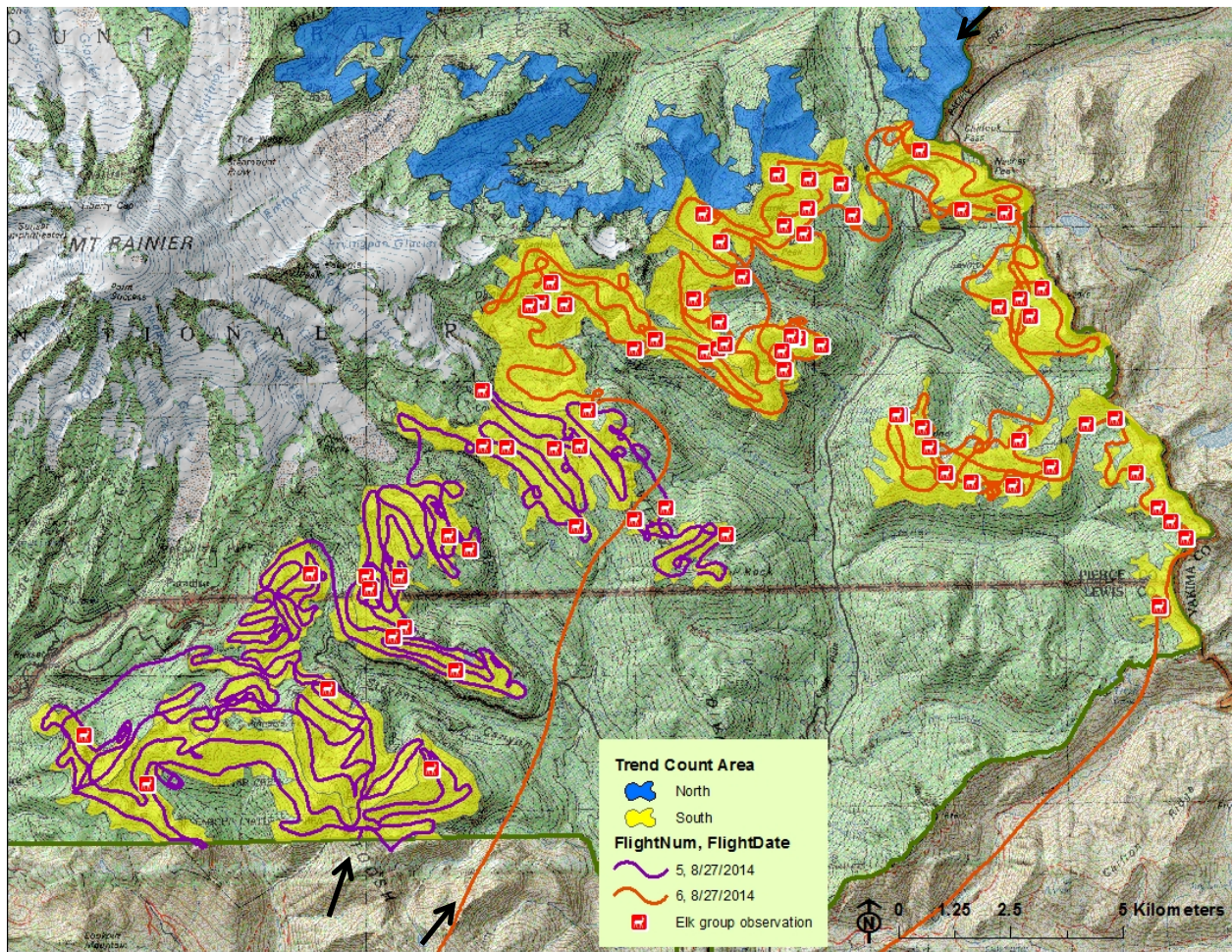


Figure 7. Flight lines (purple=flight 5, orange=flight 6) for the second replicate survey in the South Rainier elk trend count area, conducted 27 August 2014. All flights originated and ended south of the survey area; black arrows indicate the start point and the flight path direction for each flight line. Approximate locations of observed elk groups are indicated with the red icon.

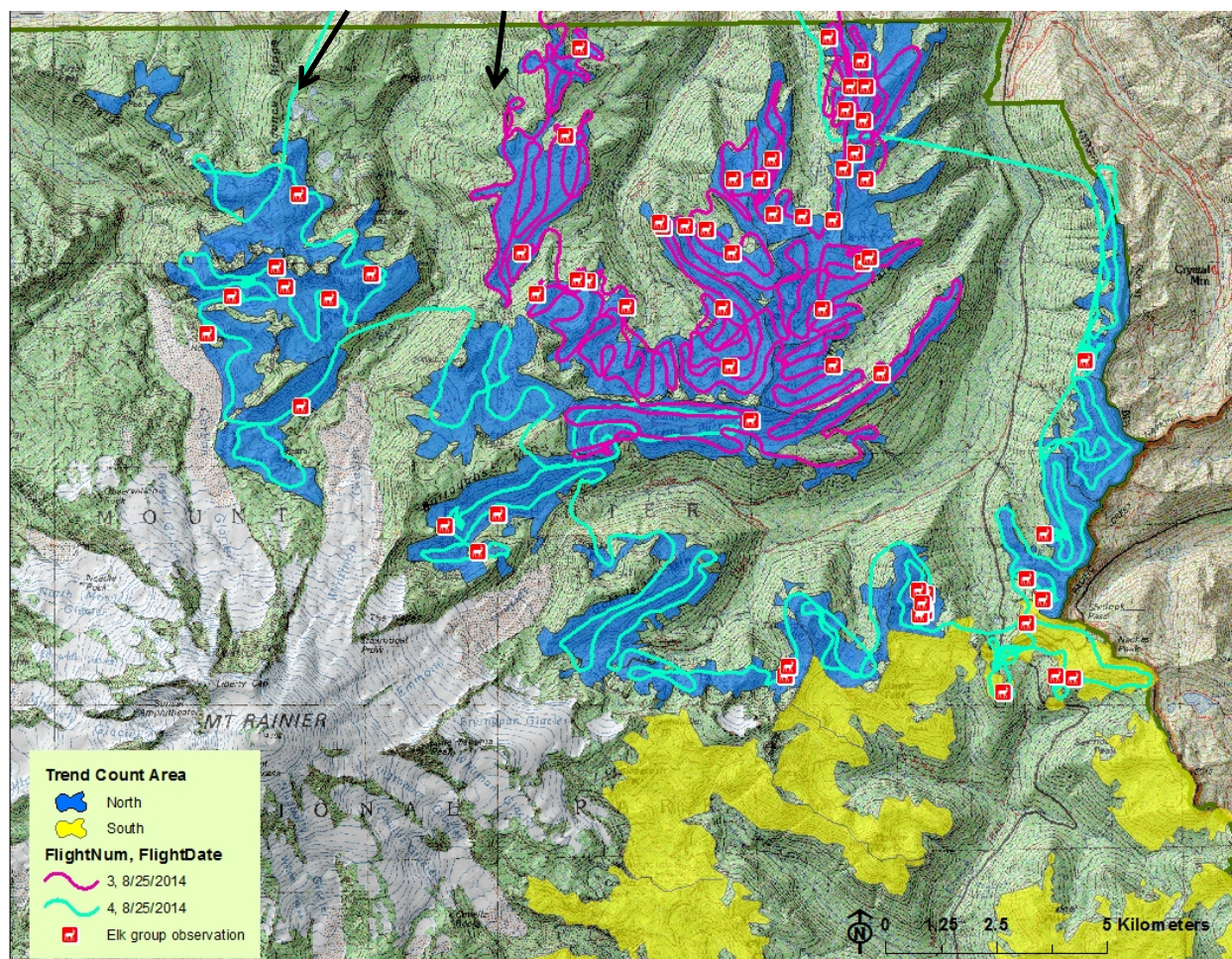


Figure 8. Flight lines (pink=flight 3, aqua=flight 4) for the survey in the North Rainier elk trend count area, conducted 25 August 2014. All flights originated and ended north of the survey area; black arrows indicate the start point and the flight path direction for each flight line. Observed elk groups 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				
South Rainier (Rep.1)	83	360	188	74	18	19	54	39.4	48.9	4.3	20
South Rainier (Rep. 2)	75	402	236	76	22	24	44	32.2	38.1	5.4	57
North Rainier	58	491	274	135	19	20	41	49.3	29.2	8.5	73

Olympic National Park Summer Surveys

Figures 9-11 show the flight paths and location of elk groups observed during the summer in OLYM in the Core, Elwha, and Quinault trend count areas. Counts and composition of elk groups seen in OLYM surveys are summarized in Table 5. We recorded more elk in the evening flights than during the morning flights (2.48 elk/ km² in the p.m. vs 0.71 elk/ km² in the a.m.; raw numbers). We counted 128 elk in 28 groups the Core; this is the lowest count recorded for this area. Group sizes were low (4.6) and the largest group seen was 25 elk. Many of the groups counted were small groups of bulls, which resulted in a very high bull: cow ratio of 94 bulls per 100 cows.

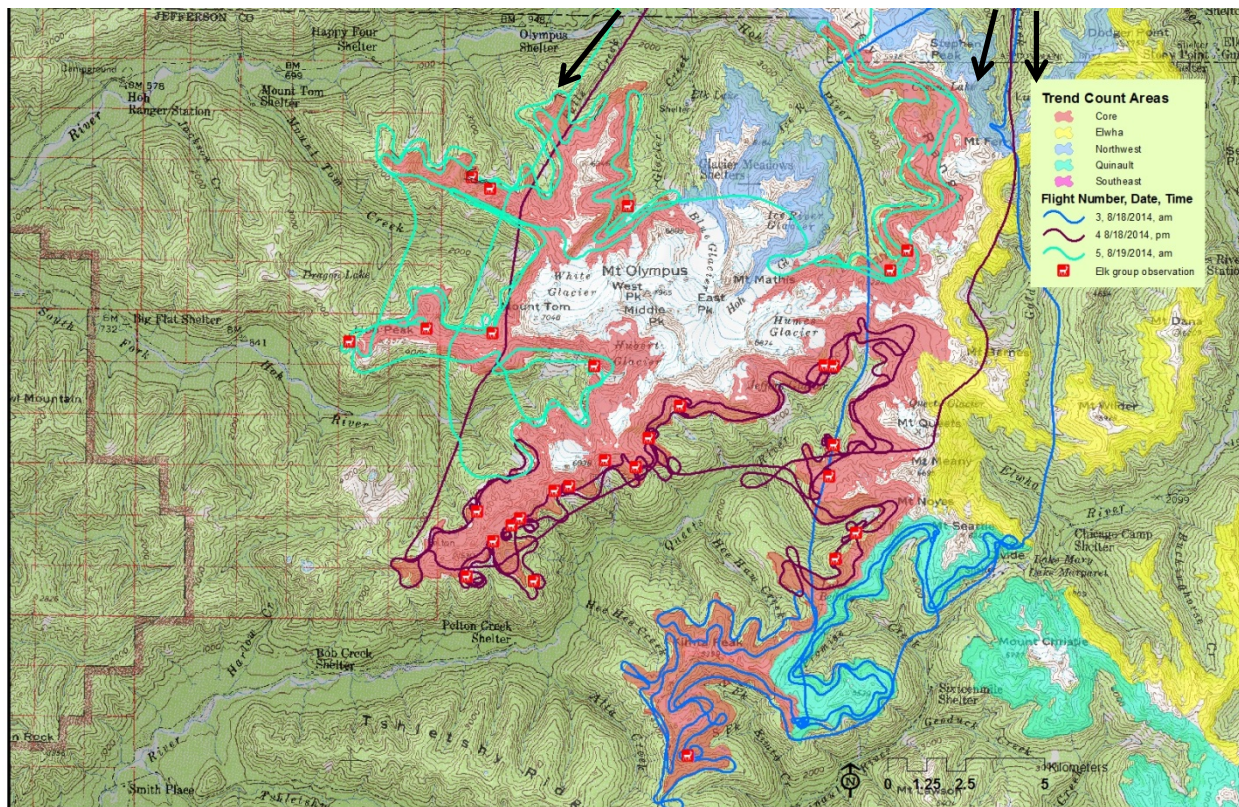


Figure 9. Flight lines in the Core elk trend count area of Olympic National Park (blue=flight 3; maroon=flight 4; aqua = flight 5) conducted 18-19 August 2014. All flights originated and ended north of the survey area. Black arrows indicate the start point and the flight path direction for each flight line. Approximate locations of observed elk groups are indicated with the red icons.

We saw only 44 elk in 11 groups in the Elwha (Figure 10, Table 5). This low count may have been influenced by our necessity to cut 38% of the planned survey route in E1, E2a and E2b due to concerns about the flight budget. In surveys of those areas, however, we did fly a complete count over the highest quality elk habitat (Figure 10). The influence of the missed survey area in the Elwha will be interpolated in the upcoming synthesis report. In the Elwha mean group size was only 4.0, and most of the groups seen were small bull groups. This led to the extremely high bull: cow ratio 163.6 bulls per 100 cows. Because we did not see the large cow group that usually occurs in C1, we also surveyed over portions of NW1, as that herd can occasionally be found in that area (we did not observe the group in NW1 either, but we did see a large group below NW1).

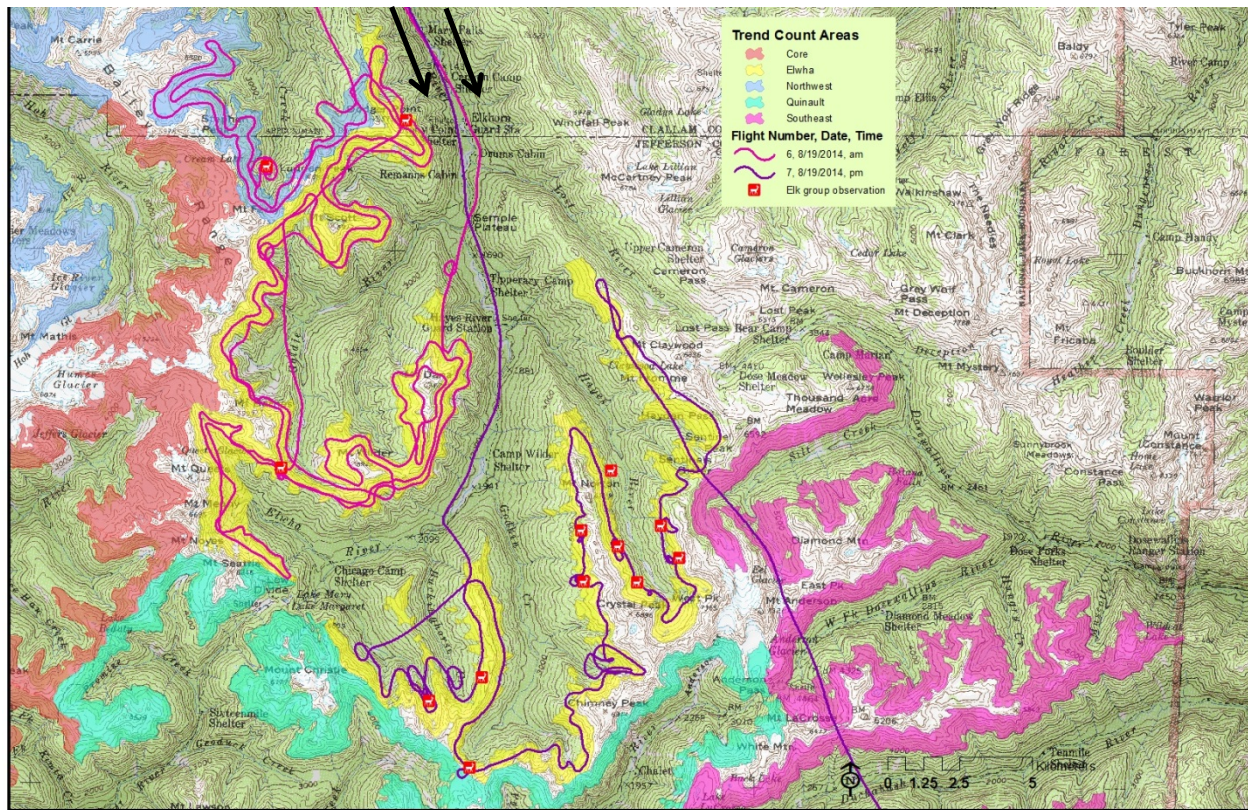


Figure 10. Flight lines in Elwha and a portion of the Northwest elk trend count areas of Olympic National Park (pink=flight 6; purple= flight 7) conducted 19 August 2014. All flights originated north of the survey area. Black arrows indicate the start point and the flight path direction for each flight line. Flight 6 ended north of the survey area and flight 7 ended in Olympia.

In the Quinault we saw 211 elk in 11 groups, but mean group size was larger (19.2) and we did see a few large cow groups – the largest of which was 50; that group, however, was in the trees and we were unable to get an accurate determination of herd composition. The bull: cow ratio in the Quinault was much lower than in the other survey areas, at 33 bulls: 100 cows. 2014 was the first time we conducted a complete survey in the Quinault trend count area.

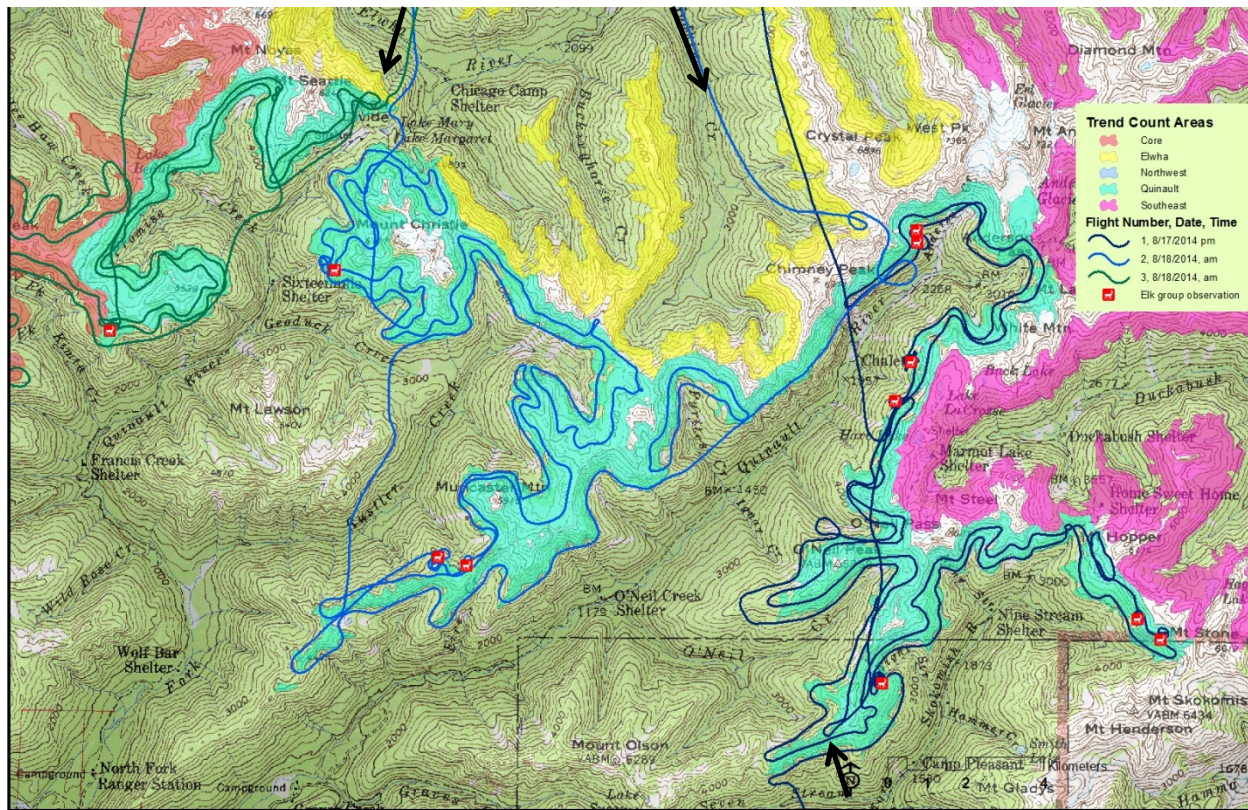


Figure 11. Flight lines in the Quinault elk trend count area of Olympic National Park (dark blue=flight 1; royal blue=flight 2, green= flight 3) conducted 17-18 August 2014. Flight 1 originated in Olympia, and flights 2 and 3 originated and ended north of the survey area. Black arrows indicate the start point and the flight path direction for each flight line.

Table 5. Summarized elk observations from summer surveys in Olympic National Park. Counts include elk seen in the survey unit and a 300m buffer around each unit.

Trend Count Area	Groups	Total Elk ¹	Cows	Calves	Bulls			Calves per 100 Cows	Bulls per 100 Cows	Mean Group Size	Max. Group Size
					Spike	Sub-adult	Mature				
Core	28	128	53	20	3	2	45	37.7	94.3	4.6	25
Elwha	11	44	11	1	1	2	15	9.1	163.6	4.0	16
Quinault	11	211	88	42	9	7	13	47.7	33.0	19.2	50

¹ includes unclassified elk.

Elk Abundance and Composition Estimates

Mount Rainier Summer Surveys

We applied the updated DO-S model to the 2014 MORA survey data (Table 6). After using the model to adjust for sightability, the estimated abundance of calves per 100 cows decreased slightly below the raw number counts, while the estimated abundance of bulls increased over raw counts for the second replicate of the South count area and the single count in the North.

Table 6. Raw and estimated numbers of elk and herd composition in the 2014 Mount Rainier National Park summer surveys in the trend count area. Numbers include only elk seen in the count area and exclude those seen in the buffer.

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
South Rainier (Replicate 1)	339	512.01	39.36	35.58	48.94	48.96
South Rainier (Replicate 2)	388	545.36	32.20	31.97	38.14	43.05
North Rainier	468	671.51	49.27	49.62	29.20	40.33

The updated DO-S model was applied to the MORA survey data from 2008 through 2014 (Figures 12-14). Trend analyses of the 2008-2011 survey data is presented in the 4-year synthesis report (Jenkins et al, 2015). Data from the 2012-2014 MORA surveys will be analyzed in the subsequent 4-year synthesis report that will be conducted following the surveys in 2015.

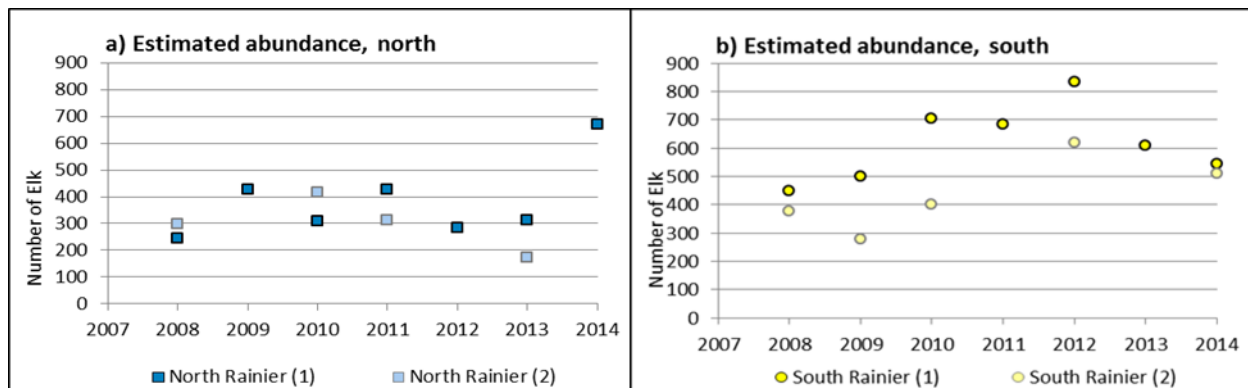


Figure 12. Estimated elk abundance in the a) North Rainier and b) South Rainier herd surveys, 2008-2014.

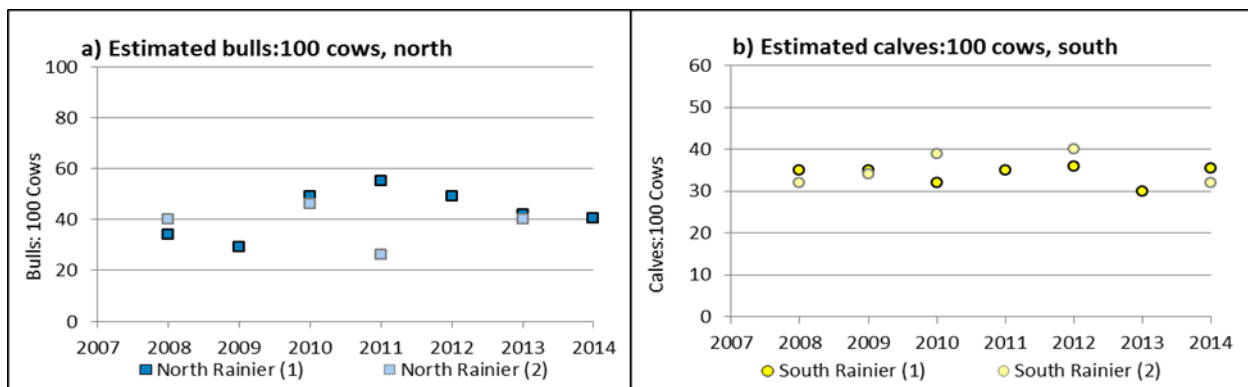


Figure 13. Estimated elk calves: 100 cows in the a) North Rainier and b) South Rainier herd. surveys, 2008-2014.

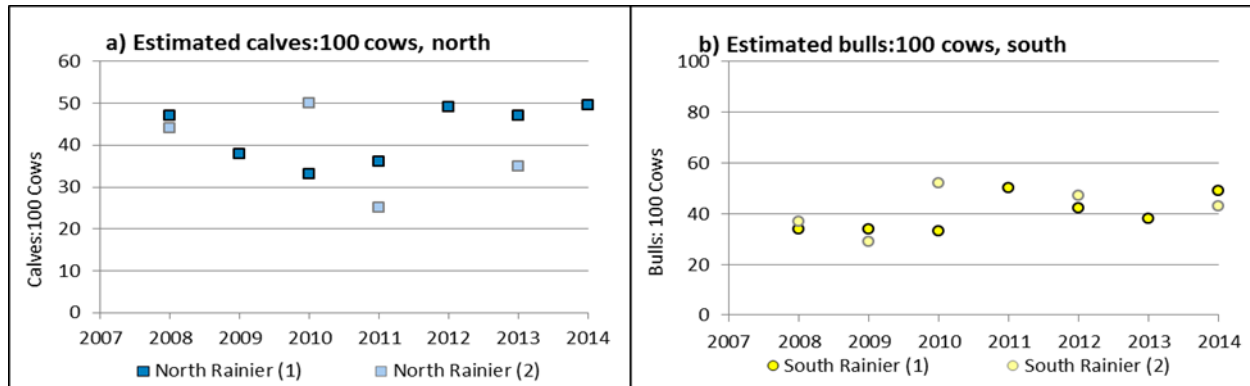


Figure 14. Estimated elk bulls: 100 cows in the a) North Rainier and b) South Rainier herd surveys, 2008-2013.

Olympic Summer Surveys

We applied the double observer sightability model to the 2014 OLYM survey data (Table 7). After using the model to adjust for sightability, the low counts in the Core and Elwha were adjusted upwards 49 and 333% respectively, and the Quinault only 18%. The bull: cow ratio in the Elwha was adjusted down from 163 to 72 bulls: 100 cows, however the bull: cow ratios in the Core and Quinault were adjusted only slightly.

Table 7. Raw and estimated numbers of elk and herd composition in the 2014 Olympic National Park summer surveys in the trend count area. Numbers include only elk seen in the count area and exclude those seen in the buffer.

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
Core	116	173.92	37.74	31.22	94.34	92.35
Elwha	43	143.21	9.09	2.69	163.64	72.22
Quinault	207	246.61	47.73	47.83	32.95	34.45

The updated DO-S model was applied to the OLYM survey data from 2008 through 2014 (Figure 15). Trend analyses of the 2008-2014 survey data will be analyzed in the synthesis report that will be conducted following the surveys in 2015.

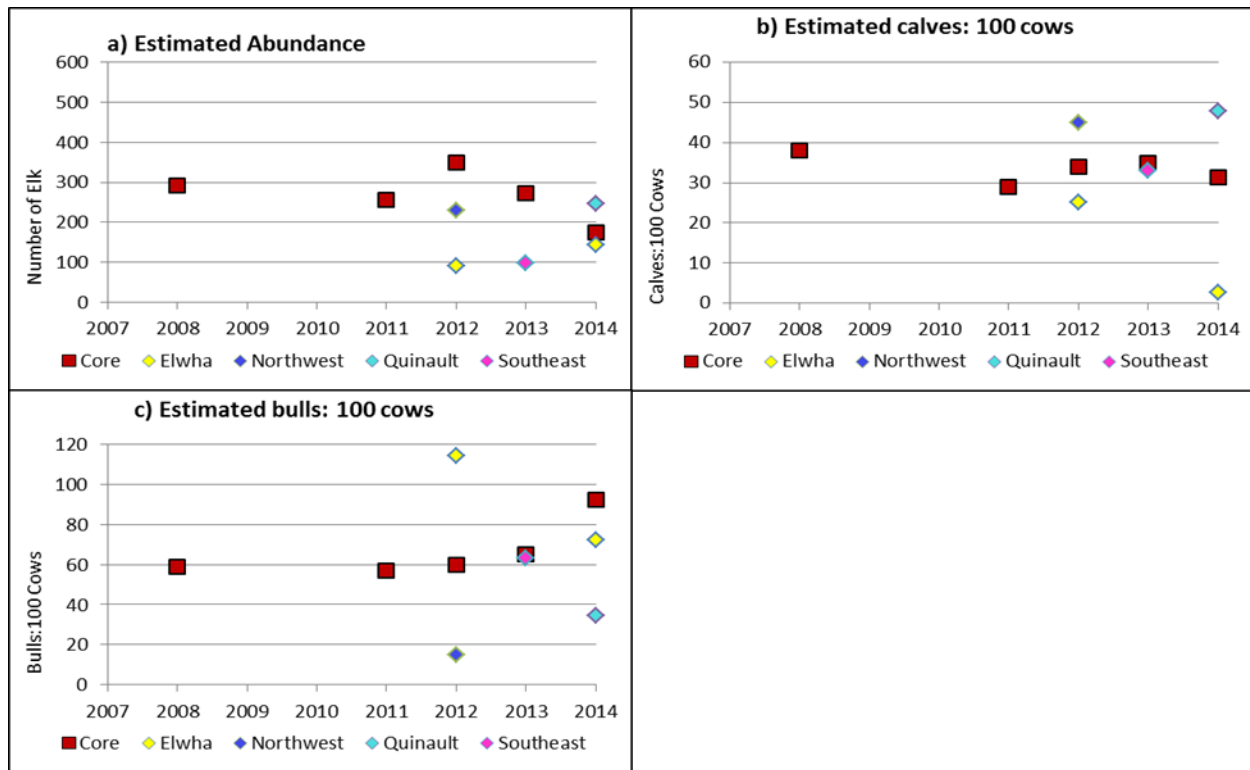


Figure 15. Estimated elk abundance, calves:100 cows and bulls:100 cows in the Core (red), Elwha (yellow), Northwest (blue), Quinault (aqua) and Southeast (pink) trend count areas of Olympic National Park, 2008-2014. No surveys were conducted in 2009 and 2010.

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., 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.
- Griffin, P. C., B. C. Lubow, K. J. Jenkins, D. J. Vales, B. J. Moeller, M. Reid, P. J. Happe, S. M. McCorquodale, M. J. Tirhe, J. P. Schaberl, and K. Beirne. 2013. A hybrid double-observer sightability model for aerial surveys. *Journal of Wildlife Management* 77:1532-1544.
- 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, D. J. Vales, B. J. Moeller, M. Tirhi, and S. McCorquodale. 2014. Mount Rainier National Park and Olympic National Park elk monitoring program annual report 2013. Natural Resource Data Series NPS/NCCN/NRDS—2014/642. National Park Service, Fort Collins, Colorado.
- Jenkins, K. J., P. C. Griffin, P. J. Happe, M. Reid, D. J. Vales, B. J. Moeller, M. Tirhe, S. McCorquodale, K. Beirne, J. Boetsch, W. Baccus, B. Lubow. 2015. Elk monitoring in Mount Rainier and Olympic national parks: 2008-2011 synthesis report. Natural Resource Report NPS/NCCN/NRR—2015/904. National Park Service, Fort Collins, Colorado.
- 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.
- Lubow, B., K. Jenkins, P. Happe, P. Griffin, and K. Beirne. 2015. Double-observer sightability model update for Mount Rainier and Olympic National Parks, 2014. U.S. Geological Survey Administrative Report to the U.S. National Park Service. U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Port Angeles, Washington.

- 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, Oregon.
- Murie, A. 1935a. 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. 1935b. 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. Schrupf. 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.

Appendix A: Other wildlife recorded during elk surveys in Mount Rainier National Park, 2014¹.

Survey Area (flight)	Species	Number of groups recorded	Number of individuals recorded
South 1	Black Bear (<i>Ursus americanus</i>)	5	5
	Deer (<i>Odocoileus hemionus</i>)	8	11
	Mountain Goat (<i>Oreamnos americanus</i>)	6	68
South 2	Black Bear	3	4
	Cascade Red Fox (<i>Vulpes vulpes cascadenensis</i>)	2	1
	Deer	4	5
	Mountain Goat	15	70
	Hoary Marmot (<i>Marmota caligata</i>)	2	2

1: other wildlife were only recorded on flights conducted in the South.



Figure A-1. Black-tailed deer (*Odocoileus hemionus columbianus*) seen during a survey in the North Herd survey unit, Mount Rainier National Park. Photography by Muckleshoot Indian Tribe.

Appendix B: Other wildlife recorded on elk surveys in Olympic National Park, 2014.

Survey Area	Species	Number of groups recorded	Number of individuals recorded
Core	Black Bear (<i>Ursus americanus</i>)	14	18
	Black-tailed Deer (<i>Odocoileus hemionus columbianus</i>)	3	4
	Mountain Goat (<i>Oreamnos americanus</i>)	7	11
Elwha	Black Bear	8	9
	Black-tailed Deer	2	2
	Mountain Goat	5	7
Quinault	Black Bear	16	17
	Black-tailed Deer	7	9
	Mountain Goat	10	16



Figure B-1. Black bears (*Ursus americanus*) in the upper Queets valley, Olympic National Park. Photography by Patti Happe, Olympic National Park.

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

NPS 963/128376, April 2015

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA TM