National Park Service
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Natural Resource Stewardship and Science

Elk Monitoring Protocol for Mount Rainier National Park and Olympic National Park

January 11, 2012

Natural Resource Report NPS/NCCN/NRR—2012/485

ON THE COVER
Elk in Olympic National Park, photographed during aerial survey on September 8, 2011.
Photo credit: P. Happe, National Park Service.

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Conversion Factors

Multiply	By	To obtain
	Length	
kilometer (km)	0.621	mile (mi)
kilometer (km)	0.540	mile, nautical (nmi)
meter (m)	0.364	foot (ft)
	Area	
hectare (ha)	2.47	acre (ac)
square kilometer (km^2)	0.386	square mile (mi^2)
	Velocity	
kilometer per hour (km/h)	0.621	mile per hour (mi/h)
kilometer per hour (km/h)	0.540	Nautical miles per hour (knots)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

(1.8 × °C) + 32 = °F.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

(°F - 32) / 1.8 = °C.

Horizontal coordinate information in this report is referenced to the North American Datum of 1983 (NAD 83), zone 10N. Some spatial layers that are associated with this project were recorded in the WGS 84 coordinate system, with transformations performed in a geographic information system.

Altitude, as used in this report, refers to distance above the vertical datum.

Elevation, as used in this report, refers to distance above sea level.

Executive Summary

Elk (*Cervus elaphus*) are key components of lowland and montane ecosystems in both Mount Rainier National Park (MORA) and Olympic NP (OLYM). MORA was created in 1899 to preserve the sights and ecosystems associated with Mount Rainier, including its fish, wildlife, and renowned subalpine meadows. OLYM was created first as Mount Olympus National Monument in 1909 by Theodore Roosevelt for the expressed purpose of protecting the last stronghold of Roosevelt elk (*C. e. roosevelti*) and its native forested habitat following the large-scale national decline in elk populations at the turn of the last century. During this century of protection, elk populations increased, leading to historical periods of heightened concerns regarding the effects of elk herbivory and trampling on the health and integrity of signature resources of each park, notably the temperate rainforests of OLYM and subalpine meadow communities in MORA. Populations of elk in both parks are also influenced by diverse management objectives and goals in lands adjoining each park, including managed legal hunting, poaching, predator management, and diverse forest management and land use practices. Threats of disease and changing climates pose other potential threats or perturbations to elk populations throughout the region.

This protocol describes helicopter-based aerial survey procedures for monitoring elk in MORA and OLYM. The primary objective in both parks is to monitor trends in raw counts, abundance, composition, and spatial distribution of migratory elk herds using selected trend count areas in subalpine summer ranges. Protocol funding from North Coast and Cascades Network (NCCN, or the network) of the National Park Service (NPS) supports these surveys in alternate years. A double-observer sightability model developed for MORA is applied to survey results from that park, to correct for detection bias. Double-observer data for each elk group that is detected includes a record of which specific observers saw the group independently. Along with this type of data, additional double-observer sightability trial data for elk groups with radio collars will continue to be collected in OLYM summer surveys for two to three more years, until similar double-observer sightability models can be tested for application to that park's summer surveys. Much of the data necessary for summer survey model development in OLYM has been collected already. The continued collection of double-observer data will allow for periodic re-assessment of model adequacy for summer survey in both parks.

The protocol's secondary objective is to monitor trends in aerial counts and spatial distribution of elk in key winter and spring ranges of OLYM. This latter objective applies only to OLYM because lowland winter and spring ranges of elk in the Mount Rainier ecosystem are largely outside the park, and OLYM has a history of management concerns associated with elk use of low elevation winter and spring ranges. There is currently no regular funding available in the NCCN budget to support this monitoring component on a regular basis. However, we incorporated this ancillary objective in recognition of the importance of this legacy monitoring program to OLYM, and to have this approved protocol in place in case supplemental or outside funding becomes available.

The protocol builds on a rich legacy of monitoring elk populations through aerial surveys in each park since the 1980's, and close collaborations between the NPS, U.S. Geological Survey, Muckleshoot Indian Tribe, Puyallup Tribe of Indians, and Washington Department of Fish and Wildlife. This protocol stands unique among monitoring efforts in the NCCN by virtue of

agreement between four project partners – NPS, Muckleshoot Indian Tribe, Puyallup Tribe of Indians, and Washington Department of Fish and Wildlife – to jointly implement and fund monitoring efforts in both parks. These four participating tribes and agencies work together to conduct summer surveys in MORA, following this protocol, whereas NPS implements the same protocol in OLYM. This protocol reflects discussions among all the project participants and several elk monitoring specialists to improve upon and standardize surveys among the two parks. This protocol represents an improvement over previously used methods, with standardized sample design, in-flight methods shared by all participating tribes and agencies, and common methods of analysis and estimation.

Specific methods in this monitoring protocol are based on three field seasons of development and testing. The protocol narrative describes the background, rationale, sampling design, field methods, analytical methods, data management, reporting, personnel requirements, and operational requirements for elk monitoring in MORA and OLYM. The sampling design reflects tradeoffs between statistical and ecological considerations, safety, and current budget considerations. For trend count areas that are surveyed every other year, the protocol provides adequate power to detect a doubling or halving of elk use in any single trend count area in eight years. Step-by-step guidance for planning and completing the monitoring tasks are in the attached standard operating procedures (SOPs).

Protocol results will allow MORA and OLYM managers to determine whether elk abundance and composition in the surveyed subalpine areas has increased or decreased or substantially changed in distribution. Any such trend could be a signal of population change that would require research into the causes of the trend, corrective management actions, or both. Although the NPS does not actively manage elk outside the parks, harvest regulations set by tribes and Washington State can have direct effects on the number and composition of elk using MORA and OLYM. Results from OLYM will be useful for National Park Service staff in discussions with tribal and state wildlife managers on the Olympic Peninsula. Results from MORA are shared with other project participants, and are useful for Muckleshoot Indian Tribe, Puyallup Tribe of Indians, and Washington Department of Fish and Wildlife elk population management outside park boundaries. Joint tribal, state, and federal participation in aerial surveys at MORA entails shared responsibility for elk monitoring, and with it a shared interest in managing elk populations to meet the various goals of all the interested tribes and agencies.

Acknowledgments

This protocol development was funded by the USGS Status and Trends of Biological Resources Program, the NPS Inventory and Monitoring Program, Washington's National Park Fund and their donors, OLYM, and MORA. We are grateful to the Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), and Washington Department of Fish and Wildlife (WDFW), which have long supported elk monitoring in Mount Rainier National Park. 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 this protocol. We are grateful to our professional predecessors, including William Bradley, Douglas Houston, Bruce Moorhead, Stan Schlegel, Ed Starkey, Rocky Spencer, and many others whose early work monitoring elk populations in Olympic and Mount Rainier National Parks laid the foundations for the current protocol. We gratefully acknowledge leadership of the NPS and USGS monitoring programs, particularly Steve Fancy and Mark Huff from the NPS and Paul Geissler from USGS for helping to secure funding and providing administrative support. We would like to thank the park staffs, notably Chiefs of Resources Management, Roger Andrascik and Cat Hawkins-Hoffman, for their stalwart support for elk monitoring, and Aviation Managers, Bill Baccus, Rich Lechleitner, Stefan Lofgren, Larry Nickey, and Alison Robb, for their assistance in planning aviation activities; as well as pilots Rob Olmstead and Jess Hagerman and biologists Dave Manson and Ellen Meyers (NPS), Phillip Dillon (PTOI), Mike Middleton (MIT), Andy Duff, Eric Holman, Sandra Jonker, Anne Marie Prince, and Tammy Schmidt, (WDFW) for their participation in designing these protocols and conducting surveys. We thank Deb Montgomery for her initial review of elk monitoring in the North Coast and Cascades Network. Our efforts were greatly assisted by Oz Garton (University of Idaho), Jeffrey Laake (National Oceanic and Atmospheric Administration), Bruce Lubow (Colorado State University), Glenn Sargeant (USGS), and Kate Schoenecker (USGS) whose recommendations and reviews of previous monitoring provided critical new ideas. We are also grateful to Bruce Lubow for his analysis of double-observer sightability data and contributions to Appendix C. Lastly, we thank Penelope Latham, Paul Geissler, and two anonymous reviewers whose comments on early drafts greatly improved this protocol.

1.0 Background and Objectives

A. Introduction

The North Coast and Cascades Network (NCCN; the network), one of 32 networks of parks in the National Park Service (NPS) System, comprises seven national park units in the Pacific Northwest. Included in the network are three large, mountainous, natural area parks (Mount Rainier National Park [MORA] and Olympic National Park [OLYM], and North Cascades National Park Service Complex [NOCA]) and four small historic-cultural parks (Ebey's Landing National Historical Reserve [EBLA], Lewis and Clark National Historical Park [LEWI], Fort Vancouver National Historical Park [FOVA], and San Juan Island National Historical Park [SAJH]). Within the network, OLYM, MORA, and LEWI identified elk (*Cervus elaphus*) populations as important vital signs that indicate the health or ecological integrity of those parks or have important management, cultural, or historical values (Weber et al. 2009). In 2007, the NCCN elicited the support of the U.S. Geological Survey (USGS) to work with staffs at each park to develop formal protocols for monitoring trends in elk population abundance, distribution, or use.

This protocol outlines the rationale, sampling designs, and methods for monitoring elk in MORA and OLYM. The protocol narrative describes the monitoring program for MORA and OLYM in relatively broad terms, and its structure and content adhere to the outline and recommendations developed by Oakley et al. (2003) and adopted by NPS. In developing this protocol we drew heavily from historical monitoring in MORA and OLYM, as well as from formal review of each park's elk monitoring program and recommendations for improvement and refinement (Jenkins 2007). Finer details of the methodology are addressed in a set of standard operating procedures (SOPs) that accompany the protocol narrative. We developed a separate monitoring protocol for LEWI (Griffin et al. 2011) because of LEWI's unique characteristics, notably the small size and disjunct distribution of its management units and the distinctiveness of the monitoring questions there. Together the two monitoring protocols, this protocol for MORA and OLYM and the parallel protocol for LEWI, comprise the elk monitoring program in the network.

Aerial surveys for elk in MORA began in 1971, were first standardized in 1978 (Bradley 1982), and have become a cooperative effort between the NPS, the Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), and Washington Department of Fish and Wildlife (WDFW). In recent years, each agency has funded at least one survey annually, each contributing to the overall monitoring effort. Hence, we have developed this protocol in close cooperation with the participating biologists from each tribe and WDFW with the intent that this protocol will be used by NPS biologists conducting surveys in MORA and OLYM and also by all other project participants contributing to elk monitoring in MORA. This protocol is unique in the NCCN as the only to be developed, conducted and cost-shared cooperatively with partnering agencies and Tribes.

B. Ecological, Historical, and Cultural Importance of Elk in MORA and OLYM

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 primevally in floodplains and riparian forests along many of the major river systems in western Washington and 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 occurred 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 (U.S. Congress 1899). 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 and spring 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 Mount Rainier National Park and summarized by Bradley (1982) indicated that elk were observed in the northern part of MORA, in Grand Park, in 1915, just a couple of years following the first releases, and that they dispersed widely by the 1930's to inhabit the primary summer ranges used by elk today.

During the 1950's to 70's, intensive logging of elk winter and spring ranges adjoining Mount Rainier National Park 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 (Bender 1962), prompting initial concerns over the potential impacts of elk on subalpine meadows, one of the parks 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: (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 (Starkey 1984)? 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 and spring 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). Through this collective body of work, it was established that elk were native to the area (Gustafson 1983), and that subspecific differences in the Rocky Mountain elk introduced near the park were not sufficiently distinctive to consider the present population non-native or exotic (Schonewald-Cox 1983, Starkey 1984). It was concluded that elk populations using the park during summer are influenced by logging practices on adjoining winter and spring ranges, but that post-logging forest succession patterns had reduced forage availability on the winter and spring 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 on subalpine summer ranges within the park (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

The area that would become Olympic National Park was set aside 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 century only 3,000 remained, primarily in the central core of the Peninsula that is currently Olympic National Park (Morganroth 1909). Mount Olympus National Monument was expanded and recreated as Olympic National Park 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, the park's boundaries represent as complete an ecological system as was possible when the park was created, including both subalpine summer ranges in the park's mountainous interior, and the many low-elevation river valleys used as winter and spring 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 'over-browsing' 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 and spring 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".

In summary, there has been nearly a century of concern and debate over potential impacts of naturally regulated elk populations and resulting levels of herbivory in low-elevation forests of OLYM. Recent research has demonstrated the ongoing significant ecological role of elk and deer herbivory in shaping both the structure and composition of the park's renowned rainforest communities (Happe 1993, Woodward et al. 1994, Schreiner et al. 1996) The century-long debate over potentially negative impacts of elk on ecosystem properties in OLYM was rekindled recently, however, by studies concluding that an overabundance of elk, wrought by the extirpation of wolves, has cascading trophic ecological effects throughout the ecosystem manifested in changes in riparian forest composition, river channel characteristics, and overall impairment of riverine ecosystems (Beschta and Ripple 2008).

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 undisputed 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.

C. Seasonal Distributions and Habitats

Elk movement patterns set the context for monitoring in each park. Elk that use MORA are altitudinal migrants – they migrate into the park in summer, then leave the park in late summer or fall for lower elevation wintering grounds beyond its boundaries (Figure 1). There are two main herds that summer in MORA: the North Rainier herd and the South Rainier herd. These two herds are managed separately outside the park (Spencer 2002, Huang et al. 2002). The portion of the North Rainier herd that summers in the park to the north and east of Mount Rainier migrates to lower elevations in the White River valley for winter; there they may mix with elk from other migratory herds and elk that reside year-round at low elevations. The portion of the South Rainier herd that summers in the park, mostly southeast of Mount Rainier, migrates to winter range in the vicinity of the city of Packwood, where they mix with elk from other migratory herds and elk that reside year-round at low elevations (Moeller 2010). A small number of Yakima herd elk descend and spend the winter to the east (not shown in Figure 1), and a small number of elk use western portions of MORA in the Carbon, Mowich, Puyallup, and Nisqually watersheds, descending to spend the winter west of the park (not shown in Figure 1).

Elk in OLYM show two distinctive life history patterns (Figure 2). Some herds migrate seasonally, using subalpine environments during summers and lower elevations during winter (Murie 1935*a*, Schwartz and Mitchell 1945, Houston et al. 1990). Other non-migratory herds live at comparatively low elevations throughout the year, especially on the park's west-side floodplains. Migratory herds in the northern and western valleys generally use winter and spring ranges within the park, whereas migratory herds in the eastern valleys tend to winter primarily outside the park (Houston et al. 1990). Some of the non-migratory elk herds that spend the year at low elevations also move outside the park at some times of year. A number of elk herds found on the Olympic peninsula do not enter the park.

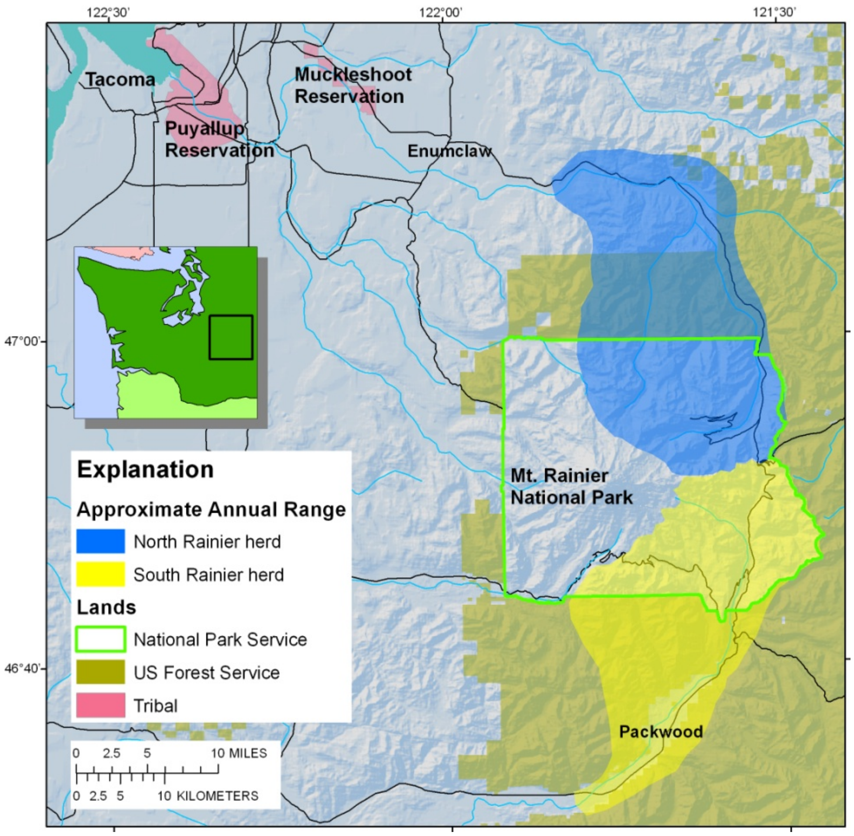

Figure 1. Approximate annual range of migratory elk from the North Rainier herd (blue) and South Rainier herd (yellow) that use MORA in summer. These elk migrate from MORA to lower elevations outside the park, where they spend the winter. Winter ranges may also be used by non-migratory elk and elk that use different high elevation summer range. The inset map shows the regional setting in the Pacific Northwest, with Washington shown in dark green, Oregon in light green, and Canada in pink.

The consistent, seasonal patterns of movement into high elevation summer range by virtually all elk that use MORA and some fraction of the elk that use OLYM allows us to designate the summer trend count areas that form the basis for monitoring. We and our monitoring partners will survey summering populations of elk within high-elevation, subalpine habitats, defined as the biotic zone between montane forest and alpine tundra. Specific guidelines defining the zone are given in **2.0 C.** *Summer Surveys in MORA and OLYM*, but generally include the area near and above treeline, high elevation meadows and shrub fields. These habitats are also the places where elk are most visible to humans because relatively little vegetation obscures them from view. The North Rainier herd trend count area (Figure 3) corresponds with summer range used by a segment of the White River herd that migrates into the park (Spencer 2002). Similarly, the South Rainier herd trend count area encompasses summer range used by a subset of the South Rainier herd that winters south of the park (Huang et al. 2002). Some small number of elk from the Yakima herd also spends the summer in the subalpine zone on the eastern margin of MORA in both the North Rainier and South Rainier herd trend count areas (WDFW 2002).

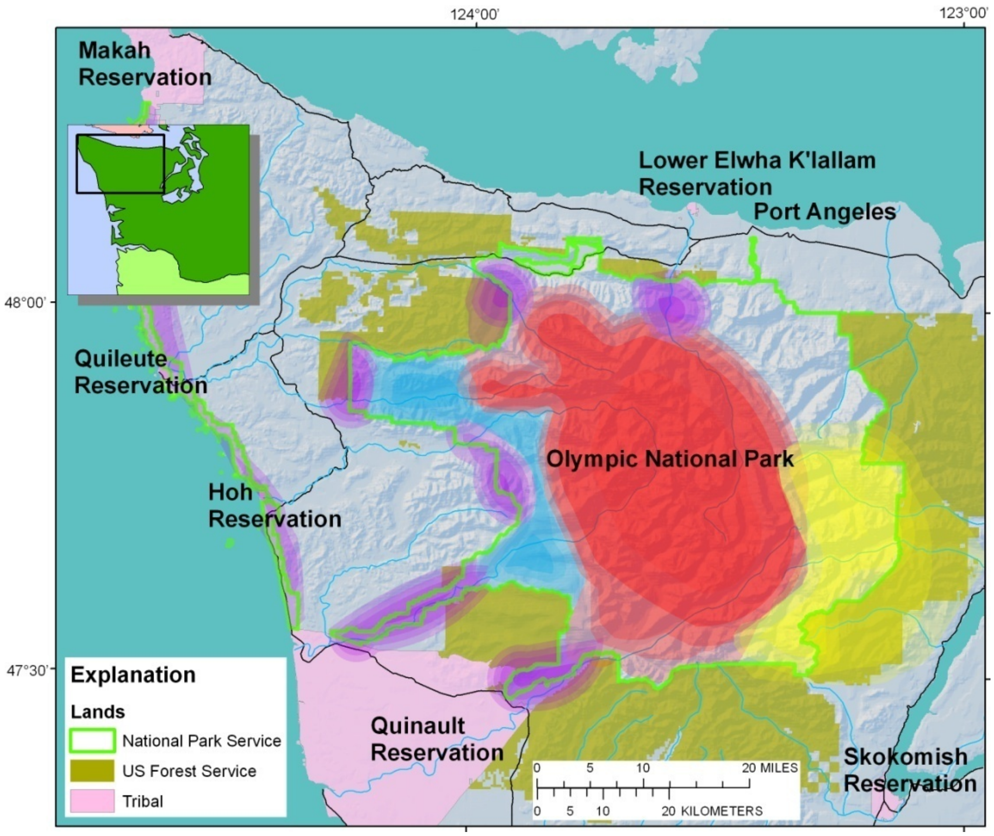

Figure 2. Map of OLYM (green boundary) and surrounding areas of the Olympic Peninsula, showing the approximate distributions of elk that use OLYM all year (park resident herds) or some part of the year. Red shading suggests the approximate annual ranges of park elk herds that migrate seasonally between distinctive summer and winter / spring ranges. Yellow suggests approximate annual ranges of migratory herds that summer in the park and winter outside the park in eastern valleys. Blue suggests approximate annual ranges of non-migratory elk herds that reside year-round in the park in low-elevation western rainforest valleys. Purple suggests approximate annual ranges of non-migratory herds that have annual ranges partly inside the park, and partly outside the park. The annual ranges of many herds may overlap, and this map does not show the ranges of all elk herds on the Olympic Peninsula.

Elk that migrate from MORA to low elevations outside the park during winter are surveyed on the late-winter ranges by MIT, PTOI, and WDFW. Those surveys provide important data used by both Tribes and WDFW to establish harvest recommendations. The methods and results of these winter range surveys conducted by MIT, PTOI, and WDFW are not part of this protocol. Our Tribal and WDFW partners participate and help to fund the summer surveys in MORA detailed in this protocol, but NPS is not involved with winter range surveys outside MORA.

Unlike MORA, OLYM contains important winter and spring range for both migratory and non-migratory elk, particularly in the broad rainforest valleys on the west side of the park. The park has a long legacy of monitoring trends in the abundance and distribution of elk on three primary spring ranges of the park.

D. Rationale for Selecting this Resource to Monitor

Elk are important agents of ecological change in riparian forest, montane forest, and subalpine ecosystems, through their influence on ecosystem processes and plant community structure and composition (Happe 1993, Hobbs 1996, Schreiner et al. 1996). Because elk are valued park resources and essential species in an ecological context, reliable and current information on elk trends in abundance, distribution, and composition is needed to understand changes in park ecosystems. Controversies regarding the ecological effects of elk on national park ecosystems have reached national prominence in Yellowstone NP and Rocky Mountain NP, but there is also a long history of research and management concerns regarding elk effects on subalpine and forested ecosystems of MORA and OLYM (Schwartz and Mitchell 1945, Bradley and Driver 1981, Bradley 1982, Happe 1993, Woodward et al. 1994, Schreiner et al. 1996, Beschta and Ripple 2008).

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 network 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.

Specifically, there are numerous current management issues regarding elk in MORA and OLYM that require information on population trend:

- OLYM is home to the largest protected herd of Roosevelt elk in their native ecosystem — the elk are a unique resource that was instrumental in the park's creation and that today represents one of the 'signature' resources for which the park is renowned. Recognizing changes in elk populations is the necessary first step in the process of determining causes of population changes and developing strategies to ensure long-term protection.

- Over several decades, there has been recurrent controversy regarding potential ecological effects of overabundant elk on ecological integrity of subalpine meadows in MORA and of lowland rainforest communities in OLYM. Information on elk population trends is necessary for comparisons with monitored changes in vegetation to evaluate the effects elk may have on ecological integrity.

- Despite protection within national parks, elk populations have generally declined since the 1980's on the Olympic Peninsula adjoining OLYM, in the MORA South Rainier herd and North Rainier herd (though the North Rainier herd appears to have grown again in recent years). There are legitimate concerns that land-use practices and the resulting successional vegetation changes on lands adjoining parks have contributed to population declines for elk herds that use adjoining managed forest lands seasonally.

- Elk harvest levels outside park boundaries are set by tribes and the state, based on survey data and population models. Outside MORA, the Tribes and State manage harvests of elk herds that migrate from the park by estimating abundance and composition of elk herds on winter / spring and summer ranges. Although winter range surveys are the primary source of information for harvest management, age and sex composition of the herds during summer are also important information for managers (e.g., one management objective for the North Rainier elk herd is based on summer counts of elk within MORA). Furthermore, summer surveys are the primary mechanism used by the NPS to evaluate the effects of elk management practices on the numbers of elk using the park during summer.

- Harvesting mature bulls outside parks also may affect sex and age composition of elk populations in both parks. OLYM is renowned for the large number of mature bulls in the population, and research indicates that mature breeding bulls that spend most of the year within the park may migrate outside of the park during the rut, where they are vulnerable to legal and illegal harvests (P. Happe, personal communication). There are no current indications that hunting has altered elk population trends or composition within OLYM, but long-term effects of hunting patterns on adjoining lands are uncertain (Houston et al. 1990). Summer surveys conducted around the time of the breeding season generally result in less biased sex ratios than surveys conducted on winter / spring range.

- There have been questions raised over whether local Indian tribes have rights to hunt elk inside the current boundaries of OLYM (Holt 1986). Up-to-date information on status and trends may be important to future discussions.

- Predator and habitat management activities near MORA and OLYM may stimulate growth of elk herds that use the parks, and could renew concerns over vegetation responses in the park. Wildlife managers have increased predator control operations to the north of MORA, and that may remain as a long-term management option outside the park. Predator harvests, along with habitat management and modified elk harvests, appear to have led to an increase in the North Rainier elk herd. Monitoring elk trends in response to management actions outside the park is needed by all project participants to evaluate elk population responses to variations in predator management outside the park.

- There have been recent proposals to reintroduce wolves in OLYM (Ratti et al. 2004), and natural recolonization of Washington is occurring with wolves dispersing from Canada or Idaho (WDFW 2009). There are currently wolf packs established north and east of MORA. Up-to-date information on elk status and trends can be used to assess wolf restoration feasibility in the Olympic Mountains or the effects of wolves on elk in the Cascades Range. Wolves may use remote areas, such as national parks, during summer more than areas with more human disturbance, and thus may have a disproportionate effect on elk that use the parks during summer.

- Nationally, the increased prevalence of wildlife diseases (e.g., chronic wasting disease, paratuberculosis, brucellosis) is a growing national concern (Daszak et al. 2000; Angers et al. 2006). Given elks' ecological roles noted already, an epidemic in elk would have profound ecological effects in MORA and OLYM.

- The effect of future climate change on elk is unknown, but elk inside and outside parks could be influenced by, among other effects, shifts in: temperature, precipitation and snowpack (Salathé et al. 2009); forest disturbance regime (Dale et al. 2001, Westerling et al. 2006); and vegetation (Zolbrod and Peterson 1999). As a result, climate change may cause changes in forage availability, and elk distribution and abundance.

None of these issues are simple, and all may have implications for policy and management, including relations with sovereign tribes and other state and federal agencies. Credible data about the current status of elk within MORA and OLYM are needed, so that the parks can have a clear understanding of the condition of this resource. Over time, elk monitoring results may be used to help the parks evaluate the effects of climate change, external impacts, and other stressors that may influence elk within and across park boundaries. Sound scientific information on elk populations and trends is a critical first step in discussing complex solutions across management jurisdictions, and is needed to interpret the effects of NPS policies on natural regulation of ungulate populations.

E. Linkages to Other Network Monitoring and Management Decisions

Because elk play an important role in structuring park ecosystems, monitoring elk populations is closely linked with the NCCN Forest Vegetation monitoring program, and the Subalpine Vegetation monitoring program (Weber et al. 2009). Knowing population trends of elk in these ecosystems will provide insights on long-term relationships between elk and vegetation structure and composition.

Also, because elk populations are affected by changes in landscapes and climate, elk monitoring is also linked to network monitoring programs that are in place to detect long-term changes in both landscape composition (the Landscape Dynamics program) and climate (the Climate program). A close association has been documented between elk populations using MORA and forest management and succession-driven land changes outside the park (Jenkins and Starkey 1996). Potential influences of adjoining land uses on elk populations have also been documented for migratory elk herds on the east side of OLYM and for resident herds along the western boundary of the park (Houston et al. 1990, Schroer 1987, Schroer et al. 1993). Climate changes and associated changes in fire effects, subalpine ecology, and forage phenology have potential to further influence elk herds throughout MORA and OLYM. Knowledge of elk population trends and spatial variation within key elk range areas will help park managers interpret key ecological influences of landscape and climate changes on the main population centers of elk in these parks.

Lastly, elk are important as prey for black bears and cougars, as well as other predators and scavengers in both parks. Black bears and cougars are important species for management as they may become conditioned to human foods, habituated to humans, or hazardous to park visitors. Close human/predator encounters are monitored through reporting systems in each park, and trends in elk abundance could prove useful to interpret trends in bear or cougar encounters.

F. Review of Previous Monitoring

For over 20 years, the MIT, PTOI, NPS, and WDFW have cooperated in monitoring trends in elk abundance and composition in both the North Rainier and South Rainier elk herds. In addition to informing the NPS on status of elk populations using the park during summer, the interagency monitoring program has provided information that is useful to these Tribes and the State in managing both herds while on winter and spring ranges outside the park (Spencer 2002, Huang et al. 2002).

Historically, MIT, PTOI, WDFW, and NPS surveyed elk nearly annually in subalpine summer ranges within MORA from either fixed wing airplanes or helicopters during evenings in late summer and early fall. Survey crews recorded the number of elk seen within spatial units defined by Bradley (1982) at three hierarchical spatial scales. Bradley defined one North and one South 'herd', each of which contained lettered 'management' units which were further subdivided into numbered 'range' units. Past surveys did not necessarily visit all range units on each evening survey flight, but there were typically three survey flights conducted per herd unit per summer.

Four indices of elk abundance were computed for each herd unit from the replicated surveys conducted each year (Bradley 1982):

> E1: The sum of the maximum counts obtained for each range unit in a year
> E2: The sum of maximum counts obtained for each management unit in a year
> E3: The maximum count of elk observed in a herd unit on any one flight
> E4: The average of E1-E3 indices

Bradley recommended using the E4 index multiplied by a factor of two as the standard metric for comparison of elk abundance over time. The multiplier was intended to account for detection biases (i.e., elk present but not seen by aerial survey crews), and was based on comparisons of counts and densities of elk computed from pellet group surveys in the Cedar River Watershed (Schoen 1977).

MIT, PTOI, and WDFW also have a long history of conducting winter range aerial elk surveys on the winter range of the North Rainier and South Rainier herds, outside the park. PTOI winter range surveys in the vicinity of the towns Randle and Packwood (Game Management Units 503, 513, and 516) include application of a sightability model that was developed for winter range helicopter surveys, using radio collared elk in that area (Gilbert and Moeller 2008). MIT and WDFW conduct winter range surveys in the elk winter range north of MORA in the White River (Game Management Unit 653).

Because OLYM contains both summer and winter / spring seasonal ranges of elk and both resident and migratory life history patterns (Figure 2), elk have been monitored on both low elevation spring ranges and subalpine summer ranges to provide the most complete information possible on elk population trends within the park. During the mid-1980's, 2007, and 2008, OLYM conducted aerial surveys of elk in high-elevation summer range to estimate elk herd composition, as well as population trends of the migratory population component that winter more broadly throughout the park or, in the case of some east-side herds, outside the park.

Elk population trends have been surveyed in late winter / early spring by helicopter since the mid 1980's in three trend count areas in the park's west-side rainforest valleys (Houston 1984, Houston 1985, Houston 1986, Houston et al. 1987), although survey frequency has been sporadic due to lack of funding. Spring surveys in OLYM have been timed to coincide with the early period of green-up in river valleys, when elk are highly visible on floodplain terraces. These spring counts occur when calves are nearly the size of adults, and when bull elk are largely without antlers. As a result, the spring surveys do not provide information about sex and age composition.

G. Program Goals and Measurable Objectives

The goal for elk monitoring is to detect changes in abundance, spatial distribution, and herd composition in selected trend count areas of MORA and OLYM where elk are seasonally concentrated and highly visible. Inferences about trends in elk abundance and composition will be limited to the trend count areas. Although it would be preferable to estimate changes in elk population characteristics at the parkwide scale, or for known subpopulations, we do not have the resources to estimate populations in large areas of the parks where elk are relatively uncommon and poorly visible. The funding issue is highlighted by the fact that elk monitoring in the NCCN is a low priority compared to other monitoring protocols funded by the network and it may be further limited by budgets in the future.

In 2007, we hosted a workshop comprised of project participants and several elk monitoring specialists to identify survey methods that will meet mutual monitoring objectives within current and projected budgetary constraints. Project participants and invited specialists generally agreed that monitoring trends in elk use and composition of key trend count areas is feasible within the project constraints and will provide useful information for all project participants. Specifically, monitoring trends in elk abundance and composition within trend count areas is useful because the trend count areas encompass primary summer or spring ranges of elk in each park, and they correspond with areas where there have been concerns about elk grazing and trampling effects historically (Bradley 1982, Schwartz and Mitchell 1945) and presently (Beschta and Ripple 2008). Furthermore, summer trend count areas selected in MORA are surveyed routinely by partners from the MIT, PTI, and WDFW, because trends in population composition supplement winter range survey results used by the State and Tribes to manage harvests of elk outside the parks. Our partners continue to support summer elk monitoring within MORA, which has immediate and future benefits of cost-sharing. These partners follow the same summer survey methods detailed in this protocol, and the combined data from the set of MORA summer elk surveys leads to estimates that will be presented in annual and four-year reports.

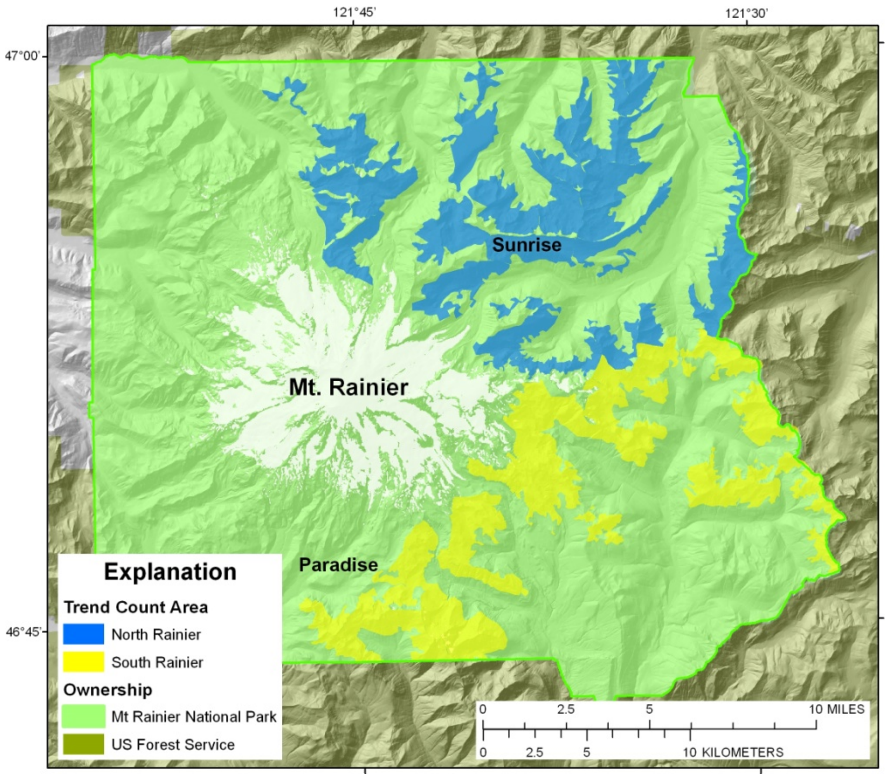

Figure 3. Summer trend count areas within MORA. The area of the North Rainier trend count area is approximately 103 km2, and the area of the South Rainier trend count area is approximately 89 km2.

Trend count areas correspond with key summering areas of elk in MORA and OLYM, and key wintering areas in OLYM. In work that is separate from this protocol, elk that summer in MORA are surveyed on key wintering areas outside the park by MIT, PTOI, and WDFW. Those winter range surveys provide data that MIT, PTOI, and WDFW need to make management decisions, and complement the jointly conducted summer surveys conducted in MORA that are detailed in this protocol.

Objective 1: Monitor trends in raw counts, abundance, spatial distribution, and population composition in selected subalpine summer ranges in MORA and OLYM during late summer.

This is the primary monitoring objective shared by both MORA and OLYM. The surveys will be conducted using a common protocol within trend count areas corresponding with the major summer ranges of migratory elk in both parks. The surveys will be conducted from helicopter between 15 August – 15 September and within four hours of sunrise or sunset, when elk use of subalpine meadows is greatest. NCCN funding is available for surveys in alternating years, and each of the partners will also contribute funding and survey teams to augment the effort beyond that available from NCCN program alone.

In MORA, the two trend count areas will 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. In each year with surveys, one of these trend count areas will be surveyed once completely, and the other twice completely. This sampling schedule is dictated largely by funding limitations of the NCCN program and contributions of our monitoring partners.

In OLYM, we will monitor trends in abundance and composition of elk that use five summer range trend count areas, which comprise most of the subalpine habitats used by elk in OLYM. We will survey the core summer range trend count area in every year of survey; this core area corresponds with summer range of migratory herds of elk that winter in the primary low-elevation spring ranges in the Hoh and Queets Valleys and summer in the subalpine zone along the western flanks of Mt. Olympus and adjoining ridges (Schwartz and Mitchell 1945, Olympic National Park, unpublished data). We will also survey elk in four adjacent summer range trend count areas (Figure 4) on a rotating schedule every four years of survey. This sampling schedule is necessarily different from that in MORA due to the greater extent of summer range in OLYM and comparable funding limitations.

We will use two metrics to depict trends in elk abundance within the trend count areas: raw counts of elk, and estimated abundance of elk. Raw counts are indices of relative abundance, based on the assumption that sightability factors do not change over time, whereas abundance is estimated using double-observer sightability models that relate the probability of aerial observers spotting elk from the air as functions of important covariates that affect detection probabilities (such as group size and the amount of concealing overstory vegetation, see **Appendix C: Analyses of Detection Bias**). We have completed a double-observer sightability model ready for immediate application in MORA. We intended to develop that double-observer sightability model for general application in both MORA and OLYM summer trend count areas, but large-scale failure of radio-collars used in model development has prevented us from collecting sufficient data to test the model's applicability to OLYM summer surveys yet. We will have the necessary data collected to generalize the model to both parks in two to three years. This data will be collected without the need for additional NCCN funding, because of funding from USGS and private donors. In the near term, we will report raw counts of elk in OLYM and both raw counts and estimated abundance of elk in MORA. All data collected in OLYM will allow retrospective computation of abundance estimates once the updated double-observer sightability model is completed.

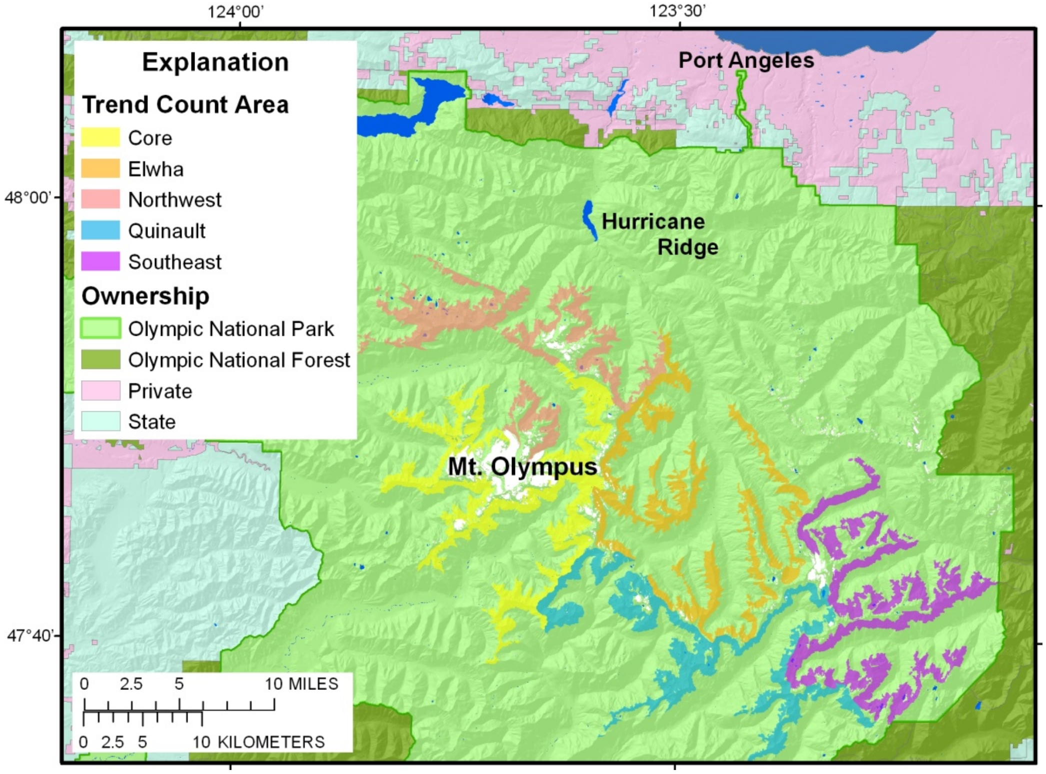

Figure 4. Summer trend count areas within OLYM, including the core trend count area that will be surveyed once per year of survey, and four peripheral trend count areas that will be surveyed once per four years of survey. The areas of the Core, Elwha, Northwest, Quinault, and Southeast trend count areas are approximately 93, 82, 74, 80, and 85 km2, respectively.

We will estimate changes in spatial distributions of elk in each park by monitoring trends in the relative abundance of elk in specific survey units within trend count areas in each park. At the finer scale, we will record specific locations of each elk group sighted in each survey and will examine temporal changes in the spatial distribution of elk group locations, in terms of elevation, vegetation type, distance to park boundary, or other spatially defined variables.

We will monitor trends in population composition based on two primary metrics: changes in bull:cow ratios expressed as the number of bulls per 100 cows, and calf:cow ratios expressed as the number of young- of- the-year calves per 100 cows. Such metrics are important indicators of hunting pressure on males and herd productivity. Changes in ratios of calves to cows, considered together with past changes in abundance, also provide an early indication about future population trends. Because hunted and unhunted elk populations may differ both in the total ratio of bulls, as well as the proportions of mature to younger bulls (Houston 1982, Jenkins and Starkey 1982, Biederbeck et al. 2001), we will record observed bulls according to yearling, subadult, and mature age categories (see **SOP 7: Conducting Helicopter Surveys**; Defining Age and Sex Categories for Composition Counts). Along with trends in summer abundance estimates, the estimation of herd composition motivates the PTOI, MIT, and WDFW to participate in cooperative surveys at MORA, because composition estimates can be valuable in making population projections and management decisions related to harvest outside the park (Harris et al. 2008).

Where possible we will report composition based on population estimates derived from the double-observer sightability models (**SOP 13: Data Summary, Analysis, and Reporting**) to minimize biases resulting from differential detectability of bull versus cow groups (McCorquodale 2001). In the initial years of the program, though, we will report composition ratios of elk in OLYM based on the raw counts observed. As described previously, population ratios derived from raw counts in OLYM will be retrospectively adjusted using estimates corrected for detection biases during the next four-year reporting summary after model development and testing is completed in OLYM.

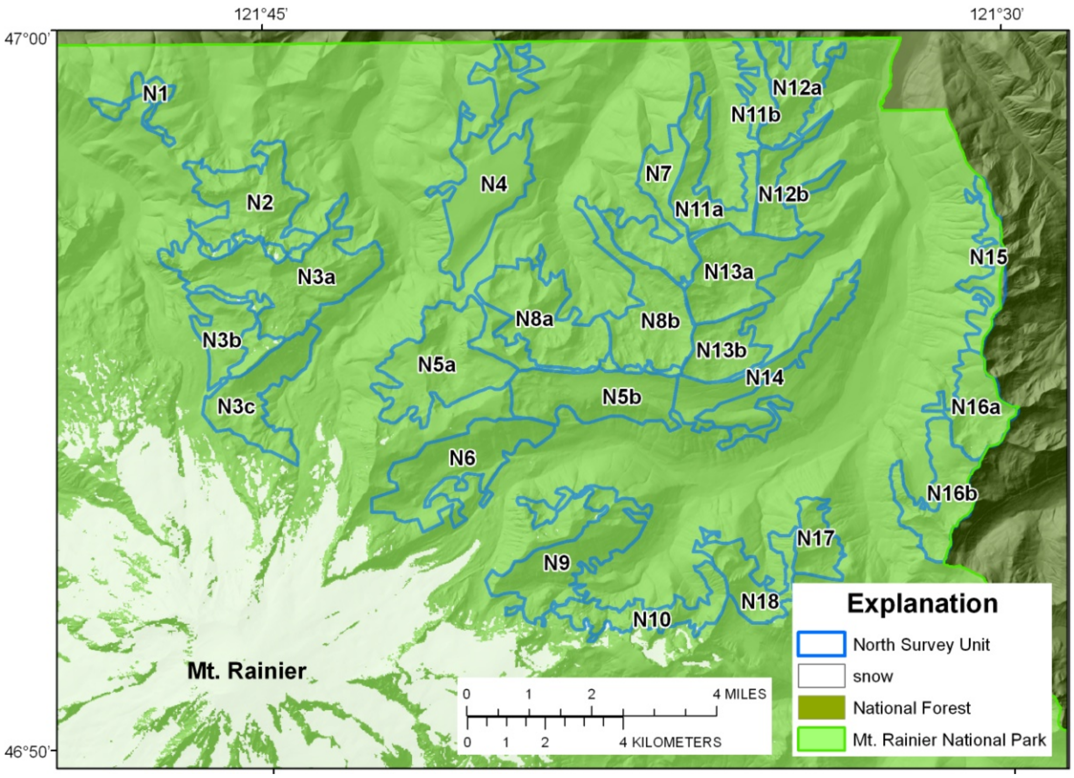

Figure 5. Map, illustrating survey units within a trend count area. Survey units of the MORA North Rainier herd trend count area are outlined in blue and prefaced with "N."

We designed our monitoring methods to detect a 10.5% rate of increase or decrease in elk abundance per year over eight years, based on a biennial sampling scheme. This rate of annual change over the time span of seven intervening years yields approximately a halving or doubling of abundance. Our choice of evaluating power of trend detection over this time period corresponds with our decision to evaluate trends following every four years of data collection (see **5.0 Analysis and Reporting**), and the availability of NCCN funding for surveys only in alternating years.

We chose these levels of change for the analyses of trend detection because an approximate halving of elk use in the park would reflect an adverse effect on the elk resource in the parks, and doubling may adversely affect other resource values. The scientific information obtained from elk monitoring has multiple applications for management decision-making, research, education and promoting public understanding of resource management issues related to elk in the park and surrounding private and public lands. Management actions, which may prove controversial or expensive, would probably not be considered by NPS managers unless such substantial levels of change were detected. Moreover, because MIT, PTOI and WDFW are partners in the MORA elk monitoring, those parties can take management actions outside the park boundary that influence elk populations. If trend analysis reveals halving or doubling in elk, that could also stimulate collaboration with the project partners (MIT, PTOI, WDFW), and possibly other agencies (i.e., U.S. Forest Service, or Washington State Department of Natural Resources), to determine feasible management solutions to problems at a broader scale.

Because trend count areas correspond with selected population segments, and are not sampled probabilistically from the entire elk population, it will not be possible to infer parkwide trends in abundance or population composition of elk from this monitoring program. Instead, trend estimates will specifically apply to selected trend count areas. Despite this limitation on inference scope, the trend count areas in each park comprise a large proportion of the elk summer ranges in each park. Further, the trend count areas correspond with subalpine ecosystems where the majority of management concern exists regarding elk/vegetation interactions in MORA. A substantial increase or decline of abundance in monitored trend count areas would signify a large change in the total elk abundance, a large change in elk behavior, or both, and would indicate changes in grazing pressure on subalpine meadow habitats.

Objective 2: Monitor trends in counts and spatial distribution of elk in three low-elevation spring range areas in the western rainforest valleys of OLYM: Hoh Valley, South Fork Hoh Valley, and Queets Valley.

This is a secondary monitoring objective that applies only to OLYM due to the extensive winter and spring ranges of elk in the park and the historical interest in elk and vegetation trends on these ranges. This objective is intended to extend the rich legacy of elk monitoring that spans over 25 years in three key spring ranges in western OLYM (Houston et al. 1987). Although elk monitoring in OLYM spring ranges has been funded sporadically over the last 25 years, primarily using special project funding, it has revealed changing patterns in distribution of elk in relation to the park's boundary that are of great interest to park managers (NPS, unpublished data). There is currently no regular funding available in the NCCN budget to support this monitoring component on a regular basis. We incorporated this ancillary objective, however, in the event that funding becomes available either through the NCCN or other funding sources in the future.

The OLYM spring range trend count areas (Figure 6) correspond with three key spring ranges that support a high density of elk (Houston et al. 1987). The three watersheds collectively hold approximately half of all elk that winter in OLYM (Jenkins and Manly 2008). The same watersheds also encompass the primary distribution of the Sitka spruce temperate rainforests for which the park is known, and sites of sustained studies of elk and vegetation interrelationships (Jenkins and Starkey 1981, Jenkins and Starkey 1984, Happe 1993, Schroer et al. 1993; Woodward et al. 1994, Schreiner et al. 1996). Each of the key spring ranges is used year round by resident herds that remain in low elevation home ranges, and also by migratory herds that move from high elevation subalpine ranges in summer to low elevation ranges primarily during winter.

In years when supplemental or outside funding allows, spring surveys will be conducted from helicopter in March, during the last weeks of winter and first weeks of spring, when forest understory plants on floodplain habitats have begun spring growth, but before leaves on overstory deciduous trees obscure visibility to ground level. Spring surveys will begin at first light, when elk use of open habitats is highest (Jenkins and Starkey 1980).

We will monitor trends in raw counts of elk observed from aerial surveys within each trend count area. We will also monitor changes in the spatial distribution of elk observed relative to the park's boundary because recent surveys suggest fewer elk have been observed in the boundary areas of the Hoh River during recent than in historical surveys (NPS, unpublished data). Although it would be desirable to estimate detection biases and trends in actual estimates of population abundance, as we do in the subalpine summer ranges, we do not anticipate having the means to do so in the foreseeable future. Because spring surveys will be infrequent, we do not expect to record a sufficient sample size of double-observer sightability data to estimate a model for detection bias for spring surveys for some time. We will, however, collect aerial survey data during OLYM spring surveys in a manner that may one day provide sufficient data to compute a double-observer sightability model for application to OLYM spring surveys and retrospective adjustments to correct for detection biases. We justify building a monitoring program based on using raw counts as indices of abundance because such legacy data has proven useful for interpreting such important management issues as the feasibility of wolf reestablishment in OLYM (Fieberg and Jenkins 2005, Jenkins and Manly 2008), and effects of adjoining land uses on park elk.

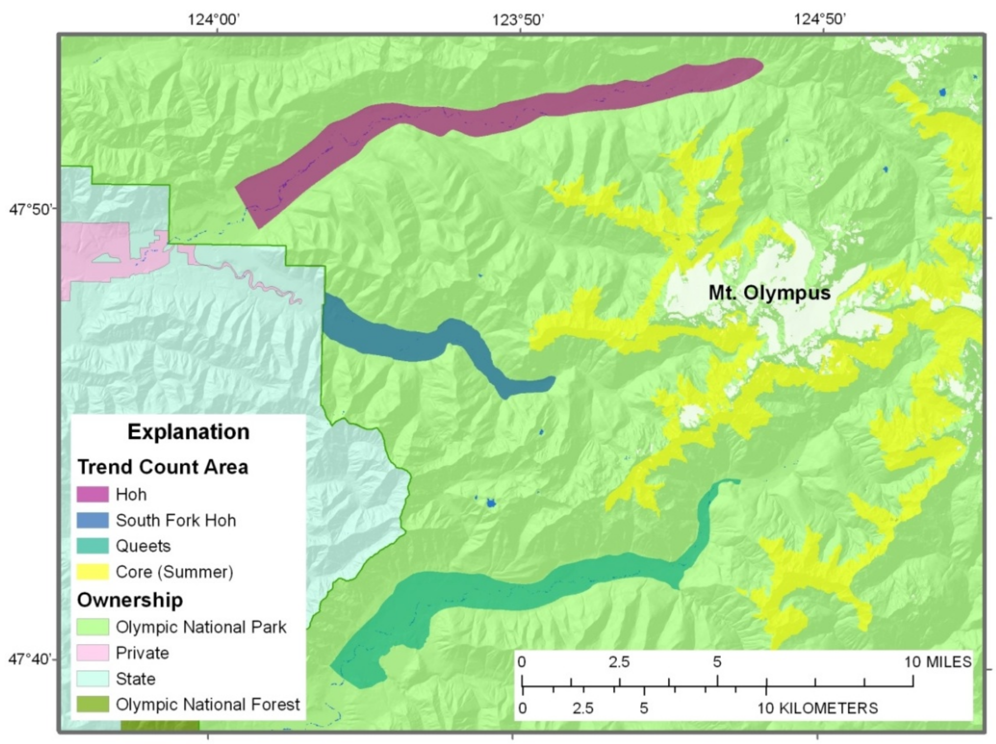

Figure 6. Map of the Hoh, South Fork Hoh, and Queets trend count areas for OLYM spring surveys. The Core summer trend count area, shaded in yellow, is shown for reference. The areas of the Hoh, South Fork Hoh, and Queets trend count areas are approximately 27, 11, and 24 km2, respectively.

2.0 Sampling Design

A. General Survey Strategy

We will count elk in their high elevation subalpine summer range (in summer surveys at MORA and OLYM) and low elevation spring range (in spring surveys at OLYM) from a type-III helicopter (i.e., a Bell 206B-3 or Hughes 500D). Common methodologies will be used in both MORA and OLYM to permit comparisons among trend count areas and to ensure consistency in the development and application of a double-observer sightability model to both parks. Trend count areas will be thoroughly searched for elk by the team of three observers and the pilot from approximately 150 m (500 feet) above ground level, with flight lines approximately 300-700 m apart for summer surveys, or 150-300 m apart for spring surveys. We will record the location and group size of all elk groups that are detected, as well as other covariate data that may be related to detection probability.

We will develop and use a hybrid double-observer sightability modeling approach on summer ranges to adjust raw counts of elk made within each trend count area and to reduce biases in abundance and composition estimates that result when not all animals present can be seen from an aircraft overhead (Samuel et al. 1987, McCorquodale 2001). The hybrid approach combines many features of both double-observer and sightability modeling methods, (reviewed in **2.0 B. Rationale for Selecting this Survey Design**), that have been used extensively to estimate sightability biases of aerial surveys.

The hybrid double-observer sightability modeling approach, adapted from the previous work of Schoenecker et al. 2006), allows for estimation of unconditional sighting probabilities of front and back seat observers, the number of elk that go undetected by all observers, and the actual number of elk present during the survey (Schoenecker et al. 2006). Double-observer sightability trials using radio-marked animals and a larger sample of double-observer data for radio-free elk groups are used together to estimate how covariates influence the unconditional probability that a given observer detects a given elk group. We include a heterogeneity effect in the double-observer sightability model (**Appendix C: Analyses of Detection Bias, *Theoretical Background***) that allows us to adjust the biased detection probabilities that would result from using only data from the double observer sightings, to more accurately reflect the unconditional detection probabilities. Unlike sightability models that have been used extensively to estimate detection biases of aerial surveys (Samuel et al. 1987, Steinhorst and Samuel 1989, Unsworth et al. 1994), the double-observer sightability model leads to separate estimates of each elk group's unconditional detection probability for the front and back seat observers. With double-observer sightability data from radio-marked groups as a benchmark, and because we will continually be recording the double-observer pattern of which observers saw which elk groups, we will be able to test for future changes in the influence of covariates on elk group detection probability.

Based on data collected from 2008-2010 at MORA, including 97 sightability trials and 510 additional double-observer trials, we have developed a double-observer sightability model for application to aerial surveys conducted on MORA subalpine summer ranges (**Appendix C: Analyses of Detection Bias, *Model Development***). The MORA data relied on elk that were radio collared by MIT and PTOI. Additional sightability trials could be recorded at MORA, but for budget reasons our intention is to begin using the MORA double-observer sightability model there immediately, while continuing to collect double-observer data indefinitely.

Our intention was to collect a sufficient number of double-observer sightability trails in OLYM to test the generality of the MORA models for application in OLYM. Due to large-scale failure of radio-telemetry collars in OLYM, however, we have not yet collected sufficient data for evaluating the applicability of the model to OLYM. As of September 2011, NPS has 18 functioning radio- or GPS-collared elk at OLYM. We will continue to collect comparable double-observer sightability data in OLYM summer surveys until we will be able to test whether the MORA double-observer sightability model is applicable at both parks. We expect that we will be able to conduct that test after two to three more years of OLYM summer surveys. The test will be relatively straightforward because methods are identical at the two parks (**Appendix C, *Example 1: OLYM Summer Survey Data compared to MORA Double-observer Sightability Model***). We will include the newly collected OLYM double-observer sightability and double-observer data in a set that also contains the original MORA data. We will then assess model fit and parameter estimates for models that include only one set of parameters for both parks, as opposed to models which fit parameters separately for each park. We will report only raw counts of elk in OLYM summer ranges until the model tests are completed.

As mentioned, there is currently no funding to support regular surveys of elk abundance on spring ranges in OLYM. Rather, to preserve the value of this legacy data, we will conduct spring surveys within three trend count areas following previously published methods (Houston et al. 1987), as funding permits. Because the collection of covariate data entails no additional costs to the planned surveys, we will collect covariate data on spring surveys in OLYM in the same manner as for summer range surveys. Such data may enable future correction of raw counts to account for detection biases, if funding becomes available in the future to support development of a double-observer sightability model for application to spring surveys.

B. Rationale for Selecting this Survey Design

In 2007, we assembled a panel of elk monitoring experts to review historically used elk population monitoring methods at MORA and OLYM, to identify potential improvements, and to evaluate what methods would best meet the parks' information needs (summary available upon request from Kurt Jenkins, USGS). The most lively discussion centered on whether or not it was feasible to estimate abundance of elk at the park-wide scale. We ruled out the possibility of park-wide abundance estimation based on logistical and funding considerations (as elaborated below in the *Park-wide Sampling* section). Panelists recognized the constraints of the total budget available for elk monitoring in MORA and OLYM (**Chapter 7: Operational Requirements**), and the stipulation that this monitoring protocol should not require the maintenance of a marked population of elk in perpetuity to meet monitoring objectives. This latter constraint reflected both budgetary limitations as well as both parks' considerations for long term-safety of park operations and maintenance of park wilderness values.

As described in **2.0 A. General Survey Strategy** (and elaborated in detail in **Appendix C: Analyses of Detection Bias**), we chose a hybrid double-observer sightability approach to model sightability biases of aerial surveys conducted within trend-count areas on subalpine summer ranges in each park. The chosen method improves upon traditional sightability modeling methods because it will allow us to evaluate evidence of changing sightability conditions through time. Furthermore, the method enhances double observer methods because estimates of detection probability incorporate sightability data, which are not biased by factors that can cause two observers' records of detected animals to be not truly independent.

A rich literature exists, describing a variety of estimation methods that we considered along with the chosen method. We considered and rejected several alternative sampling and survey methods, including:

Park-wide Sampling
We considered and rejected two approaches to park-wide estimation of elk populations within each park: design-based estimation and model-based estimation. Design-based estimation involves making observations within probabilistically selected sampling units drawn from the entire population of interest (Gregoire 1998). In design-based estimation, samples are selected in a manner that permits inferences to be drawn to the larger population represented by the samples. We rejected probabilistic sampling of both Mount Rainier and Olympic National Parks based on several practical considerations. Dense coniferous forests comprise the majority of land area in both parks. Upland coniferous forests often contain low densities of elk under conditions of very low detection probabilities. Costs associated with surveying upland forests would be prohibitive. Other concerns influencing survey design included financial constraints on the number of sampling units that could be covered within fixed budgets, potentially high sampling variance associated with patchy distributions of elk aggregations, and potentially low precision expected of sightability models based on conditions with poor detection probability.

Model-based estimation involves estimating animal densities in selected areas and extrapolating densities based on modeled relationships between indices of use or density measured in selected sites (Gregoire 1998). We considered extrapolating density estimates from trend count areas based on fecal pellet surveys implemented at the park-wide scale, and based on indices of relative use measured from radio-telemetry. We have experience developing indices of fecal density of deer and elk and using those indices to extrapolate survey results in the estimation of density (Jenkins and Manly 2008). Such surveys are inherently variable, resulting in high costs, low precision, or both. We ruled out model-based extrapolation of trend count densities based on radio-telemetry derived indices of use based on concerns over costs, precision, and the need to maintain collared samples in perpetuity.

'E4' Population Index in Mount Rainier
We considered continuing to use the 'E4' index that was developed in the late 1970's for use in Mount Rainier (Bradley 1982). With the consensus of MIT, PTOI, and WDFW, however, we agreed not to adopt the E4 index for long-term use. Although all project participants recognize the possible value of computing E4 for a transitional period of time, the index was rejected for long-term use because it is biased by replication effort, and it lacks the formal structure and statistical properties of an estimator. Consequently, it is not possible to estimate uncertainty associated with the index.

Uncorrected Aerial Survey Counts or Fixed Correction
We considered using raw uncorrected survey counts as an index of population size for summer survey trend count areas, but we rejected this idea based on the rich literature demonstrating that the ability of aerial observers to detect ungulates from aircraft frequently varies among observers

or as functions of group size, animal behavior, concealing vegetation, or other factors (Samuel et al. 1987, Otten et al. 1993, Unsworth et al. 1994, Thompson et al. 1998, Cogan and Diefenbach 1998, McCorquodale 2001, Schoenecker et al. 2006, Lubow and Ransom, 2007).

We also considered using a fixed (i.e., scalar) adjustment of survey results to account for detection bias. Historically, E4 indices of elk abundance were multiplied by a factor of two to account for detection biases, based on comparisons of pellet group estimates of elk abundance and aerial survey results in the Cascades Range (Bradley 1982). Similarly, raw counts of elk in Olympic National Park were adjusted by a factor of 1.35, based on previous aerial surveys that detected 74% of 19 groups of elk containing a collared individual. Although such fixed adjustments may improve accuracy, they also fail to account for changing detection probabilities over time.

We recognize that we will need to report uncorrected survey results until such time as sightability models are completed for OLYM summer surveys (see **2.A General Survey Strategy**). We will, however, collect covariate data during all surveys in such a manner that will allow retroactive correction for detection biases in the subsequent four-year reporting cycles.

The same concerns exist in using uncorrected index counts to infer trends in elk on spring ranges as on summer ranges. Based on our examination of the legacy data from OLYM spring surveys, however, we recognize the value to management of continuing to record uncorrected counts of elk on OLYM spring ranges until such time as funding is available to model, and correct for, detection bias in spring surveys.

Sightability Modeling

Sightability models have been used widely to estimate the probability that aerial survey crews detect groups of elk under variable sighting conditions, such as variations in group size, animal behavior, and amount of concealing vegetation (Samuel et al. 1987, Unsworth et al. 1994). Sightability models can be developed from data collected in survey areas containing radio-collared animals. Such models have been developed for elk winter range surveys just south of MORA (Gilbert and Moeller 2008) and for elk on eastern Cascade mountain winter range (McCorquodale 2001), but not for elk summer range in the Cascade or Olympic mountains, or spring range in the Olympics. The data include covariates for groups that are detected by the aerial survey crew during surveys, and for groups that were missed during surveys but found immediately afterward with the aid of radio telemetry. Logistic regression models can then estimate the probability of sighting elk groups as a function of measured covariates. These estimated probabilities can then be applied to raw survey data to adjust for detection bias. Based on the assumption that radio-collared animals are distributed at random through the population being sampled, sightability data reflect the unconditional, unbiased effect of covariates on detection probability (Steinhorst and Samuel 1989). A primary advantage of the method is that once a sightability model has been developed, it can be applied under similar conditions without the reliance on marked animals. A disadvantage of the method is that estimated sightability biases are insensitive to changes in survey staff, aircraft, or other unmeasured variables that may change over time and affect sightability. We chose the double-observer sightability model over the standard sightability model because the double-observer trials provide a means to examine evidence for whether or not sightability parameters are changing over time.

Simultaneous Double-observer Sampling

Over many years, simultaneous double-observer sampling (the 'double-observer' method) has been used as an alternate method to estimate visibility biases of aerial surveys in which there are no radio-marked animals (Caughley and Grice 1982, Graham and Bell 1989, Pollock et al. 2006, Schoenecker et al. 2006). Double-observer analysis is akin to mark-resighting studies, but independent observations recorded by two or more observers working in the same aircraft are treated as independent samples, as if from separate marking events and resighting surveys. Early double observer methods estimated abundance from the two observation sets using simple mark-resighting estimators (e.g., the Petersen-Lincoln index; Seber 1982) that tend to be biased by unmodeled sources of heterogeneity in sighting probabilities (Pollack and Kendall 1987). Huggins (1989) introduced the use of logistic regression methods as a means to reduce problematic sources of heterogeneity by modeling the influences of measurable covariates on detection probabilities, based on conditional likelihoods estimated from observed data. A primary advantage of using Huggins (1991) models to analyze double-observer data is that the effect of covariates on detection probabilities can be estimated even without radio-marked animals (Lubow and Ransom 2007, Griffin et al. 2009). However, those effects are estimated only based on groups that were seen by at least one of the observers; this results in *conditional* probabilities of detection that only apply to that segment of the population that was potentially visible to observers (Huggins 1991). As a result, one disadvantage of using double-observer analyses alone is that if detections are not fully independent among observers, particularly if there are animals that are completely or nearly invisible to both observers, then the estimated detection probabilities may be biased high, and the resulting correction factors are biased low (Barker 2008). For this protocol, we rejected the standard double-observer method because we concluded that, in the forested areas where these elk surveys take place, there are likely to be elk groups with very low detection probabilities. Estimating detection probabilities from double observer data alone for such groups would likely to lead to bias, as already noted.

Distance Sampling

We considered distance sampling as a potential approach to the estimation of detection probabilities (Buckland et al. 2001), but all project participants rejected the approach, based on operational concerns. Conducting randomly-placed straight line transects is problematic in the subalpine summer range because helicopter power is not sufficient to climb most slopes without orbiting. Randomly placed transects along contours in steep terrain significantly complicates survey design (Thomas et al. 2007) and may cause survey coverage to be uneven if the animals are not randomly distributed, relative to the transect (*sensu* Welsh 2002). It is most likely that elk are not uniformly or randomly distributed with respect to elevation within the subalpine survey units, which are often bounded by rock or snow at the upper margin, and forest of variable density at the lower margin. Another assumption in distance sampling is that animal movements are minimal or random, relative to the observer (Buckland et al. 2001), but elk may violate this assumption if their movements when exposed to the sound of approaching helicopters are non-random, i.e., if they head downhill toward trees. Lastly, the assumptions of perfect detection on the line transect and accurate measurement of distances in complex topography (Buckland et al. 2001) were likely unachievable or unrealistic.

Mark-recapture distance sampling (MRDS) incorporates double-observer estimators of variable detection probabilities on the line transect and distance methods to estimate detection probability away from the lines (Quang and Becker 1997, Buckland et al. 2004, Borchers et al. 2006). We rejected MRDS out of similar practical considerations of flying transects and estimating distances in mountainous terrain. MRDS has been conducted in mountainous topography (Becker 2001) but is most useful for estimating density over wide areas of unsampled land, whereas we will have complete survey coverage for the trend count areas identified.

Mark-Resighting Methods

If there is a known number of marked animals present in the survey area, then detection probability can be estimated based on the number of marked animals seen (Seber 1982). Maintaining a high fraction of the total population with marks decreases the uncertainty around estimates of detection probability, but having a high number of marked animals is not in keeping with safety and wilderness goals of these national parks. The WDFW temporarily marked elk on winter range with paint-balls in 1995 and 2000 to estimate abundance. Elk which were chased by helicopters and shot, however, may have changed their behavior near helicopters for some years afterward (D. Vales, Muckleshoot Indian Tribe, personal communication). In the interest of keeping elk behavior relatively constant, relative to helicopter presence, we do not advocate paint-ball based mark-resight methods. Moreover, knowing the exact number of marked animals in the trend count areas is difficult unless the animals are radio-collared, but maintaining a sample of radio-collared elk is not feasible with the current budget, nor desirable from a wilderness standpoint. Marking large numbers of elk with permanent methods (i.e., ear tags or collars) would require an extensive and ongoing Aerial Capture, Eradication and Tagging of Animals (ACETA) capture operation that would be beyond the budget of this monitoring program.

Pellet Counts

We considered monitoring trends in elk population abundance and distribution based on park-wide surveys of fecal pellet group counts. We have experience using these methods in OLYM (Jenkins and Manly 2008) and have developed pellet group surveys as one basis for monitoring trends in elk use and spatial distribution in the Fort Clatsop unit, in LEWI (Griffin et al. 2011). Pellets are not suitable for monitoring elk in MORA and OLYM, however, because counting pellets over the large park areas would be extremely labor-intensive, and because there is an unknown relationship between pellet density and elk density.

Recent studies have also demonstrated that DNA extracted from fecal samples of deer can be used successfully to identify individuals and estimate density of deer at the watershed scale in southeast Alaska (Brinkman et al. 2011). That technology has potential for estimation of elk populations at the scale of our trend count areas in the future, but costs and logistical constraints would likely be problematic for long-term monitoring under the fixed budgets available. Further, although DNA can theoretically be used to assess sex from fecal pellets, at this time we know of no way for pellets to provide data about age composition of a population.

C. Sampling Frame, Survey Locations, and Scope of Inference

Summer Surveys in MORA and OLYM

Two trend count areas established in MORA (Figure 3) and five in OLYM (Figure 4) comprise most of the subalpine summer ranges used by elk in each park. In MORA, trend count areas for the North Rainier and South Rainier herds correspond roughly to herd units first defined by Bradley (1982) and used historically as the framework for subsequent surveys. In OLYM, five trend count areas were required to encompass the majority of summer ranges used by elk. Inferences about trends in abundance will be limited to elk that use the selected trend count areas at the time of surveys.

We objectively refined trend count area boundaries in both parks, based on elevation and forest canopy cover, as elaborated in this section, to improve standardization of surveys. Of the five summer trend count units established in OLYM, the Core trend count area around Mount Olympus corresponds with the majority of the summer ranges used by elk that winter and are surveyed on primary elk spring ranges in the Hoh, South Fork Hoh, and Queets Valleys. The four peripheral trend count areas will inform park managers about the status of elk throughout the remaining primary summer ranges used by elk in OLYM.

Trend count areas are sampled in their entirety, with no subsampling. Within each of the trend count areas, we identified several smaller survey units, all of which are surveyed. The finer scale of the survey units streamlines data recording and analysis, and safety (helicopter flight following) during the surveys.

To counteract the considerable variation in subalpine elk habitats and corresponding variation in survey coverage in years past, we developed explicit definitions of areas included and excluded from trend count areas. We defined trend count areas on the basis of elevation and forest canopy cover, as determined by remote sensing for 25 x 25-m pixels of park lands (Pacific Meridian Resources 1996). The spatial scale, methods of estimation, and categories for the remotely sensed forest canopy cover classes are not the same as for the percent concealing vegetation that observers record as a covariate for each elk group seen in surveys (defined in **SOP 7: Conducting Helicopter Surveys, *Defining Elk Group Covariate Categories***). In the MORA North Rainier trend count area, subalpine vegetation generally doesn't extend below 1500 m, while in the South Rainier trend count area, there are areas of large, open habitat that extend to approximately 1350 m, and two open areas extending down to 1200 m, on the SW facing slopes of Stevens Ridge and Shriner Peak. In MORA, elevations above ~2100 m are alpine (Franklin et al. 1988). Accordingly, 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 survey down to 1200 m. Subalpine habitats are found down to lower elevations in OLYM, so we defined summer trend count areas in OLYM as ranging between 1200 m and 1650 m. This choice of elevations and forest canopy cover for survey was informed by data from elk that carried GPS radio collars in the park (OLYM and USGS, unpublished data).

Within the elevation boundaries of trend count areas, we used each park's vegetation cover map (Pacific Meridian Resources 1996) to identify areas of continuous dense forest canopy cover or rock and snow. We excluded the following:

- Dense forest patches, defined as areas in which >70% of the pixels in a 175 m x 175 m moving window were classified as 71-100% canopy cover.
- 25 m x 25 m pixels of forest that are 71-100% or greater canopy cover, if that forest pixel is adjacent to a patch of dense forest excluded from the moving window analysis.

- Small meadow openings less than ~50 m x 50 m in area only if they are surrounded by dense forest.
- Forest patches that are 10-70% canopy cover if the patches are less than 200 m x 200 m *and* surrounded by 'dense' forest.
- Talus, boulder field, ice or snow larger than 200 m x 200 m.
- At OLYM, we excluded portions of the park for logistical reasons dictated by helicopter fuel limitations, including subalpine areas near the park boundary in the South and East; and we excluded subalpine areas in the park's northeast corner, which is outside of the known elk distribution.
- At MORA, we excluded the scattered open subalpine areas in the park's northwest, west, and southwest regions; these are areas where very few elk have been reported historically.

Spring Surveys in OLYM

Three spring trend count areas in OLYM correspond to key low-elevation spring ranges in the Hoh, South Fork Hoh, and Queets watersheds (Figure 6). Trend count areas and flight guidelines for OLYM spring surveys were developed by Houston et al. (1987), updated with the integration of GIS and GPS technology (Jenkins et al. 1999), and later repeated from 2004 -2007. These areas encompass both a segment of the migratory elk that are counted in the Core summer trend count area, and the resident, non-migratory elk in the lower valleys.

Spring trend count areas include spring range below 500 m, where the valley is broad enough for safe helicopter flights at low altitudes above treetops. Experience has shown that these trend count areas along the major river floodplains are open enough to see elk with reasonable detection probability and are large enough to minimize boundary effects (i.e., effects on confidence intervals coming from one group being inside or outside the trend count area), but small enough to be sampled during early morning when elk are reliably present on the floodplain (Jenkins 1980).

D. Survey Timing and Frequency

Summer Surveys in MORA and OLYM

NCCN I&M funding for summer surveys is available only every other year. These surveys may be flown more frequently, however, if MORA or OLYM secure additional funding or commit base funding. In years when surveys occur, we will conduct summer surveys of elk within four hours of dawn or dusk between August 15^{th} and September 15^{th}. We determined these optimum windows based on lengthy field experiences of survey crews as well as examination of seasonal movements of 18 GPS-collared cow elk in MORA (D. Vales, Muckleshoot Indian Tribe, unpublished data) and 7 GPS-collared elk in OLYM (USGS and NPS, unpublished data). It may, occasionally, be necessary to survey outside this time frame, due to logistical and weather difficulties, but under no circumstances should summer surveys be scheduled after September 25th, because elk have typically begun moving out of the subalpine zone by that date (MIT, USGS, and NPS, unpublished data).

We will survey according to different revisit designs (McDonald 2003) in each park, reflecting differences in the extent of summer ranges used by elk in each park, funding limitations, and funding contributed by partner Tribes and WDFW in MORA. Completing a survey of the entire North or South herd trend count area on a single sampling day requires two helicopters surveying simultaneously. Current funding from NCCN, MIT, PTOI, and WDFW is sufficient to fund three such complete, paired helicopter surveys of either the North or South herds. As a result, we will complete two replicate surveys of one trend count area and one replicate of the other in alternating years of survey. For example, in a given year two replicated surveys will be completed in the North Rainier herd trend count area, whereas only one survey will be completed in the South Rainier herd. In the next year that surveys are conducted (either two-years later or the next year if ancillary funding permits), the pattern will be reversed with South Rainier herd trend count area being surveyed twice (Table 1).

Because summer ranges of elk in OLYM cover more than twice the area as in MORA, and there are no contributing partners participating in the surveys, it was necessary to devise a different sampling schedule in OLYM to ensure complete coverage of important summer ranges. To provide greater geographic extent of survey coverage, we will survey the core area once each year that surveys are conducted and will survey four peripheral trend count areas in a repeating pattern once per every four years of survey (Table 1). Each summer OLYM trend count area requires one helicopter during a 4-hour morning or evening survey window. This revisit design differs somewhat from the "augmented serially alternating" design of Urquhart et al. (1998), because our goal is to estimate trend separately for each trend count area, not to estimate a single value for trend across the park. If additional funding is available, more than one peripheral trend count area may be surveyed (as in 2011), or the Core trend count area may be surveyed in years when NCCN funding is not available, or both. The sampling design at OLYM summer trend count areas accomplishes widespread sampling over the OLYM summer range, but also documents changes in abundance in the Core trend count area in each year of survey.

Table 1. Sampling schedule for MORA and OLYM summer trend count areas. At MORA, each trend count area is alternatingly surveyed either once (shown in the table as X) or twice (shown in the table as XX) per year of survey. At OLYM, the core trend count area is surveyed biennially, while the four peripheral trend count areas (High Divide, Quinault, Elwha, and Southeast) are each surveyed once per four years of survey.

Trend Count Area	Sample Occasion							
	2011	2013	2015	2017	2019	2021	2023	2025
MORA North	XX	X	XX	X	XX	X	XX	X
MORA South	X	XX	X	XX	X	XX	X	XX
OLYM Core	X	X	X	X	X	X	X	X
OLYM Northwest	X				X			
OLYM Quinault		X				X		
OLYM Elwha			X				X	
OLYM Southeast				X				X

Spring Surveys in OLYM

As mentioned, spring surveys in OLYM are not regularly scheduled, due to funding limitations. When funding is available, however, elk will be surveyed on the spring trend count areas within four hours of sunrise between March 1–30, typically after March 15. Timing of the spring surveys corresponds with time of year and time of day when elk are most visible, feeding on early green-up in deciduous forest communities, but before deciduous trees leaf out (Jenkins and Starkey 1984, Houston et al. 1987). In protocols established by Houston et al. (1987), each of the three valleys was surveyed three times per year, and surveys took place as late as mid-April. We will aim to survey each trend count area once per year of survey, requiring one helicopter for three mornings of flight. Low-level flights over potential nesting habitat of the federally threatened Marbled Murrelet (*Brachyramphus marmorata*) are restricted after March 31.

E. Statistical Power to Detect Change

Power to detect a trend increases as a function of sampling replication, frequency and precision (Gerrodette 1987). We used simulations to model prospective estimates of the power (i.e., one minus the type II error rate, 1-β) of our sampling design to detect a halving or doubling of abundance for a single trend count area over eight years. Over seven intervening time steps, this translates to a rate of population decline or increase of about 10.5% per year. For those trend count areas that are scheduled for biennial surveys, we strove for a power of 0.8 – that is, an 80% probability of detecting a declining or increasing trend with a 2-tailed test, and a 10% probability of falsely concluding that a decline has occurred (i.e., the type I error rate, α). The sampling design was not intended to provide high power to detect these levels of decline for the OLYM peripheral summer trend count areas that are sampled less frequently, or for OLYM spring trend count areas that are surveyed opportunistically.

Trend estimates based on survey data are a reflection of the underlying rate of change, and two sources of variation: process variance, and estimation error (Thompson et al. 1998). Although there may be an average annual rate of change for abundance, that rate can fluctuate due to process variance, such as might be explained by variation in annual mortality rates from year to year or changes in elk distribution. Estimation error, in the context of this protocol, is imprecision in the estimates of any single value for abundance due to uncertainty about the number of elk that were present in the sample frame, but not seen – this imprecision is estimated using the double-observer sightability model (**Appendix C: Analyses of Detection Bias**).

We conducted Monte Carlo simulations (Crowley 1992) to estimate the statistical power of this protocol to detect changes in abundance, using values for estimation error and process variance from preliminary analyses of 11 complete surveys in MORA trend count areas. In 2008-2011, there were five complete surveys of the North Rainier herd trend count area and six of the South Rainier herd trend count area, to which we applied the double-observer sightability model. For each of 1000 iterations of simulated abundance change over time, we determined whether a trend was detected from the estimates of abundance. We interpreted the proportion of iterations in which a statistically significant trend was detected as the power to detect the simulated trend.

We found separate values of process variance for the North and South Rainier herds, and then used the average as the CV for process variance in simulations. For the six point estimates of South Rainier herd abundance, we calculated the mean value and the variance for those six points around the mean; the CV of process variance for the mean abundance in the South Rainer herd was 13.6%, where CV is defined as the standard error divided by the mean. For the five point estimates of North Rainier herd abundance, the CV for process variance, similarly calculated, was 9.5%. In simulations we used the average of these two CVs for process variance, which was 11.6%. This is a reasonable value to use for a long-lived ungulate (Gaillard et al 1998). For each survey, we found the CV of estimation error as the standard error of the estimate of abundance, divided by the estimate of abundance. We used the average of those 11 values, 12%, as the CV of estimation error for simulations.

Each iteration of simulated population trend started with a common abundance value that was normally distributed around 400, with a CV of 11.6%. We simulated abundance trajectories to change as a function of the annual rate of change, while also incorporating process variance in each simulated time step. For a simulated population decline, the simulated population abundance was decreased by the fixed 10.5% annual rate, and then we added or subtracted a simulated process variance term. This process variance term was the abundance times a randomly drawn value from a normal distribution with mean of zero and standard deviation equal to 11.5% (the CV of process variance). Simulations with increasing population were structured identically, but with 10.5% per year increases.

We simulated estimates of abundance according to schedules that match the survey frequency for MORA trend count areas, or the OLYM Core summer trend count area. In the eight years of simulated time, four of the years included survey. For MORA trend count areas, two of those four years of survey included two replicate surveys. We modeled imprecision in each estimate of abundance by adding an estimation error term to the true abundance for the year surveyed. The estimation error term was the product of the true abundance in the year of survey, times a randomly drawn value taken from a normal distribution with mean of zero and standard deviation equal to 12%, the CV of estimation error.

For each iteration, we fit a linear regression through all available log-transformed estimates of abundance, with time on the x-axis. A given iteration was considered to have a statistically significant slope if the ratio of the estimated slope divided by the estimated standard error of the slope was greater than the critical value from a t-distribution, with d.f = n-2 (Gerrodette 1991).

The power to detect 10.5% per year changes in abundance after eight years was adequate for trend count areas at MORA ($1-\beta=0.896$), and for the OLYM summer core trend count area ($1-\beta=0.822$). The actual power to detect a trend should be slightly higher than simulated values, because the start of the monitoring period had more frequent sampling. Multiple surveys at MORA were conducted, for example, in 2008, 2009, 2010, and 2011.

3.0 Field Methods

A. Permitting and Compliance

Park management staff members have reviewed this protocol to ensure that resource protections are adequate. There are no further permitting or compliance requirements with the National Environmental Policy Act, according to the categorical exclusion concerning resource management actions that are "…nondestructive data collection, inventory (including field, aerial, and satellite surveying and mapping), study, research, and monitoring activities."

In both parks, this monitoring protocol is a continuation of pre-existing programs, with minor modifications. Several permitting and compliance measures must be taken periodically to ensure that the protocol is in keeping with park regulation. Each park's project manager should keep up-to-date copies of compliance documents in the project workspace, in the Documents/Compliance folder (**SOP 1: Project Workspace and Records Management**); these documents are not necessarily the same format for both parks. The documents must be revisited every year, to ensure that the required processes are approved for compliance. The existing Programmatic Biological Assessment / Biological Opinion for the OLYM spring surveys may need to be assessed and re-approved every five years, and updated in the future if there are any changes to the protocol. OLYM spring survey flights take place over Marbled Murrelet and Northern Spotted Owl nesting habitat, so the mitigation measure to minimize take of those species is to cease all survey activities by April 1. Because flight elevations are above the range of any threatened or endangered species, there are no concerns at present that would necessitate a BA/BO for MORA or OLYM summer surveys.

Despite the use of a helicopter over parts of MORA and OLYM that are designated wilderness, these elk surveys represent the minimum required tool for accomplishing elk monitoring; minimum requirements worksheets should be saved for each park. Helicopter flight over the wilderness has only localized short-term impacts to the wilderness character, and is the only practical method to survey elk over large areas (**2.0 Sampling Design**).

B. Safety

The project manager for each park must ensure that the Aviation Safety Plan is updated and approved. Development of Aviation Safety Plans is a component of each park's aviation program, and is beyond the scope of this protocol. Aviation safety planning requires the project manager, helicopter manager, and park aviation manager to explicitly consider and document aerial hazards, risk, risk mitigation, flight following procedures, protective equipment, emergency search and rescue measures, flight dates, locations, participants, aircraft, pilots, and costs. Guidelines for planning are available in the Interagency Helicopter Operations Guide ("IHOG;" NIAC 2009) and the Department of Interior Aviation Management Directorate (AMD). Further, past aviation safety plans will be saved in the project workspace to help guide the task of annual preparation (under MAa12_Elk_Aerial\Documents\Compliance\Aviation Safety).

All flights with federal personnel on board must adhere to guidelines from IHOG (NIAC 2009) and AMD. Flights conducted by MIT, PTOI, and WDFW do not need federal aviation safety plans, but the timing of all MORA survey flights must be coordinated with the MORA project manager and other project participants (see **3.0 C. Field Season Preparation and Equipment**

Setup). **SOP 3: Training Observers** includes guidelines on safety training requirements for personnel that involved with survey flights, which include pilots, helicopter managers, observers and their supervisors. Additional safety guidelines for observers are listed in a Job Hazard Analysis (**Appendix G: Supplementary Documents**).

Before surveys begin, the MORA project manager is responsible for coordinating the exact flight path of helicopters that participate in joint elk surveys in MORA (**SOP 7: Conducting Helicopter Surveys**). On any evening in MORA when two helicopters are scheduled to conduct surveys, for safety reasons no two helicopters will survey unless both helicopters are in communication with each other and with park dispatch.

C. Field Season Preparation and Equipment Setup

For the complete pre-season checklist of actions, see **SOP 2: Survey Preparation** and **Appendix A: Yearly Project Task List**. For each year when surveys are scheduled, the OLYM project manager makes sure that summer flights (and spring flights, if funding is available for them) are on the OLYM flight list, and the MORA project manager does the same for summer flights in MORA. At OLYM, this process must be completed in November, in response to an annual query from the OLYM aviation manager about any updates to the expected 5-year aviation plan. At MORA, requests for flights must be submitted (on an internal A-70 form) at least two weeks prior to requested dates. The Project Manager at each park must ensure that a Project Aviation Safety plan is completed and submitted by the Helicopter Manager to the respective park Aviation Manager for approval prior to initiating federally funded flights.

Four to six months before surveys, the MORA project manager must schedule an in-person meeting or teleconference call for all project participants. Because coordination and shared financial support between tribes and state and federal agencies is a linchpin of this elk monitoring program, meeting in person is preferable. This meeting should take place at least two to three months before surveys. The purpose of this meeting is for participants to review the previous year's successes and failures, to address, as a group, any questions about past analyses, and to collectively plan the logistics and scheduling for upcoming surveys. The MORA project manager should solicit input for meeting agenda items and should share the agenda ahead of time with all participants, including the OLYM project manager. Meeting minutes and resolutions should be shared among participants promptly afterward.

At least one month before surveys are to begin, the project manager at each park should schedule the survey crew members, and an aviation manager, for NPS flights. Wildlife biologists from MIT, PTOI, and WDFW should, similarly, arrange for crew members. Crew members should receive training in survey methods ahead of time, and there should be two experienced observers on any survey flight with a new observer (**SOP 3: Training Observers**). All survey crew members should clear their schedules for time windows around upcoming flights. Each park's project manager arranges for backup personnel to be available in case of crew member illness, or in case bad weather necessitates scheduling changes. Project managers at MORA and OLYM should coordinate, to minimize the risk of scheduling conflict if there are a limited number of helicopters or pilots, or both, available for flights. The project manager in MORA must coordinate flight information between all the other participants (MIT, PTOI, and WDFW), also informing dispatch and the MORA aviation manager. For federally funded flights, the helicopter manager reviews and updates the flight request form and aviation safety plan, if necessary, and submits them to the park aviation manager. All crew members should review notes and recommendations from the prior year of survey, and check out necessary personal protection equipment (PPE) for flights.

In the week prior to any flight, the project manager sends an update to the park management team to remind them of the upcoming flights. At that time, for federally funded flights, the helicopter manager also sends the updated aviation safety plan out to the survey crew, park dispatch, and pilot. The helicopter manager coordinates with park dispatch, and arranges for dispatch personnel to come in early or stay late, if needed, for flight following. For flights that are funded by MIT, PTOI, or WDFW, the wildlife biologists from those tribes or agency communicate with the MORA project manager about flight planning. The GIS Specialist prepares maps, GIS files, field forms, GPS units, a GPS-enabled laptop, and the audio recorder. Survey crew members should review instructions for survey (**SOP 7: Conducting Helicopter Surveys**).

D. Sequence of Events for Surveys

The decision to call up, or retain, a helicopter for any survey will depend on weather conditions. The project manager and helicopter manager at each park should assess weather patterns and long term forecast before making the decision to order the helicopter. Coordinating with the pilot and helicopter company is critical to the success of the mission, and to staying within the budget. Because ambient temperatures, rain, fog, and wind are weather conditions that could influence flight safety and elk visibility, these contribute to the go / no-go decision (**SOP 5: Summer Survey Weather** and **SOP 6: Spring Survey Weather**). All federally funded flights must adhere to guidelines presented in IHOG (NIAC 2009).

The helicopter and crew should arrive at the airport or helispot at least one hour before takeoff to allow for inspection by the helicopter manager, preparation of the flight manifest and load calculations, refueling, mission and safety briefings, and equipment installation. The GIS Specialist should install and prepare GPS antennas and laptop (**SOP 4: GPS Use**), and the audio recorder (**SOP 8: Digital Audio Recorder Use**). The GIS Specialist or another crew member may need to upload outlines of the survey units onto the pilot's GPS unit (**SOP 4: GPS Use**). In-flight GPS flight path should be recorded with at least two devices.

The pilot will radio to inform park dispatch at take-off and landing, and whenever the helicopter enters a new survey unit. Park dispatch will monitor flights with the Automated Flight Following (AFF) system. If AFF fails during flight, then flight following via radio call-in will be on 15 minute intervals, unless other arrangements are made ahead of time with dispatch and the helicopter manager.

After each survey flight is over, the helicopter should be released from service, or retained if there is another survey flight scheduled for the next day, and weather conditions are favorable. When the helicopter is released, the helicopter manager completes and signs the Aircraft Use Report form, AMD-23, which includes an itemized list of costs that the aircraft company will bill to the agency. The helicopter manager and project manager review the aircraft costs and total costs (including any park service staff overtime salary and travel), and adjust plans for subsequent survey flights, if needed.

Park-specific Considerations

There are minor differences in frequency and timing of aerial surveys between MORA and OLYM that relate to differences in logistical considerations as well as funding. The extra replication of surveys in MORA is possible because of the smaller survey areas than in OLYM and funding contributed by all project participants. All surveys will be conducted within four hours of dawn or dusk. Surveys traditionally have been conducted in MORA during the evening sessions to facilitate coordination among project partners, and during the mornings in OLYM to accommodate the larger areas and commuting times required of surveys. Such minor differences in protocols will not influence development or application of sightability correction models between the two parks or comparison of trends over time.

MORA surveys entail at least six survey flights between August 15 and September 15, two or more of which are funded by NCCN (see **Chapter 7: Operational Requirements**); the other four are supported by MIT, PTOI, and WDFW. Survey flights at MORA begin at one of several places, including the Olympia, Puyallup, Packwood, or Ranger Creek airports, or Kautz helibase. Surveys should not begin more than four hours before sunset, and may not occur on weekends to avoid visitor conflicts. 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. A stated goal of project participants is to use two helicopters to survey all North Rainier trend count area survey units on a single evening and, similarly, to use two helicopters to survey all South Rainier herd survey units on a single evening. Which survey units will be surveyed by which helicopter, and the order of survey for those units, must be clearly identified to all participants before takeoff. No two helicopters will ever plan on surveying the same survey unit, and each helicopter's order of survey units must be chosen so that the helicopters remain far from each other at all times. Clear communication between helicopter crews is needed to completely avoid any risk of two helicopters being in the same airspace. The survey flight path within survey units is at the discretion of the pilot and crew, but should cover all of the survey units. For example, survey units that extend along ridges may be flown as single elevation contours, or a pair of contours, while broader parklands and plateaus may require a series of non-overlapping passes. Flight groundspeed should average ~45 knots (83 km/hr).

Summer OLYM elk surveys entail two to three mornings or evenings of survey between August 15 and September 15. Summer OLYM flights will typically begin at the Port Angeles airport, Sweet's Field, or Obstruction Point helispots. OLYM summer surveys are the same as MORA summer surveys, except that surveys at OLYM may begin at dawn (ending no later than four hours after sunrise) or end at sunset (beginning no earlier than four hours before sunset) OLYM survey flights may not take place on weekends without prior approval from the superintendent. Because the topography in OLYM includes more ridgelines and less subalpine parklands than in MORA, summer survey units can typically be searched by flying along one or two elevation contours [i.e., at ~1360 m (4500 ft) and ~1575 m (5200 ft)]. Flight groundspeed may vary, but should average ~45 knots (83 km/hr).

Spring surveys in OLYM entail three mornings of survey, funding permitting, typically in the last two weeks of March. **SOP 6: Spring Survey Weather** includes guidelines for making the decision about when to order the helicopter. Survey flights begin at the Forks airport. Parallel flight lines of the survey are perpendicular to the axis of the river valley and spaced ~150-300 m (0.08 – 0.16 nautical miles) apart (Figure 7). Crews search for elk throughout the floodplain vegetation mosaic, which includes river channels, gravel bars, and alluvial terraces that are variously unvegetated, sparsely vegetated, or forested with deciduous trees, coniferous trees, or both, and with a range of canopy closure. The helicopter flies at an altitude above the highest trees (i.e., ~ 100 m). Flight groundspeed should be ~55 km/hr (30 knots) but may increase over open gravel bars, where elk group visibility is high.

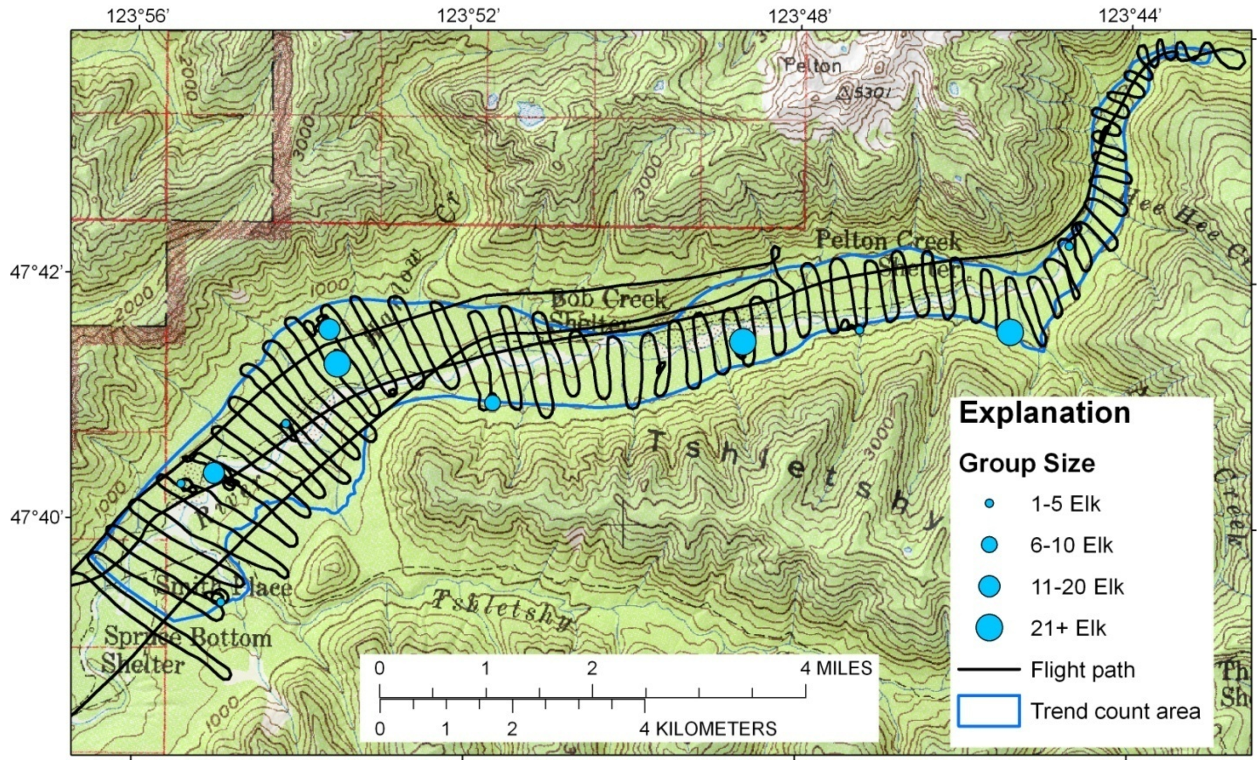

Figure 7. Flight path (black line) of 2008 spring survey flight in the Queets trend count area, outlined in blue. Blue circles indicate the locations of elk groups detected during the survey.

E. Details of Taking Measurements

Flight Crew

This section describes roles and responsibilities of flight crew members on flights conducted by National Park Service crews. There may be minor differences in how the MIT, PTOI, and WDFW partition survey crew responsibilities, seating arrangements, and electronics, but the essential methods (**SOP 7: Conducting Helicopter Surveys**) are the same as on NPS flights, which are standardized in both MORA and OLYM.

The crew of all survey flights includes a pilot and three other observers. The pilot's responsibility is to fly the aircraft safely and to communicate with dispatch, and with any other aircraft flying in the park, about the status of flight operations. So long as it does not interfere with safely flying the helicopter, the pilot may also contribute observations of elk.

The front seat observer sits next to the pilot (and may be left or right depending on the helicopter configuration). Typically this observer sees the most elk because the seat affords the best field of view, through the large front window, the side window, and the window at the observer's feet.

The front seat observer's duties are to look for elk with minimal distractions. Additional duties of the front seat observer, if needed, are helping to guide the pilot, navigation, photography, telemetry, and make decisions about continuing or ending a survey.

There are two back seat observers. Of these, the data recorder sits behind the front seat observer. The data recorder's duties are to observe elk and to write data on paper field forms. There are two field forms that the data recorder completes for every elk survey flight: the Flight Information Form and the Census Data Form (**SOP 7: Conducting Helicopter Surveys**). The Flight Information Form contains background information for each day's flights, including date, survey times, observers, and weather conditions. Written records on the Census Data Form include all information related to elk observations and specific survey units. Because the data recorder is typically the person most cognizant of the time, the data recorder also prompts the pilot so that flight following with park dispatch takes place at the required 15-minute time intervals, if the automated flight following system (AFF) is not functional. On NPS flights, the data recorder will also start and stop a digital audio recorder that NPS survey teams use to record the cockpit conversation and observations of other species (**SOP 8: Digital Audio Recorder Use**). NPS crews record the cockpit conversations because, in addition to recording observations of elk, the NPS is also interested in recording other species of wildlife observed. The digital audio recorder allows NPS crew members to record their observations of other wildlife species without distracting from the main purpose – observing elk. It is the data recorder's responsibility to repeat out loud the observations of other species made by other observers to improve clarity of the recording. From the audio recording, any spoken observations of other species seen on the flight can be transcribed onto an "Other Species Data Form" after the flight (**SOP 8: Digital Audio Recorder Use**).

The pilot should generally be able to navigate to the desired survey unit with reference to the survey unit boundaries loaded onto the helicopter's GPS unit. However, one crew member should be prepared to assist with navigation. The navigator's in-flight duties are to observe elk, to help guide the pilot to survey units, and to ensure the survey unit is covered adequately. On NPS flights in both parks, the back-seat observer on the pilot's side generally serves as navigator, but for flights conducted by cooperators, the navigator may sit elsewhere. Some flexibility in seating is required to accommodate differences in experience and GIS capabilities of individual crew members serving on the different crews. The choice of who will be the navigator must be made clear before take-off. In the event of total GPS failure, the front-seat observer must be prepared to guide the pilot with paper maps.

Double-observer Data Collection and Covariate Recording

The helicopter is a single platform carrying four independent observers that each search for elk groups (an elk group is defined here as any group of one or more elk that move together as part of the same social unit). In-flight procedures are identical for all survey crews working in both MORA and OLYM. These procedures allow each observer to act independently in searching for and initially detecting elk groups, but to collaborate in determining group size, composition, and covariates of detected groups. A complete set of guidelines, including detailed instructions for completing data forms, is in **SOP 7: Conducting Helicopter Surveys**.

When the pilot or any observer sees an elk group, she or he should mentally note the location and attributes of that group and should continue to monitor its location. That observer should not alert any others about the elk group until the elk group is slightly past perpendicular to the helicopter's flight path (i.e., slightly past the observer's left or right shoulder). At that time, any observer who has seen the elk group alerts the entire crew. The pattern of who independently detected each elk group forms an important part of the monitoring program data set.

After any observer has alerted the rest of the crew to the presence of an elk group, the pilot takes the helicopter closer to the elk group. The data recorder tells everyone the observation number, writes the time when the helicopter is closest to that elk group, and asks who independently saw the group. By writing down the time, the location of the elk group is effectively recorded (**SOP 4: GPS Use**). The recorder notes the side or sides of the helicopter from which the group was visible – left, right or both; if the elk group was only visible directly under the helicopter's narrow flight path, it is recorded as having been at the center.

The crew collectively determines total group size and its composition, recorded as the number of cows, calves, yearling bulls, subadult bulls, and mature bulls. Any large group is photographed with a high resolution digital camera (Schoenecker et al. 2006); later, the group size or composition data, or both, can be updated if the photo yields a more complete count (**SOP 10: Processing Digital Photographs**). The crew also works together to determine values for other covariates that may influence detection probabilities, including the lighting condition, the animal activity, the level of concealing vegetation, and the cover type.

Special Circumstances

If the first observer to see an elk group alerts other crew members (e.g., by speaking or pointing) before they have had an independent chance to detect or miss that group, the observation is recorded as not independent. Such observations are not used in double-observer analyses (**SOP 13: Data Summary, Analysis, and Reporting**).

Elk groups with a radio collared animal may serve as 'double-observer sightability trials' that are useful for developing the double-observer sightability model in OLYM, or for continuing to refine the double observer sightability model in MORA. Such trials will be an important component of summer elk surveys in OLYM, to continue building data for testing and evaluating the generality of the MORA model in OLYM (see **Appendix C, *Example 1: OLYM Summer Survey Data Compared to MORA Double-observer Sightability Model***). Furthermore, if MORA project cooperators maintain a sample of radio-collared elk that use the survey areas during summer, then the continued recording of double-observer sightability trial data is encouraged as opportunity allows, because it would provide the most rigorous test of whether detection probabilities change over time. After visually detecting each elk group, the crew uses radio telemetry to determine whether the group includes any radio collared elk known to be in or near the survey unit. If the group contains a collared elk, then the group with the collar is recorded as having been 'seen' during the survey. After completing each survey unit, or any designated area within a unit (often a large topographic feature such as a valley or ridge), the crew uses radio telemetry to locate any radio collared elk that were in the survey unit, but were not detected during survey. An elk group that was not seen during surveys, but which includes a collared elk, is recorded as having been 'missed.' The crew records the full set of observation data for any missed group. Radio-collared elk that are outside of any survey unit are not considered to have been missed, because those areas are outside of the survey area searched.

Sometimes, elk groups are detected close to, but outside of, any survey unit. The survey crew should record as much data about such groups as time permits, without taking away from the survey of the designated survey units. Groups that are 300 m or closer to a survey unit will be included in composition measures, but not in abundance measures for trend count areas. The determination of how far a group was from a survey unit boundary is made after the flight, with reference to a geographic information system (GIS) and the GPS-based record of the flight path (**SOP 11: Geospatial Data Management**).

F. Post Flight Processing of Data

Upon landing, the observers review the data forms to note and correct any discrepancies. Data files from the GPS units, audio recorder, and camera should be downloaded immediately after the flight. The project manager ensures that helicopter flight lines from the laptop or GPS unit, or both, are downloaded to the NCCN computer server as soon as possible. Tribal and WDFW biologists send copies of their completed data forms, the associated GPS files for the helicopter flight path or other spatial information, and any photographs of large elk groups to the MORA project manager. The project manager transfers spatial files to the Network GIS Specialist, who saves them in the project geodatabase. The GIS Specialist prepares flight maps portraying the flight paths and the locations where elk groups were seen (**SOP 11: Geospatial Data Management**).

The project manager ensures that audio recordings from the audio recorder are downloaded (**SOP 8: Digital Audio Recorder Use**). The project manager delegates the task of transcribing any audio recording from NPS flights, for the purposes of recording observations of other species seen during survey flights.

The project manager or technician processes photos; if inspection of photos leads to a revision for group size or composition, then the pertinent photos are annotated and saved, and changes are made to the data forms (**SOP 9: Data Entry and Verification** and **SOP 10: Processing Digital Photographs**). The project manager for each park oversees elk group observation data entry in the NCCN elk monitoring database, and ensures that the data entered are accurate (**SOP 9: Data Entry and Verification**). The MORA project manager is responsible for entering survey data recorded on MIT, PTOI, and WDFW flights.

After each flight or set of flights, the project manager in each park writes a summary Flight Report, which describes the flight conditions and raw data, and includes notes and reminders that may improve subsequent flights (**SOP 13: Data Summary, Analysis, and Reporting**).

The data manager oversees data quality review and certification and submits the certification report (**SOP 12: Data Quality Review and Certification**). After data have been certified, the MORA and OLYM project manager send hard copies of data forms to NCCN curatorial staff at each park for long-term storage (**SOP 14: Product Delivery, Posting, and Distribution**). Also after certification, a read-only copy of the database is sent to participating wildlife biologists from MIT, PTOI, and WDFW.

G. End-of-season Procedures

Following each set of flights, the helicopter manager closes out the AMD-23 form with the pilot, prepares the aviation bill for the project manager's approval, and forwards the bill to the park's aviation manager. The project manager keeps a copy of the bill for budget reconciliation and flight planning for subsequent years.

Following the completion of the survey, the crew does a final debrief and makes any recommendations to the project manager for changes next year. Using notes from the flight reports, the project manager records any changes made during the flight, and records any new guidance that should be incorporated into subsequent years' flights (**SOP 15: Revising the Protocol)**.

4.0 Information Management

This chapter describes the procedures for data handling, analysis, and report development. Additional details and context for this chapter are provided in the NCCN Data Management Plan (Boetsch et al. 2009), which describes the overall information management strategy for the network. The NCCN website (http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm) also contains guidance documents on various information management topics (e.g., report development, GIS development, GPS use).

A. Project Information Management Overview

Project information management may be best understood as an ongoing or cyclic process, as shown in Figure 8. Specific yearly information management tasks for this project and their timing are described in **Appendix A: Yearly Project Task List**. Readers may also refer to each respective chapter section for additional guidance and instructions.

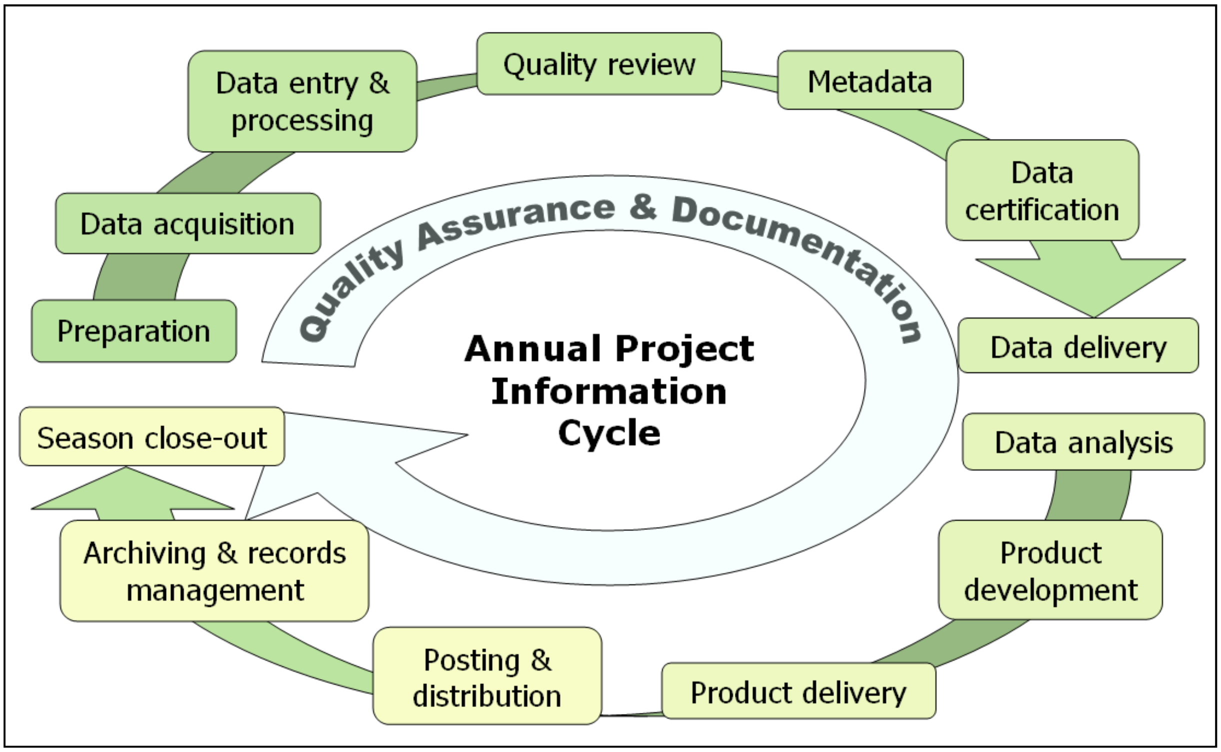

Figure 8. Idealized flow diagram of the cyclical stages of project information management, from pre-season preparation to season close-out. Note that quality assurance and documentation are thematic and not limited to any particular stage.

The stages of this cycle are described in greater depth in later sections of this chapter, but can be briefly summarized as follows:

- *Preparation* – Training, logistics planning, print forms and maps, review any problems with past data collection
- *Data acquisition* – Flight surveys to acquire data
- *Data entry & processing* – Data entry and database uploads, GPS data processing, etc.

- *Quality review* – Data are reviewed for structural integrity, completeness and logical consistency
- *Metadata* – Documentation of the year's data collection and results of the quality review
- *Data certification* – Data are certified as complete for the period of record
- *Data delivery* – Certified data and metadata are delivered for archiving
- *Data analysis* – Data are summarized and analyzed
- *Product development* – Reports, maps, and other products are developed
- *Product delivery* – Deliver reports and other products for posting and archiving
- *Posting & distribution* – Distribute products as planned and/or post to NPS clearinghouses
- *Archiving & records management* – Review analog and digital files for retention (or destruction) according to NPS Director's Order 19. Retained files are renamed and stored as needed.
- *Season close-out* – Review and document needed improvements to project procedures or infrastructure, complete administrative reports, and develop work plans for the coming season

B. Pre-season Preparations for Information Management

Project Workspace Setup

A section of the networked file server at each host park is reserved for this project, and access privileges are established so that project staff members have access to needed files within this workspace. Prior to each season, the Project Lead should make sure that network accounts are established for each new staff member, and that the Data Manager is notified to ensure access to the project workspace and databases. Workspace structure, naming conventions, and additional details are provided in **SOP 1: Project Workspace and Records Management**.

GPS Loading and Preparation

The GIS Specialist and Project Lead should work together to ensure that target coordinates, background data, and data dictionaries are loaded into the GPS units prior to the onset of field work, and that the software for downloading GPS data is available and ready for use. Additional details on GPS use and GPS data handling are provided in **SOP 4: GPS Use** and in NCCN GPS Guidelines (NCCN 2009).

Project Database Application

Prior to the field season, the Data Manager will update the project database application as needed to ensure proper access on the part of the project staff. Refer to **Section 4C, Overview of Database Design** for additional information about the database design and implementation strategy.

C. Overview of Database Design

We maintain a customized relational database application to store and manipulate the data associated with this project. The design of this database is consistent with NPS I&M and NCCN standards. The Data Manager is responsible for development and maintenance of the database, including customization of data summarization and export routines.

The database is divided into two components – one for storing data in a series of related tables composed of fields and records (i.e., the "back-end database"), and another that acts as a portal or user interface through which data may be entered, viewed, edited, error-checked, summarized and exported (i.e., the "front-end application"). By splitting the database into front-and back-end components, multiple users may interact with the data simultaneously, and user interface updates can be implemented without service disruptions.

The back-end database schema (tables, fields and relationships) is documented in **Appendix B: Elk Aerial Survey Database Documentation**. The back-end database is implemented in Microsoft SQL Server to take advantage of the automated backup and transaction logging capabilities of this enterprise database software.

The front-end is implemented in Microsoft Access. It contains the forms, queries, and formatted report objects for interacting with the data in the back-end. Its features and functionality are customized using Visual Basic for Applications (VBA) programming code. The application has separate forms for data entry that mirror the layout of hard-copy field forms used during data collection. There are also forms for browsing and editing data, for completing the annual quality review, and for summarizing and exporting data to other software (e.g., for analysis and graphics production).

D. Data Entry and Processing

During the field season, NPS project crew will be provided with a copy of the project database front-end, through which they enter, process, and quality-check data for the current season. The park project manager or a technician should enter data as soon as possible after each survey in order to keep current with data entry tasks, and to identify any errors or problems as close to the time of data collection as possible. The MORA project manager or MORA technician will enter survey data received from MIT, PTOI, and WDFW wildlife biologists. NPS computer network security features preclude MIT, PTOI, and WDFW wildlife biologists from having direct access to the database.

The front-end database application is found in the project workspace. For enhanced performance, it is recommended that users copy the front-end onto their workstation hard drives and open it there. This front-end copy may be considered "disposable" because it does not contain any data, but rather acts as a pointer to the data that reside in the back-end database. Whenever updates to the front-end application are made available by the Data Manager, an updated front-end should be copied from the project workspace to the workstation hard drive.

The functional components of the front-end application are described in **SOP 9: Data Entry and Verification**. Each data entry form is patterned after the layout of the corresponding field form, and has built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged to use only these pre-built forms as a way of ensuring maximum data quality.

Regular Data Backups

Automatic database backups are scheduled in the SQL Server database management system to help prevent data loss in case of user error, drive failure, or database file corruption. Full backups are scheduled on a weekly basis, with daily transactional backups to enable restore operations to a point in time within a moving eight-week window. Weekly backups and transaction files are retained for eight weeks to conserve drive space. Full monthly backups are stored for at least one year after data have been certified. Snapshot backup copies of certified data, made at the time of certification, are retained indefinitely.

Data Verification

As data are being entered, the person doing the data entry should visually review them to make sure that the data on screen match the field forms. This should be done for each record prior to moving to the next form for data entry. At regular intervals and at the end of the field season the project manager for each park should inspect the data being entered to check for completeness and perhaps identify avoidable errors. The project manager for each park may also periodically run the Quality Assurance Tools that are built into the front-end database application to check for logical inconsistencies and data outliers (this step is described in greater detail in **Section 4E, Data Quality Review** and also in **SOP 12: Data Quality Review and Certification**).

Field Form Handling Procedures

As field data forms are part of the permanent record for project data, they should be handled in a way that preserves their future interpretability and information content. If changes to data on the forms need to be made subsequent to data collection, the original values should not be erased or otherwise rendered illegible. Instead, changes should be made as follows:

- Draw a horizontal line through the original value, and write the new value adjacent to the original value with the date and initials of the person making the change.
- All corrections should be accompanied by a written explanation in the appropriate notes section on the field form. These notes should also be dated and initialed.
- If possible, edits and revisions should be made in a different color ink to make it easier for subsequent viewers to be able to retrace the edit history.
- Edits should be made on the original field forms and on any photocopied forms.

These procedures should be followed throughout data entry and data revision. On an annual basis, data sheets are to be scanned as PDF documents and archived (see the product delivery specifications in **SOP 14: Product Delivery, Posting and Distribution**). The PDF files may then serve as a convenient digital reference of the original if needed.

Image Handling Procedures

This section addresses photographic images collected by project staff, or volunteers, during the course of conducting project-related activities. Procedures outlined here and in **SOP 10: Processing Digital Photographs** also apply to images of surveyed elk that are sent to the MORA project manager by other participating wildlife biologists from MIT, PTOI, or WDFW.

Care should be taken to distinguish data photographs from incidental or opportunistic photographs taken by project staff. Data photographs are those taken for at least one of the following reasons:

- To capture larger groups of elk (20 or more) to verify counts and composition
- To document the phenological stage of forage at set photo points

- To document classification variables (e.g., cover type, or percent concealing vegetation) for crew training and consistency between years
- To document counting conditions and other covariates
- To document a species detection that is also recorded in the data

Data photographs are often linked to specific records within the database, and are stored in a manner that permits the preservation of those database links. Refer to **SOP 10: Processing Digital Photographs** for more details on how to handle and manage image files. Other photographs – e.g., of field crew members at work, equipment setup, or photographs showing the morphology or behavior of certain elk individuals – may also be retained for training, communication, and outreach, but are not necessarily linked with database records. Images that are acquired by other means – e.g., downloaded from a website – are not project records and should be filed and named in such a way that they will not be confused with project records.

GPS Data Procedures

The following general procedures should be followed for GPS data (see **SOP 4: GPS Use** and **Appendix A: Yearly Project Task List**):

1. GPS data should be downloaded by the survey crew from the units at the end of each survey and stored in the project workspace (see **SOP 1: Project Workspace and Records Management**).
2. Survey crew members should notify the GIS Specialist (if the GIS Specialist was not present during the flight) that the raw files are available in the project workspace for processing and correction.
3. The GIS Specialist will process the raw GPS data and store the processed data in the project workspace.
4. The GIS Specialist will upload corrected coordinate information into the database and create or update any project GIS data sets as needed.

The project manager for each park should periodically review the processed GPS data to make sure that any errors or inconsistencies are identified early.

E. Data Quality Review

After the data have been entered and processed, they need to be reviewed by the Project Lead for structural integrity, completeness and logical consistency. The front-end database application facilitates this process by showing the results of pre-built queries that check for data integrity, data outliers and missing values, and illogical values. The user may then fix these problems and document the fixes. Not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is documented and included in the metadata and certification report (see **Sections 4F, Metadata Procedures** and **4G, Data Certification and Delivery**, and **SOP 12: Data Quality Review and Certification**).

Data Edits after Certification

Due to the high volume of data changes and/or corrections during data entry, it is not efficient to log all changes until after data are reviewed and certified. Prior to certification, daily backups of the database provide a crude means of restoring data to the previous day's state. After certification, all edits to certified records are tracked in an edit log (refer to **Appendix B: Elk Aerial Survey Database Documentation**) so that future data users will be aware of changes made after certification. In case future users need to restore data to the certified version, we also retain a separate, read-only copy of the original, certified data for each year in the project workspace.

Geospatial Data

The Project Lead and GIS Specialist may work together to review the surveyed coordinates and other geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate, and also to determine which coordinates will be used for subsequent mapping and field work.

F. Metadata Procedures

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition and other characteristics of a given data set. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all NCCN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed and synthesized.

At the conclusion of the field season (according to the schedule in **Appendix A: Yearly Project Task List**), the Project Lead will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager. The Data Manager and GIS Specialist will facilitate metadata development by consulting on the use of the metadata interview form, by creating and parsing metadata records from the information in the interview form, and by posting such records to national clearinghouses.

An up-to-date metadata record is a required deliverable that should accompany each season’s certified data. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect changes in contact information and taxonomic conventions, to include recent publications, to update data disposition and quality descriptions, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for creating, parsing and posting the metadata record are provided in NCCN Metadata Development Guidelines (NCCN 2007). General procedures are as follows:

1. After the annual data quality review has been performed and the data are ready for certification, the Project Lead (or a designee) updates the metadata interview form.
    a. The metadata interview form greatly facilitates metadata creation by structuring the required information into a logical arrangement of 15 primary questions, many with additional sub-questions.
    b. The first year, a new copy of the NCCN Metadata Interview form (available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm) should be downloaded. Otherwise the form from the previous year can be used as a starting point, in which case the Track Changes tool in Microsoft Word should be

activated in order to make edits obvious to the person who will be updating the XML record.

   c. Complete the metadata interview form and maintain it in the project workspace. Much of the interview form can be filled out by cutting and pasting material from other documents (e.g., reports, protocol narrative sections, and SOPs).
   d. The Data Manager can help answer questions about the metadata interview form.
2. Deliver the completed interview form to the Data Manager according to the product delivery instructions in **SOP 14: Product Delivery, Posting and Distribution**.
3. The Data Manager (or GIS Specialist for spatial data) will then extract the information from the interview form and use it to create and update an FGDC- and NPS-compliant metadata record in XML format. Specific guidance for creating the XML record is contained in NCCN Metadata Development Guidelines (NCCN 2007).
4. The Data Manager will post the record and certified data to the NPS Data Store, and maintain a local copy of the XML file for subsequent updates.
5. The Project Lead should update the metadata interview content as changes to the protocol are made, and each year as additional data are accumulated.

G. Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks (**Section 4E, Data Quality Review**); and 3) they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is a requirement for all tabular and spatial data for years with surveys. The Project Lead is responsible for completing an NCCN Project Data Certification Form, available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm. This brief form should be submitted with the certified data according to the timeline in **Appendix A: Yearly Project Task List**. Refer to **SOP 12: Data Quality Review and Certification** and the delivery specifications in **SOP 14: Product Delivery, Posting and Distribution** for specific instructions.

After the data are certified each year, a copy will be sent to participating wildlife biologists from MIT, PTOI, and WFDW.

H. Analysis, Reporting and Product Development

After data for the current season have been certified, data analysis and report development may proceed. Specific analysis methods and report content are described in **Chapter 5: Analysis and Reporting**.

Standard Report Format

Annual reports and four-year reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Technical Report (NRTR) template, and four-year reports and other peer-reviewed technical reports will use the Natural Resource Report (NRR) template. These templates and documentation of the NPS publication standards (National Park Service 2010) are available at: http://www.nature.nps.gov/publications/NRPM/index.cfm.

Annual and four-year reports will be reviewed by contributing wildlife biologists from MIT, PTOI, and WDFW (see **5.0 C. Reporting**). These contributing wildlife biologists will be co-authors on all reports, and reports will include logos and explicit acknowledgement of the participation by participating tribes and agencies.

Review Products for Sensitive Information

Before preparing data in any format for sharing outside NPS – including presentations, reports, and publications – the Project Lead should refer to the guidance in the next section. Certain information that may convey specific locations of sensitive resources may need to be screened or redacted from public versions of products prior to release.

I. Identifying and Handling Sensitive Information

Note: Because elk are not threatened or endangered, elk location observation data, as collected following this protocol do not meet the NPS definition of sensitive information. We do not anticipate that this monitoring project will collect, manage or report on information related to protected resources. As a result, there are no plans to implement coordinate offsets or data redaction at this time. However, project data will be evaluated on an annual basis in case information on protected resources is included. If so, data will be handled in keeping with network standards (Boetsch et al. 2009), and an SOP will be developed with handling procedures specific to this protocol.

Certain information related to the specific locations of rare or threatened taxa may meet criteria for protection and as such should not be shared outside NPS except where a written confidentiality agreement is in place prior to sharing (for example, the location of a bald eagle nest noted during a helicopter flight would be sensitive information). Before preparing data in any format for sharing outside NPS – including presentations, reports, and publications – the Project Lead should consider whether or not the resulting information might put protected resources at risk. Information that may convey specific locations of sensitive resources may need to be screened or redacted from public versions of products prior to release.

Although it is the general NPS policy to share information widely, the NPS also realizes that providing information about the location of park resources may sometimes place those resources at risk of harm, theft, or destruction. This can occur, for example, with regard to caves, archeological sites, tribal information, and rare plant and animal species. Therefore, information will be withheld when the NPS foresees that disclosure would be harmful to an interest protected by an exemption under the Freedom of Information Act (FOIA). The National Parks Omnibus Management Act, Section 207, 16 U.S.C. 5937, is interpreted to prohibit the release of information regarding the "nature or specific location" of certain cultural and natural resources in the national park system. Additional details and information about the legal basis for this policy are in the NPS Management Policies (National Park Service 2006) and in Director's Order #66 (available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm).

These guidelines apply to all NCCN staff, project participants, contractors, and other partners who are likely to acquire or otherwise have access to information about protected NPS resources. The Project Lead has primary responsibility for ensuring adequate protection of sensitive information related to this project.

The following are highlights of our strategy for protecting this information:

- *Protected resources*, in the context of the NCCN Inventory and Monitoring Program, include species that have State- or Federally-listed status, and other species deemed rare or sensitive by local park taxa experts.
- *Sensitive information* is defined as information about protected resources that may reveal the "nature or specific location" of protected resources. Such information must not be shared outside the National Park Service, unless a signed confidentiality agreement is in place.
- In general, if information is withheld from one requesting party, it must be withheld from anyone else who requests it, and if information is provided to one requesting party without a confidentiality agreement, it must be provided to anyone else who requests it.
- To share information as broadly as legally possible, and to provide a consistent, tractable approach for handling sensitive information, the following shall apply if a project is likely to collect and store sensitive information:
    - Random coordinate offsets of up to 2 km for data collection locations, and
    - Removal of data fields likely to contain sensitive information from released data set copies.

J. Product Delivery, Posting and Distribution

Refer to **SOP 14: Product Delivery, Posting and Distribution** for the complete schedule for project deliverables and instructions for packaging and delivering them. Upon delivery products will be posted to NPS websites and clearinghouses (e.g., IRMA, NPSpecies, NPS Data Store) as appropriate. After peer review is complete, annual and four-year reports will be shared with MIT, PTOI and WDFW, which may also distribute the reports as they choose.

Holding Period for Project Data

To permit sufficient time for priority in publication, certified project data will be held upon delivery for a period not to exceed two years after data certification. After the two-year period has elapsed, all certified, non-sensitive data will be posted to the NPS Data Store. Note: This hold only applies to raw data, and not to metadata, reports or other products which are posted to NPS clearinghouses immediately after being received and processed.

Special Procedures for Sensitive Information

Products that have been identified upon delivery by the Project Lead as containing sensitive information will normally be revised into a form that does not disclose the locations of protected resources – most often by removing specific coordinates and only providing coordinates that include a random offset to indicate the general locality of the occurrence. If this kind of measure is not a sufficient safeguard given the nature of the product or the protected resource in question, the product(s) will be withheld from posting and distribution.

If requests for distribution of products containing sensitive information are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (i.e., the full data set that includes sensitive information) may be shared <u>only</u> after a confidentiality agreement has been established between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Refer to **Section 4I, Identifying and Handling Sensitive Information** for more information.

K. Archiving and Records Management

All project files should be reviewed and organized by the Project Lead on a regular basis (e.g., annually in January). Unneeded draft documents and other intermediate files should be deleted to conserve space and maintain a clear and unambiguous record for future project staff. See **SOP 1: Project Workspace and Records Management** for more details. Decisions on what to retain and what to destroy should be made following guidelines stipulated in NPS Director's Order 19 (available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm), which provides a schedule indicating the amount of time that the various kinds of records should be retained.

Because this is a long-term monitoring project, good records management practices are critical for ensuring the continuity of project information. Files will be more useful to others if they are well organized, well named, and stored in a common format. Details for handling project files are described in **SOP 1: Project Workspace and Records Management**. In addition, files containing sensitive information must be stored in a manner that will enable quick identification. Refer to **Section 4I, Identifying and Handling Sensitive Information**.

L. Season Close-out

After the conclusion of the field season, the Project Managers, Data Manager, and GIS Specialist should meet to discuss the recent field season, and to document any needed changes to the field sampling protocols, to the database structure or front-end application, or to any of the SOPs associated with the protocol. If information from the NCCN Landscape Dynamics monitoring program or from survey observations indicates that a large disturbance (i.e., severe fire, extensive windthrow) has caused gross changes in vegetation structure in any summer trend count area, then the Project Lead, GIS Specialist, and Program Manager from the affected park (along with wildlife biologists from MIT, PTOI, and WDFW, if the observed change is at MORA) should discuss whether any survey unit boundaries should be reconfigured.

5.0 Analysis and Reporting

Annual reports will be completed for each year that surveys are conducted, with a more in-depth synthesis report produced after every fourth year of surveys (hereafter referred to as four-year reports). This protocol calls for one annual report per year of elk survey, reflecting the combined results from both parks. A single four-year synthesis report will include results from both parks.

Annual reports are intended to provide results useful to park managers and all project participants shortly after completing surveys. Annual reports will report survey maps and raw counts of elk observed for each trend count area in which there were surveys, and report estimated abundance and composition values for trend count areas where a double-observer sightability model is available (Table 2). At present, we have a double-observer sightability model for MORA summer surveys (see **5.0 D. Double-Observer Sightability Models**). We expect to be able to test whether data from OLYM summer surveys are consistent with the MORA model, using two to three more years of OLYM survey data. Although time series of estimated abundance and composition will be included in annual reports, we will only test for trends statistically once per every four years of survey data collection, because the estimation of variance around abundance and composition point estimates requires a more involved bootstrap analysis than can be performed with database queries (**Appendix C: Analyses of Detection Bias**).

Four year reports will report annual estimates of abundance and composition with variance, as well as trends in the estimated abundance, composition ratios, and elk distribution in the two parks (Table 2). If park managers request a more frequent analysis of trend or spatial distribution, that could be produced; substantial annual changes over two or three years of survey, for example, may trigger managers to request more in-depth analysis sooner than the scheduled four-year trend analyses.

A. Annual Analysis

After data are entered, validated, and certified (see **4.0 Information Management**), database queries are used to summarize and analyze elk group observations, abundance and composition, and the geodatabase and GIS are used to map survey flights and observations. Detailed instructions for annual analyses are in **SOP 13: Data Summary, Analysis, and Reporting**.

Flight Statistics

The project manager for each park summarizes information about the number of survey flights that took place, which trend count areas were surveyed, the sponsors of the flights (at MORA), the number of hours of total flight time, and the survey time per trend count area.

Elk Observations, Abundance and Composition

The project manager for each park ensures that data from each observed elk group are properly entered into the database (**SOP 9: Data Entry and Verification**). The GIS Specialist associates a location with each observed elk group in the spatial database. Locations are based on: a waypoint recorded in-flight with a GPS unit or GPS-enabled laptop; coordinates for the GPS record of the helicopter's position at the time when the helicopter was closest to that group; or coordinates at the center of a circle defined by the helicopter's circular orbit around a group. The GIS Specialist prepares maps that depict the helicopter flight lines and the approximate locations of observed elk groups for each survey of each trend count area (Figure 9). Only elk groups that were seen within a survey unit contribute to abundance estimates. Elk that were seen up to 300 m outside the boundary of any survey unit are not used for abundance estimates but are noted in annual reports, and are added to other observations for composition count estimates.

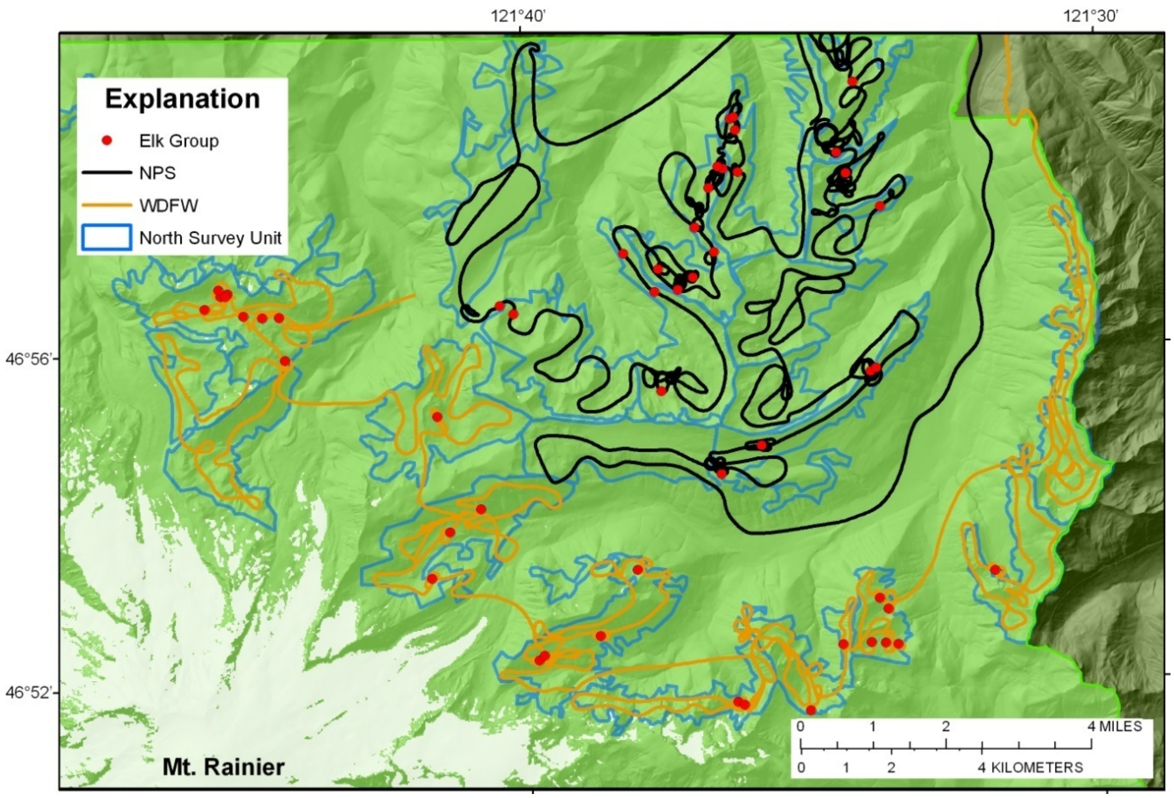

Figure 9. Flight lines and elk group locations observed during August 17, 2009 survey flights in the North Rainier herd trend count area. Survey units are outlined in dark blue. Elk groups are noted as red circles. Flight paths are colored to indicate flight sponsor: orange for WDFW and black for NPS. Surveys were slowed by radio-telemetry, so two survey units to the northwest (N1 and N2), were not surveyed.

Because a double-observer sightability model has been completed for application to summer surveys in MORA, but not yet OLYM, annual reporting of population abundance and composition within the summer trend count areas will differ between the two parks, at least until a comparable double-observer sightability model is completed for OLYM summer surveys, or until the MORA model has been validated or modified for use with OLYM summer surveys (see **5.0 D. Double-Observer Sightability Models**). The project manager for each park uses database queries to compile the uncorrected counts of elk observed during aerial surveys, leading to the following for each complete survey of a trend count area: number of observed groups; mean observed group size; maximum observed group size; raw total count of observed elk; and raw ratios for observed number of calves per 100 cows, and observed number of bulls per 100 cows.

In MORA, covariates recorded for each observed group are exported with the data base query qs_Covariates and pasted into the "Theta_hat calculator" spreadsheet to determine group-specific correction factors; the resulting values for Theta_hat are stored in the data base (**SOP 13: Data Summary, Analysis, and Reporting**). The project manager then uses the data base query, qry_Est_Abundance, to estimate abundance for each trend count area, based on the raw counts and corrections for detection bias.

Similarly, the data base query, qry_Est_Composition, is used to find the summed products of the group-specific correction factor times the number of cows, calves, and bulls in each group, yielding the point estimates for composition ratios (calves per 100 cows, and bulls per 100 cows) in each trend count area. These composition estimates account for detection bias.

Annual reporting for MORA will include separate values for estimated abundance and composition for each replicate of surveys conducted in a trend count area. The point estimates will be presented in a time series that also includes estimates from previous years. Because uncertainty estimates will not be available until four-year analyses, we will not test for trends in annual reports.

B. Four-year Analysis

Four-year reports will include the same information as annual reporting, but will also estimate trends in abundance and population composition, changes in spatial distribution, and will examine potential changes in the double-observer sightability model. As described in **5.0 D. Double-Observer Sightability Models**, reporting for OLYM will be based on raw counts (uncorrected for detection biases) until the appropriate models can be developed. We expect that two to three more years of survey data collection will be necessary before we can test whether the pattern of detection bias for OLYM summer surveys is comparable to the MORA model. The first four-year summary report will be completed in 2012. Because we hope to have completed a model for application in OLYM within the next four years, we anticipate using the same summary reporting methods based on detection bias modeling for both parks in subsequent four-year reports. Detailed instructions for four-year analyses are in **SOP 13: Data Summary, Analysis, and Reporting**.

Trend Estimation

After every four years of survey, we will test for positive or negative trends in elk abundance and composition in each trend count area. We will test for a trend using all available data, and also for shorter time periods based on the preceding 8, 12, and 16 years. A trend exists if the slope of a linear regression line through log-transformed abundance values is significantly different from zero. The coefficient of variation (CV; standard error of abundance, divided by the estimate of abundance) for each estimate of abundance is estimated during four-year analyses. These estimates of CV are based on the bootstrapped, simulated abundance estimates for each survey (**Appendix C: Analyses of Detection Bias)**, where the 68% confidence interval (68% C.I.) for each estimate of abundance is based on the 68 (of 100) bootstrapped values closest to the mean estimate, and standard error is based on an assumption that the 68% C.I. is the mean estimate +/- one times the standard error of the estimate. For significance testing of the slope of trends, we will use two-tailed tests and a type I error rate (α) of 0.1. We will only begin testing for a trend in the OLYM peripheral summer trend count areas after at least two surveys in those areas.

Before 2008, the area surveyed in MORA elk surveys was inconsistent, and covariates other than group size and composition were not recorded. As a result, it is not possible to estimate correction factors for those surveys, so we will not use those data in trend estimates. Similarly, there are no comparable elk survey data for summer trend count areas in OLYM before 2007.

Assessing Change in Spatial Distribution

Trend estimates in this protocol reflect changes in abundance at the scale of trend count areas. Our data collection, however, documents the spatial distribution of elk at the smaller spatial scale of survey units within trend count areas. For each survey, we will use the double-observer sightability model to find the point estimate for the number of elk present in each survey unit. Relative abundance for each survey unit will be defined as the decimal fraction of the total trend count area's estimated elk abundance that is found in that survey unit. We will map the mean value of estimated trends in relative abundance for each survey unit (**SOP 13: Data Summary, Analysis, and Reporting**). Positive or negative trends in relative abundance, identified by estimating the slope of a regression of relative abundance on time, would reflect increases or decreases in the use of a given survey unit, relative to other survey units in the same trend count area.

Even finer scale spatial distribution data come from elk group locations. Elk group location is approximated from GPS units on the helicopter, at the time the group was noted. Nonetheless, each elk group location will have an estimate for the elevation above sea level for the ground immediately below the helicopter. We will report the mean and standard deviation of that elevation for each trend count area for each year of survey.

The spatial record of elk group locations made in this monitoring program will also provide data that will be used to test for changes in the distribution of observations relative to park boundaries. This is of concern in OLYM spring survey trend count areas, because changes in land use or hunting pressure on resident low-elevation herds just outside of park boundaries may be decreasing local elk abundance near park boundaries (P. Happe, personal communication).

Testing for Changes in the Applicability of the Double-observer Sightability Model

Over time, there may be changes in observer acuity or elk behavior that could influence detection probabilities. If the double-observer sightability model developed from MORA 2008-2010 data does not account for such changes, then that model could yield biased abundance estimates in the future. Therefore, we will continue collecting double-observer data, and to test whether those data are consistent with the same model structure and parametric estimates of covariate effects as the original model. We will compare parameter values of the updated double-observer sightability model to previous models during each four-year analysis. Double-observer sightability trial data can also be opportunistically recorded into the future, and incorporated into these comparisons.

If double-observer sightability models based on future data indicate that there is high support for different parameterizations of the heterogeneity parameter or the effects of covariates on detection probabilities, relative to those parameter estimates in original double-observer sightability model, then we may need to take steps to account for a change in the detection bias. Depending on the nature of the change in detection bias, prescribed actions may include higher training levels for observers, rotating observer positions in the helicopter, relying only on recent double-observer data to create a new double-observer sightability model, or concerted collection of new sightability trial data (**Appendix C: Analyses of Detection Bias**).

Supplemental Analysis

Under some circumstances, it may be desirable to conduct the analyses scheduled for four-year summary reports before four years of survey data have been recorded. For example, park managers may ask for estimates of the CV of abundance, or for an assessment of recent elk trends, if there were concern that a newly emergent disease was adversely affecting elk. Such analyses could always be conducted, provided that funding is available. Results from any supplemental analyses should be included in the next annual report.

C. Reporting

The project managers each contribute results that are included in the annual report, which is finalized by the Project Lead. Details about annual report guidelines are provided in **SOP 13: Data Summary, Analysis, and Reporting**. Annual and four-year reports should include information as outlined in Table 2. In addition to posting on NPS web sites (**SOP 14: Product Delivery, Posting and Distribution**), these reports are shared with all contributing tribal and agency personnel. It is the intent of this protocol that the contributing wildlife biologists from MIT, PTOI, and WDFW be invited to be authors on all annual and four-year reports. Annual and four-year reports will include logos and explicit acknowledgement of the participation by participating tribes and agencies.

Table 2. Results to include in annual and four-year reports.

Annual reports
Names and roles of project personnel
Flight statistics
Number of survey flights; sponsors of those flights
Total hours of flight time; total hours of survey time
Survey time per trend count area
Elk observations
Maps of flight lines, showing observed elk groups in and near trend count areas
Summary table of raw number of elk groups seen, raw total number of elk seen, mean observed group size, maximum observed group size, raw observed Calf:Cow and Bull:Cow composition by antler class. Values reflect totals for each trend count area
Elk abundance and composition estimates
Point estimates of total elk abundance in each surveyed trend count area, after accounting for visibility bias with the double-observer sightability model
Figure depicting changes in estimated abundance for each trend count area, over time*
Point estimates of composition in each surveyed trend count area, after accounting for visibility bias with the double-observer sightability model
Figure depicting changes in estimated Calf:Cow ratio and Bull:Cow ratio for each trend count area over time*

Four-year reports
Annual report for the preceding year
Abundance and composition estimation, based on sightability model
Variance estimates for abundance estimates, for previous surveys
Summary tables of annual abundance estimates for each trend count area
Summary table of Bull:Cow and Calf:Cow annual estimates, by trend count area
Trend estimation for each trend count area
Figure depicting changes in estimated abundance over time†
Figure depicting changes in estimated Calf:Cow ratio and Bull:Cow ratio over time†
Tables presenting slope estimates for regressions of abundance and composition versus time, based on all available data, and on the preceding 8, 12, and 16 years
Spatial Distribution
Map of relative abundance trends for survey units in each trend count area
Model Development at OLYM
Present progress toward double-observer sightability model development for OLYM
Test of Double-observer Sightability Model
Conduct these tests when there are sufficient numbers of data points
Estimate the most parsimonious Quadrennial Double-observer Models for MORA summer range and OLYM summer range
Test for differences in model structure and effect sizes in the newest Double-observer Sightability Model, versus the Original Model

* In annual reports, figures depicting temporal changes in abundance or composition will not include estimates of uncertainty for point estimates made since the preceding four-year report.

† In four-year reports, figures depicting temporal changes in abundance or composition will include estimates of uncertainty for all years of survey, including the most recent four years.

D. Double-observer Sightability Models

We will apply a double-observer sightability model to survey results, as a way of estimating and correcting for detection bias (**2.0 Sampling Design**). We have developed a double-observer sightability model for MORA summer surveys, and we will continue to collect data to test whether detection bias for OLYM summer surveys is described by the MORA model; that test should be possible after two to three more years of OLYM summer survey. We have no plans to finish a double-observer sightability model for application to the OLYM spring surveys, but, we will continue to collect data in OLYM spring surveys in such a way that, if ever there is a large enough sample of double-observer sightability trials from spring surveys, a model for detection bias for spring surveys could be developed in the future.

Double-observer Sightability Models for MORA Summer Surveys

We recorded data from 97 double-observer sightability trials for elk groups with at least one radio-collared animal during aerial surveys conducted in MORA from 2008-2010. These data included detection outcomes for each elk group by three sets of independent observers: the front seat observers, the back seat observers, and a radio-telemetry 'observer' (referring to detections made by the aerial survey crews, using radiotelemetry). In addition, we collected 510 double-observer data points for other elk groups in MORA not containing collared animals; the radio-telemetry 'observer' could not detect such groups. In analyses, the front-seat observer and the pilot are pooled as one observer, while the back-seat observers are pooled as a second observer (Griffin et al. 2009). We used the combined data set of 607 data points to estimate a double-observer sightability model for MORA surveys (**Appendix C: Analyses of Detection Bias, *Model Development***) that we will use to correct for detection bias in future surveys.

What we refer to as the MORA double-observer sightability model is actually a set of 15 contributing model structures, the predictions of which are weighted through model averaging (Burnham and Anderson 2002). The 15 contributing model structures were selected from a set of 28 candidate models, based on support from the data, i.e., having AIC_c scores within 4.0 of the top-ranked model structure (Burnham and Anderson 2002). We selected the candidate set of models *a priori*, based on hypothesized relationships between several variables and sightability derived from previous studies. Each contributing model structure is a Huggins (1991) closed capture estimator, structured in program MARK (White and Burnham 1999) to estimate detection probabilities for front and back observers. Each contributing model structure also includes an estimate of the apparent difference in detection probabilities between radio-marked elk groups and non-radio marked elk groups; this difference is quantified by the 'heterogeneity parameter.' Observers have an inherently lower detection probability than radio telemetry, because 100% of groups with a radio collared animal are found by the telemetry 'observer.' If detection probabilities were estimated only from non-radio marked elk groups, the resulting detection probabilities could be biased high, because such probabilities would only be estimated, *conditional* on the groups in the data set having been observed by at least one observer (Barker, 2008). Including the sightability trials in the data set, and the heterogeneity parameter in the models, allows us to estimate each group's unconditional detection probabilities – that is, the probability that such a group present in the survey frame would be detected by at least one of the observers in the helicopter.

The effects of three covariates – elk group size (n), the amount of concealing vegetative cover near the group, and pilot experience – are included in all 15 of the averaged model structures.

Differences between the contributing model structures reflect inclusion of other covariates (including lighting conditions, cover type, or animal activity) and differences in whether observer detection probabilities and the heterogeneity parameter are constrained to be either equal or unequal for front- and back-seat observers.

Group-specific correction factors are weighting factors that account for groups of similar attributes that were likely missed during the survey. Group-specific correction factors are related to the inverse of a given elk group's overall detection probability. For example, if covariates measured for a single group (e.g., lighting conditions, concealing vegetation, or group size) indicated a detection probability of 0.4, then the group would be weighted by a correction factor of 2.5. Recorded covariate values for group *j*, and the 15 contributing model structures are used to estimate the model-averaged group-specific correction factors, $\overline{\hat{\theta}_j}$. The estimated group-specific correction factors are stored in the Theta_hat field of the project database (**SOP 13: Data Summary, Analysis, and Reporting**).

The total estimated abundance for a surveyed trend count area, $\hat{N}$, is the sum of all elk observed during the survey, each weighted by a group-specific correction factor. Similarly, point estimates of composition are based on the estimated total number of cows, calves, and bulls – these totals come from summed products of each group's correction factor times the number of cows, calves, and bulls in that group. Point estimates of $\hat{N}$ and composition estimates for each survey are presented in annual reports.

The variance of abundance estimates are calculated from bootstrapped simulations of the observation data (Wong 1996, Lubow et al. 2002). One hundred iterations of simulated observation data sets are generated without replacement from simulated 'superpopulations' of elk groups derived from the actual observational data (see **Appendix C: Analyses of Detection Bias, *Estimating Variance in Abundance Estimates with Bootstrapping***).

Simulated detections and non-detections within each iteration are simulated as follows. Each simulated elk group is recorded as either detected or not detected by front observers, based on evaluating a random number against model-averaged estimates of detection probabilities for the front observers; these probabilities come from the MORA double-observer sightability model, and the covariate values of the simulated elk group. Similarly, the back observer is simulated to either 'see' or 'miss' the simulated elk group, based on comparison of a different random number against the estimated back seat observer detection probability. Radio telemetry is always simulated to detect groups with a radio collared elk, and to not detect those without a radio collared elk. In this way, front, back, and radio observer detections are simulated for each elk group out of the simulated superpopulation of elk groups. The simulated observation data set for each iteration only includes those elk groups that were determined to be detected by at least one of those simulated observers.

For each iteration, parameter optimization in program Excel (Microsoft Corp., Redmond, Washington) is used to solve for the parameter estimates and AIC_c estimates for each of 15 contributing model structures (see **Appendix C: Analyses of Detection Bias**). These model structures are used to estimate group-specific correction factors, which are multiplied by group size for simulated observed groups to estimate the simulated abundance for each iteration of simulated surveys.

The standard error of the mean for each actual abundance estimate is taken as half of the 68% confidence limits. Out of a sample of 100 bootstrapped simulations, that is half of the distance between the 17th lowest and 17th highest simulated value (the 16 lowest and 16 highest values are considered to be outside the 68% confidence limits). Similarly, the 95% confidence limits for each actual abundance estimate are based on the 95 simulated abundance estimates closest to the median. The coefficient of variation for each actual estimate of abundance is the standard error, divided by the point estimate for abundance. These measures of variance are calculated in four-year analyses (**5.0 B. Four-year Analysis**). The variance measures are needed to estimate the significance of any apparent trends in each trend count area.

Double-observer Sightability Model for OLYM Summer Surveys

For summer surveys, the survey frame definitions, in-flight methods, helicopters, pilots, crew members, and vegetation are comparable in MORA and OLYM; hence it is likely that the double-observer sightability model derived in MORA also applies to OLYM. We will continue to collect double-observer sightability trial and double-observer data at OLYM until we have enough data (approximately 30-40 double-observer sightability data points) to test that assumption. Until then, we will report raw (uncorrected) counts only for OLYM summer surveys. As of September 2011 there are 18 radio-collared elk that may use the OLYM summer survey trend count areas, so we anticipate recording data from an adequate number of summer sightability trials in OLYM to test the assumption about model applicability before producing the second four-year report.

Double-observer Sightability Model for OLYM Spring Surveys

All trends in spring surveys will be based on raw counts of elk observed, as models completed for the summer range surveys will not be applicable to spring surveys. With the anticipated sporadic funding and irregular intervals of conducting spring surveys we do not anticipate developing a double-observer sightability model. As mentioned previously, however, we will note the presence of any radio-collared elk present on the spring ranges during surveys and record double-observer sightability trial data on any groups of elk containing radio-collared elk. Such information may prove useful if additional funding eventually allows development of sightability models for application to spring surveys.

6.0 Personnel Requirements and Training

A. Roles and Responsibilities

Multiple agencies and tribes support elk surveys at MORA. In years with aerial surveys, NPS currently funds at least two survey flights per year, over portions of either the North Rainier or South Rainier herd trend count areas. MIT and WDFW Region 6 each fund one survey flight over a portion of the North Rainier herd trend count area. PTOI and WDFW Region 5 each fund one survey flight over a portion of the South Rainier herd trend count area. Any proposed changes in this arrangement for MORA flights should be discussed no later than the spring pre-survey meeting. After MIT, PTOI, and WDFW share data collected on flights with NPS, NPS will enter, verify, and certify those data, and make the resulting certified data available to the project participants. NPS will produce annual reports summarizing observed raw elk counts, and estimated abundance and composition according to North Rainier or South Rainier herd trend count area.

NPS field work for the project is primarily planned by the OLYM project manager and by the MORA project manager, in conjunction with wildlife biologists from MIT, PTOI, and WDFW. The project manager for each park must have extensive experience with helicopter surveys and aviation operations. It is the responsibility of the project manager to organize the project annually in each park. This overall program oversight at each park includes: safety planning; coordination with participating staff, other agencies and tribes; assuring the project is in compliance with park regulations; budgetary planning; making go / no-go flight decisions; observing elk during surveys; overseeing data entry, data verification, analysis and reporting; and coordinating data handling with the Data Manager and GIS Specialist. Either the OLYM project manager or MORA project manager also serves as the Project Lead with the responsibility of assuring that reports, metadata, and other products are certified and completed on time. Currently, the OLYM project manager serves in this capacity.

Other federal, tribal, state, and contracted participants that play important roles in this protocol include biologists and other observers from MTI, PTOI, and WDFW, the GIS Specialist, pilots, aviation managers and helicopter managers, the Data Manager, the Data Analyst, and the NCCN Coordinator. Tribal and state wildlife biologists coordinate with the MORA project manager and conduct elks surveys with methods that parallel those outlined in this protocol. The GIS Specialist helps in the collection, processing, analysis, and presentation of spatial data, including map creation for annual and four-year reports. Helicopter managers interact with pilots to assure that interagency helicopter operating guidelines are met, and work with park dispatch to assure that flight following occurs during all survey flights. Aviation managers review the safety planning for all federal flights. The Data Manager creates and maintains the project database, including the data entry interface, oversees data quality assurance and data certification, creates database output tables for annual and four-year reporting, and assists with product delivery. The NCCN Coordinator reviews reports and assures that NPS standards are met. Specific responsibilities of all personnel involved with this project are detailed in Table 3, and the information management task list associated with these roles and responsibilities are found in **Appendix A. Yearly Project Task List**.

B. Qualifications

All members of flight crew on any federal flight, including non-federal personnel, must have passed the B3 basic aviation safety training course within the previous two years. All flight crew members must have a proven ability to observe and conduct their duties in a moving, spinning environment; that is, they must not get motion sick to the point that it affects their observations. More detailed descriptions of the qualifications for observers are provided in **SOP 3: Training Observers.**

Project managers for each park must, in addition, have current M3 training, DOI aviation management training for supervisors. The helicopter managers must have current training at the S-372 level, interagency helicopter manager. All efforts should be made to hire only pilots who, in addition to being credentialed for low-level flight, have extensive wildlife survey experience. The Data Analyst involved with four-year analyses must be familiar with the use and operation of program MARK (White and Burnham 1999) or another comparable mark-recapture analytical tool.

C. Training Procedures

Survey crew changes should be kept to a minimum to increase safety of the operation and to control the level of observer bias. Illness and schedule conflicts do happen, however. Experienced crewmembers will cross train all on all positions in the helicopter, so that any one of them could fill in for a missing crew member. The project manager at each park will maintain a list of other qualified personnel in the NCCN that could be called upon to serve as observers, such that two or more potential substitutes are available for surveys. Qualified MIT, PTOI, and WDFW staff may also serve as crew members on MORA flights.

Training is outlined in **SOP 3: Training Observers**. Observers must have current helicopter safety certification, and must read and thoroughly understand **SOP 7: Conducting Helicopter Surveys**. New observers discuss **SOP 7** with the project manager, or experienced tribal or state wildlife biologist. New crew members will be briefed and closely supervised by existing crew members. Any new crew members must have the required qualifications for low-level helicopter flights and, preferably, ought to have some experience with wildlife surveys or helicopter-based search and rescue missions. New observers will be placed in a back seat while they gain experience. If the front seat observer needs to be absent, an experienced back seat observer should occupy that position.

Table 3. Table of roles and responsibilities for elk aerial surveys in the NCCN.

Role	Responsibilities	Name / Position
Project Lead	• Responsible for completion of monthly, annual and four-year reports • Manage NCCN elk budget, track project objectives, budget, requirements, and progress toward meeting objectives • Coordinate and ratify changes to protocol • Maintain and archive project records • Certify each season's data for quality and completeness • Complete reports, metadata, and other products according to schedule	Patti Happe, Wildlife Biologist, OLYM
Park Project Manager	• Ensure project compliance with applicable statutes and regulations • Organize helicopter survey dates • Convene annual pre-survey meeting of other MORA project participants • Prepare NPS aviation safety plan • Contact park staff to alert them about scheduling of surveys • Conduct surveys; record data • Write post-flight flight report • Coordinate budget with Project Lead • Ensure data are entered into database • Participate in data quality review • Oversee creation of park-specific metadata • Complete park-specific sections of monthly, annual, and four-year reports	Mason Reid, Wildlife Ecologist, MORA Patti Happe, Wildlife Biologist, OLYM
State and Tribal Wildlife Biologists	• Secure agency funding • Provide critical guidance • Participate in planning meetings • Schedule helicopter and crew • Conduct survey; collect observation data • Forward data sheets, photos, and GPS data of flight paths to MORA Project Manager • Review drafts and co-author final reports	David Vales, MIT Barbara Moeller, PTOI Michelle Tirhi, WDFW R6 Pat Miller, WDFW R5
Helicopter Managers	• Prepare OLYM aviation safety plans • Coordinate with park aviation manager and helicopter pilot(s) • Manage helicopter • Provide advice on go / no-go decisions • Interact with park dispatch to assure successful flight following • May serve as an observer on flights	Rich Lechleitner, MORA Bill Baccus, NCCN Kathy Beirne, NCCN
Aviation Manager	• Review aviation safety plans	Stefan Lofgren, MORA Larry Nickey, OLYM

Table 3. Table of roles and responsibilities for elk aerial surveys in the NCCN (continued).

Role	Responsibilities	Name / Position
Technicians	• Observe elk groups; record data • Data entry • Audio transcription of other species noted on survey flights • Assist with creation of metadata	Bill Baccus, NCCN Ellen Myers, MORA Kathy Beirne, NCCN
GIS Specialist	• Prepare GIS and GPS for preflight; upload survey polygons to pilot's GPS unit • Prepare flight maps for crew, manager, and park dispatch • Install GPS and audio recording equipment on ship • Process GIS data after flights for entry into geodatabase • Maintain geodatabase • Assist with spatial elements of metadata creation • Prepare maps for annual reports, four-year reports, and presentations	Kathy Beirne, GIS Specialist, NCCN
Data Manager	• Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule • Maintain and update database application • Provide database training as needed • Facilitate custom database output for data quality assurance, annual reports and four-year reports	John Boetsch, NCCN Data Manager
Data Analyst	• Estimate abundance per trend count area • Estimate trends in abundance and spatial distribution • Develop and test four-year double-observer models • Develop OLYM summer survey sightability model (and possibly OLYM spring survey sightability model)	NCCN, USGS, or accomplished through a Cooperative Agreement
Network Program Manager	• Review annual and four-year reports for completeness and compliance with I&M standards and expectations	Mark Huff, NCCN Program Manager
Park Curator	• Receive and archive copies of annual reports, analysis reports, and other publications • Facilitate archival of other project records (e.g., originals of completed data forms from surveys, digital copies of photographs and flight audio recordings)	Brooke Childrey, MORA Gay Hunter, OLYM
USGS Liason	• Consult on technical issues related to project sampling design, statistical analyses, or other issues related to changes in protocol and SOPs	Kurt Jenkins, Research Wildlife Biologist, USGS-FRESC Paul Griffin, Wildlife Biologist, USGS-FRESC

7.0 Operational Requirements

A. Annual Workload and Field Schedule

Appendix A: Yearly Project Task List presents a table of annual project tasks that need to be completed during years in which surveys are planned. A list of who is responsible and the annual timing of those tasks is also provided. Planning for surveys will require attention from the Project Manager at each park, GIS Specialist, Helicopter Manager, Aviation Manager, and other participating observers at MORA. Before any flights, the GIS Specialist must prepare survey unit polygons for uploading to the helicopter's on-board GPS system, and prepare GPS units and a laptop computer for in-flight data recording.

Planning for MORA summer surveys includes a meeting with other project participants to discuss budget status and flight scheduling; this should take place during April - June. Planning for summer surveys at OLYM may include flight scheduling to share costs with other park programs, such as back-country campsite maintenance. NPS survey crew staffing and backup staffing for summer surveys should be settled by June. Two summer surveys at each park take place in August – September. Conducting any NPS-sponsored survey requires at least three person-days of staff time if one of the crew members is also a helicopter manager, and four person-days of time if the helicopter manager is not on the survey crew.

In years when supplemental funding for spring OLYM surveys is available, NPS survey crew staffing and backup staffing for spring surveys at OLYM should be settled by February. Spring surveys require at least three mornings of survey flights, but poor weather often means that the three-person survey crew must be ready to fly during the entire period of March 15 – 31.

The Project Manager from each park writes a brief Flight Report after each attempted flight. Post-flight data entry includes downloading and processing photos **(SOP 10: Processing Digital Photographs)**, entering written data into the database, downloading the GPS data representing the survey flight path, downloading the survey audio recording transcribing data for other species (**SOP 9: Data Entry and Verification**). All of the written data should be verified. The GIS Specialist creates flightline and location feature records in the geospatial database. Project Managers at each park should solicit the input of all participants in a post-season debriefing that identifies successes and problems.

The Data Manager assists with data Quality Assurance and Certification for spring survey results in May, and the OLYM project manager uses database queries and geodatabase map outputs to write an interim report, summarizing results of the spring surveys. The spring survey interim report is not intended for public distribution. The Data Manager assists with data Quality Assurance and Certification for summer survey results in November. Certified MORA data, including the summaries that are of central interest to MIT, PTOI, and WDFW, are shared with those project participants as soon as possible. Tabular reporting from the database and maps from the geospatial database go directly into the annual report, which the project managers and Project Lead compile and write in January - February. Annual reports should be sent to the NCCN Coordinator by late February. Park Curatorial staff assists with data form and digital photograph archiving.

B. Facility and Equipment Needs

No new equipment needs to be purchased for this project. Ongoing equipment needs are identified in a checklist in **SOP 7: Conducting Helicopter Surveys**, and include:

- AMD approved Type III helicopter
- AMD approved pilot
- Personal Protection Equipment (PPE) for low level helicopter flights (e.g. full fire retardant/Nomex outerwear, leather boots, helicopter helmets)
- At least two GPS units
- Laptop capable of receiving GPS signals, or connecting to a GPS unit
- Digital camera, high quality, with zoom lens (preferably image-stabilized)
- Digital voice recorder, and associated adapter to helicopter audio system
- Field forms and clipboards
- Portable park radios
- Emergency survival kits

For the few occasions each year when surveys will take place, NPS vehicles that are already owned and operated by MORA or OLYM will be used in each park to transport park staff to and from helicopter landing zones. There is no need to acquire new vehicles for this protocol.

C. Startup Costs and Budget Considerations

The program detailed in this protocol is in keeping with the existing NCCN elk monitoring annual implementation budget (Table 5), which currently funds elk monitoring in both parks during alternate years. During years when elk monitoring is funded, the total cost of this protocol to the NPS is approximately $54,286, including about $25,185 from the NCCN operating budget (primarily helicopter costs), $13,708 of in-kind salary contributions from MORA and OLYM, and $15,397 of salary contributed by NCCN staff for data management and conducting aerial survey operations. In addition, substantial funding is provided by the Muckleshoot Indian Tribe, Puyallup Tribe of Indians, and two administrative regions of the Washington Department of Fish and Wildlife. In addition to these biennial costs incurred during the survey years, every fourth funding year (i.e., eight years) an additional $12,000 is required from the I&M program for analysis and preparation of synthesis reports (out of $38,638 total cost to the NPS).

Start-up costs associated with the continued development of a double-observer sightability model in OLYM are minimal because data for model development has already been partially collected, and will continue to be collected during regularly scheduled aerial surveys in OLYM (Table 5). Additionally, over $21,000 has been contributed to date by USGS ($11,000) and Washington National Parks Fund ($10,100), which will fund additional replicated surveys for two survey seasons to increase the sample size of double-observer sightability trials. During subsequent survey seasons, we will continue collecting double-observer sightability trials during regularly funded aerial surveys in OLYM. An additional $6,000 will be needed from the NCCN or other sources during the second four-year reporting cycle sometime after 2014. The extra funding will pay for biometric support to help refine a generalized model that will be suited for application in both MORA and OLYM as described in **Appendix C: Analyses of Detection Bias**.

Table 4. NPS implementation budget for elk monitoring at MORA and OLYM. Manager for each park is abbreviated as “PM” Costs of annual project tasks are in 2011 dollars. One out of every four years the budget includes the additional costs of four-year analyses and reporting. Costs of project implementation borne by other tribal and agency participants (MIT, PTOI, and WDFW) are approximated here.

Project Stage / Budget Category	Personnel	Grade	Pay Periods	NCCN I&M Basic Protocol Costs	In-Kind Support from MORA	In-Kind Support from OLYM	Other NCCN I&M Support Costs	Costs to MIT, PTOI, and WDFW
Preparation								
	MORA PM	GS-12	0.2		$ 846			
	OLYM PM	GS-12	0.4			$ 1,658		
	GIS Specialist	GS-9	0.2				$ 618	
	Helicopter Manager	GS-7	0.5				$ 1,310	
	Data Manager	GS-11	0.5				$ 1,590	
	Tribal & WDFW Wildlife Biologists							$ 2,500
Data Collection, Entry & Processing	Summer MORA Surveys							
	MORA PM	GS-12	0.3		$ 1,269			
	Bio Tech	GS-7	0.3		$ 810			
	GIS Specialist	GS-9	0.3				$ 926	
	Travel			$ 285				
	Premium pay (Hazard & OT)	Varies		$ 2,100				
	Tribal and WDFW Wildlife Biologists and Technicians (12)							$ 2,800
	Helicopter Costs			$9,400				$18,800
	Summer OLYM Surveys							
	OLYM PM	GS-12	0.3			$ 1,243		
	GIS Specialist	GS-9	0.3				$ 926	
	Helicopter Manager	GS-7	0.4				$ 1,048	
	Hazard pay	Varies		$ 1,300				
	Helicopter Contracting			$12,000				

Table 4. NPS implementation budget for elk monitoring at MORA and OLYM. Manager for each park is abbreviated as “PM” Costs of annual project tasks are in 2011 dollars. One out of every four years the budget includes the additional costs of four-year analyses and reporting. Costs of project implementation borne by other tribal and agency participants (MIT, PTOI, and WDFW) are approximated here (continued).

Project Stage / Budget Category	Personnel	Grade	Pay Periods	NCCN I&M Basic Protocol Costs	In-Kind Support from MORA	In-Kind Support from OLYM	Other NCCN I&M Support Costs	Costs to MIT, PTOI, and WDFW
Quality Review	MORA PM	GS-12	0.1		$ 423			
	OLYM PM	GS-12	0.1			$ 414		
	Data Manager	GS-11	0.5				$ 1,590	
	GIS Specialist	GS-9	0.1				$ 309	
Metadata	MORA PM	GS-12	0.05		$ 212			
	OLYM PM.	GS-12	0.05			$ 207		
	Technician	GS-7	0.3				$ 786	
	Data Manager	GS-11	0.1				$ 308	
Data Certification & Delivery	MORA PM	GS-12	0.2		$ 846			
	OLYM PM	GS-12	0.2			$ 829		
	Data Manager	GS-11	0.6				$ 1,908	
Annual Data Analysis	MORA PM	GS-12	0.1		$ 423			
	OLYM PM.	GS-12	0.2			$ 829		
	Helicopter Manager	GS-7	0.2				$ 524	
	GIS Specialist	GS-9	0.1				$ 309	
Reporting & Product Development	MORA PM	GS-12	0.2		$ 846			
	OLYM PM.	GS-12	0.3			$ 1,243		
	Data Manager	GS-11	0.1				$ 318	
	GIS Specialist	GS-9	0.1				$ 309	
	Tribal and WDFW Wildlife Biologists (4)							$ 800
Product Delivery, Posting & Distribution	Data Manager	GS-11	0.3				$ 954	
	NCCN Coordinator	GS-12	0.1				$ 392	

Table 4. NPS implementation budget for elk monitoring at MORA and OLYM. Manager for each park is abbreviated as “PM” Costs of annual project tasks are in 2011 dollars. One out of every four years the budget includes the additional costs of four-year analyses and reporting. Costs of project implementation borne by other tribal and agency participants (MIT, PTOI, and WDFW) are approximated here (continued).

Project Stage / Budget Category	Personnel	Grade	Pay Periods	NCCN I&M Basic Protocol Costs	In-Kind Support from MORA	In-Kind Support from OLYM	Other NCCN I&M Support Costs	Costs to MIT, PTOI, and WDFW
Archival & Records Mgmt.	Data Manager	GS-11	0.1				$ 318	
	Project Lead[1]	GS-12	0.1			$ 414		
	MORA Curator	GS-11	0.05		$ 177			
	OLYM Curator	GS-11	0.05			$ 177		
Season Close-out	MORA PM	GS-12	0.1		$ 423			
	OLYM PM.	GS-12	0.1			$ 414		
	Data Manager	GS-11	0.3				$ 954	
Travel								
Supplies				$ 100				
Total cost of surveys in years with annual reports (three out of four years of survey)				**$25,185**	**$ 6,275**	**$ 7,429**	**$ 15,397**	**$ 24,900**
Additional costs of four-year analyses and reporting	Wildlife Biologist[2]	--	--	$12,000				
	GIS Specialist	GS-9	1.5				$ 4,635	
	Data Manager	GS-11	1.0				$ 3,180	
	Project Lead	GS-12	0.5			$ 2,073		
	MORA PM	GS-12	2.0		$ 8,460			
	OLYM PM	GS-12	2.0			$ 8,290		
	Additional cost of four-year report, once per four years of survey			**$12,000**	$8,460	$ 10,363	$ 7,815	

[1] At this time, the Project Lead is also the OLYM Project Manager (see Table 3).

[2] Through interagency agreement or contract.

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SOP 1: Project Workspace and Records Management

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP describes how and where project files and records are managed by project staff. Workspace structure, naming conventions, and procedures for handling project files are included.

NCCN File Workspace

NCCN has a centralized file system and project workspaces available for use by field crews and project staff at: \\inpolymfs\parkwide\NCCN. This will help avoid the problem of NCCN projects having several versions of files on different servers around the network. These folders are set up so that park and network staff members at the network parks all have read privileges throughout the directory structure. Project leads and a few other individuals associated with each project have full privileges for their project folder so they can manage their own permissions. These workspaces are intended to be a more familiar and convenient way of storing information, as an adjunct to the NCCN SharePoint site. Apart from reports and protocols (which are to be maintained in the NCCN Digital Library (a section of the NCCN SharePoint site), project leads will decide what is to be stored locally in these project workspaces as opposed to on the team SharePoint site. Examples of files kept in these project workspaces include: working files for project field crews, GPS downloads, GIS map files, database files, and other project records.

The NCCN file workspace is organized as follows under four main folders: Libraries, Projects, Temp, and Workspace. Project staff members will primarily be working in one or more of the project folders under Projects, and may wish to make desktop shortcuts to one or more of the project subfolders by right-clicking on the desired folder and selecting Send To > Desktop (create shortcut).

Project staff members should create a network shortcut to the project workspace by going to the Desktop in Windows Explorer and adding a new network place under My Network Places. Project staff located at OLYM will typically already have this path available to them via a mapped drive (e.g., the I:\ drive); however, they should still create this network shortcut where multiple parks are concerned for the sake of communications and consistency among parks. Performance is the main rationale for using network shortcuts instead of mapped drives at other parks.

Instructions for creating a network shortcut to the NCCN workspace:

1. Open an instance of Windows Explorer. One way is from the Start menu, go to: All Programs > Accessories > Windows Explorer. Another is to open My Documents, My Computer, or any other folder browser shortcut.
2. Navigate to the Desktop, and then to My Network Places.
3. Double-click the Add Network Place option to open the setup wizard.
4. Choose the option to specify the network location, then under network address, type in: \\inpolymfs\parkwide\NCCN
5. When prompted for a name for the network place, enter "NCCN" (or something similarly brief and meaningful).
6. This network place shortcut should now be available each time you log in to that particular computer, and can be accessed when navigating within most Windows software.

Project Workspace

A section of the NCCN workspace is reserved for this project. The recommended file structure within this workspace is shown in Figure 1.1

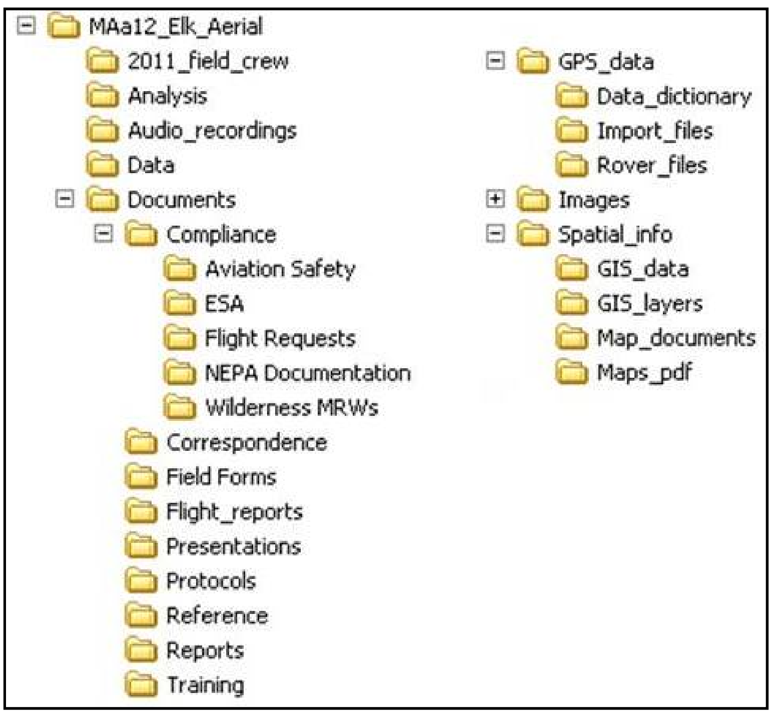

Figure 1.1. Recommended file structure for project workspace. Note: The workspace folder name includes ‘MAa12’, the NCCN project code.

Each major subfolder is described as follows:

- Analysis – Contains working files associated with data analysis.
- Audio_recordings – contains files of cockpit conversations, recorded during helicopter surveys.
- Data – Contains the front-end database application file for the season. The back-end database for the project is maintained in Microsoft SQL Server. Database exports and

other intermediate summary information can be stored here as well; these files are most effectively managed within subfolders named by calendar year.

- Documents – Contains subfolders to categorize documents as needed for various stages of project implementation. Additional folders and subfolders may be created as needed to arrange information in a way that is useful to project staff.
- GPS data – Contains GPS data dictionaries, and raw and processed GPS data files. This folder contains subfolders to arrange files by year. Each of these subfolders also contains the project code to make it easier to select the correct project folder within the GPS processing software.
- Images – For storing images associated with the project. This folder has subfolders named by calendar year to make it easier to identify and move files to the project archives at the end of each season. Refer to **SOP 10: Processing Digital Photographs** for details on how to handle and manage image files.
- Spatial info – Contains files related to visualizing and interacting with GIS data.
    - GIS data – Geodatabase for relational spatial data, plus new working shapefiles and coverages specific to the project
    - GIS layers – Pointer files to centralized GIS base themes and coverages
    - Map documents – Map composition files (.mxd)

Seasonal Workspace

In addition to these permanent folders, a temporary seasonal workspace is established at the beginning of each field season (e.g., "2011_field_crew"). This temporary workspace provides a place for field crew members to create and modify files while limiting access privileges for the remainder of the project workspace. Subfolders are created for Images and GPS data to allow field crew members to process incoming files as needed. Temporary workspaces may also be established on other servers to provide local access to crews stationed at other parks. At the end of the season, files in these temporary workspaces are then filed in the appropriate permanent folder(s).

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- No spaces or special characters in the folder name.
- Use the underbar (“_”) character to separate words in folder names.
- Try to limit folder names to 20 characters or fewer.
- Dates should be formatted as YYYYMMDD (this leads to better sorting than other date naming conventions).

File Naming Standards

Unless otherwise specified, file names should follow these guidelines:

- No spaces or special characters in the file name.
- Use the underbar (“_”) character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Dates should be formatted as YYYYMMDD.
- Correspondence files should be named as YYYYMMDD_AuthorName_subject.ext.

- Files with audio recordings should follow the naming conventions listed in **SOP 8: Digital Audio Recorder Use**.
- Files with photographs should follow the naming conventions listed in **SOP 10: Processing Digital Photographs**.
- Files with spatial information should follow the naming conventions listed in **SOP 11: Geospatial Data Management.**

Workspace Maintenance Procedures

Prior to each season, the Project Lead should:

1. Make sure that network accounts are established for each new staff member, or reactivated for returning staff members. By default, the IT staff puts new user accounts into a group that has read-only access to all files.
2. Create new folders named by year under the Images and GPS data sections.
3. Create the seasonal workspace, with subfolders for Images and GPS data.
4. Add user logins for the seasonal crew members to the seasonal workspace, with modify privileges. This can be done by right-clicking on the seasonal workspace folder, selecting Properties > Security, then adding users one at a time and checking the box in the Allow column for Modify privileges.
5. Provide the Data Manager with a list of user logins that need access to the database.

After each season, the Project Lead should:

1. Review the workspace organization and clean up any temporary files and subfolders that are no longer needed.
2. Move files from the seasonal workspace folders into the appropriate permanent folder(s), and archive or delete the seasonal workspace folders as desired. Refer to **SOP 10: Processing Digital Photographs** for specific instructions for image files.
3. Compare older files against the retention schedule in NPS Director's Order 19 (available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm). Dispose of files that are beyond their retention schedule if they are no longer needed. As a long-term project, many files associated with this project are likely to be scheduled for permanent retention. This makes it all the more imperative to clean out unneeded files before they accumulate and make it harder to distinguish the truly useful and meaningful ones.
4. Convert older files to current standard formats as needed to maintain their usefulness.
5. Identify files that may contain sensitive information (as defined in Section 4I of the narrative). Such files should be named and filed in a way that will allow quick and clear identification as sensitive by others.
6. Post final documents and files to the NCCN Digital Library for long-term storage. See **SOP 14: Product Delivery, Posting and Distribution**.
7. Send analog (non-digital) materials to the park collections for archiving.

SOP 2: Survey Preparation

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides an overview of general tasks that should be completed in preparation for survey flights. The included checklist refers to SOPs that contain specific instructions on how to complete those tasks.

Tasks

The following is a checklist of general tasks for reference by each park's project manager. For groups of tasks, the approximate time frame is in parentheses. For some tasks on the checklist, the appropriate SOPs or Appendices are denoted in parentheses. Use this checklist in the season before, and during, surveys. Appendix A includes a list of all tasks for the project, including their timing relative to spring or summer surveys and the person who is responsible for completing that task.

Check status of compliance (months before survey)

- ☐ Aviation safety plan
- ☐ Environmental compliance
    - NEPA, PEPC, Wilderness Minimum tool, Biological Assessment

Coordinate MORA interagency/intertribal cooperation (begin in April)

- ☐ Schedule meeting with tribal & state biologists
- ☐ Conduct meeting with tribal & state biologists

Schedule helicopter and crew (months to weeks before survey)

- ☐ OLYM: Add flights to annual flight planning request (January)
- ☐ MORA: A70 request for flights (June)
- ☐ Reserve helicopter time, including weather backup day(s)
- ☐ Schedule crew members
- ☐ Confirm that crew members have AMD helicopter certifications (SOP 3)
- ☐ Confirm availability of helicopter manager
- ☐ Finalize aviation safety plan (e.g., helicopter vendors, crew members, etc.)
- ☐ Review survey methods (SOP 7); train new crew members (SOP 3)

Database, geodatabase and records planning (weeks before survey)

- ☐ Prepare background maps on GPS units
- ☐ Print maps
- ☐ Deploy database for data entry

Prepare Equipment (weeks to days before survey)

- ☐ Check availability of survey equipment (SOP 7; Equipment Checklist)
- ☐ Review "Reminder checklist for elk surveys" again (SOP 7)
- ☐ Check status of digital audio recorder (SOP 8), digital camera
- ☐ Check status of GPS unit(s) and laptop (SOP 4)
- ☐ Gather and organize equipment
- ☐ Ask helicopter to come equipped for radio telemetry (if needed)
- ☐ Ensure that survey unit boundaries are on laptop (SOP 4)
- ☐ Ensure GPS connection to laptop works (SOP 4)
- ☐ Print data forms (SOP 7)
- ☐ Distribute maps to dispatch & helicopter manager
- ☐ Approximate location of radio-collared elk, if sightability trials will be conducted

Conduct survey flights (day before survey; day of survey)

- ☐ Check the weather and make sure it is OK to fly (SOP 5 or SOP 6)
- ☐ Review "Reminder checklist for elk surveys" again (SOP 7)
- ☐ Develop flight plan for each helicopter, including units to be surveyed
- ☐ Transfer survey unit boundaries to pilot's GPS unit (SOP 4)
- ☐ Install and check radio telemetry equipment (if needed)
- ☐ Synchronize all clocks, camera, digital audio recorder to GPS time
- ☐ Install audio recorder (SOP 8), GPS units, laptop (SOP 4) in helicopter
- ☐ Mission briefing
- ☐ Safety briefing
- ☐ Check that helicopter radio communicates with dispatch (both helicopters, at MORA)
- ☐ Check that all flight helmets have a functioning audio system
- ☐ Start audio recorder, state time
- ☐ Conduct survey; record data (SOP 7)
- ☐ Debrief and review data forms with crew members

Immediately after survey flights

- ☐ Download digital data to computer
  - o GPS (SOP 4)
  - o Audio (SOP 8)
  - o Photo (SOP 10)
- ☐ Draft flight report
- ☐ Process photos; update group size or composition, if needed (SOP 10)
- ☐ Transcribe other species data (SOP 8)
- ☐ Enter data into database (SOP 9)
- ☐ Verify data accuracy (SOP 9); inform Data Manager and GIS Specialist

SOP 3: Training Observers

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

Successful elk surveys hinge on close cooperation between all helicopter crew members, and a clear understanding of mission safety and data collection goals. A successful monitoring program depends also on clear planning and successful communication among NPS staff with a role in the project, and between NPS staff and staff from the tribes and agencies who contribute to completing the elk surveys at MORA – the Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), and Washington Department of Fish and Wildlife (WDFW). Training outlined in this SOP includes safety training required for any crew members on federally funded flights, and general training in survey methods for all participating crew members. Federally funded flights are those funded by MORA, OLYM, or USGS, and operate under IHOG (NIAC, 2009) and NPS aviation policies. State flights are funded, managed, and conducted by WDFW, and tribal flights are funded, managed, and conducted by MIT or PTOI.

Helicopter Safety Training

Helicopter use entails risks, and all crew members should contribute to a culture of safety on every flight. Every opportunity must be taken to ensure safety on these low level (less than 500 feet above ground level) flights. NPS helicopter use follows rules laid out within the Department of Interior Aviation Management Directorate Departmental Manuals (DM's) that include training requirements, in NPS RM 60 Aviation Management policies, in the Interagency Helicopter Operations Guide ("IHOG": NIAC 2009), within the OLYM Aviation Management Plan and within the MORA Aviation Management Plan. The training necessary to meet the qualifications for federal flights is not under direct supervision of the project manager. MIT, PTOI, and WDFW flights are not under federal control, so they are not required to follow IHOG guidelines unless there is an NPS employee on the flight. Also, none of the federal flight safety training detailed here is required for crew members on MIT, PTOI, and WDFW flights.

Observers

Observers on any federally-funded flights must complete the "B3 Combination Helicopter / Airplane Safety" course offered by AMD. NPS staff and non-NPS participants in high risk helicopter operations must initially take this one-day course from an instructor, and can complete subsequent refresher courses online once per two years, dependent on MORA and OLYM park-specific standards. After initial instructor led training, refresher training may be completed on-line (https://www.iat.gov/Training/pages/online.asp). Depending on the MORA Aviation Management Plan, non-federal personnel that fly on federally-funded flights at MORA may complete the training on-line (https://www.iat.gov/Training/pages/online.asp). The course includes five modules covering: aviation safety; aviation life support equipment; aviation mishap reporting; preflight checklist and briefing / debriefing; and crash survival. Average completion time for all five on-line modules totals 120 minutes.

Observers may also attend the S-271 Helicopter Crewmember Training (HECM) to receive certification. HECM trainee certification follows a one week training course (S-271) from an instructor.

Observers on federal flights must approach and depart from the helicopter under escort from the helicopter manager or a qualified helicopter crewmember (HECM).

Supervisors

The supervisors of any federal employee who will be an observer on survey flights must complete "M3 Management Training for Supervisors" course offered by AMD. Initial training for this course must be with an instructor, but subsequent refresher training can be completed on line one per two years. The course covers an overview of aviation policy and the supervisor's responsibilities to employees who use aircraft for NPS missions.

Helicopter Managers

Helicopter Managers are required to be qualified at the S-372 level, interagency helicopter manager, and must keep their certification current.

Pilots

Pilots on federally funded flights must be certified by the AMD for mountain flying and for conducting low-level flights in Type III helicopters.

Survey Flight Method Training for Observers

General Methods

Even a person who has extensive experience on other large animal surveys should be considered a 'new observer' for training, because there are elements of this protocol that are uncommon in other surveys. All new observers should read and thoroughly understand **SOP 7: Conducting Helicopter Surveys**. The project manager should review the survey methods in detail with any new observer. In the case of tribal or state flights, the tribal or state wildlife biologist should do this review with new observers. Experienced observers should also review **SOP 7** before every survey season. Preferably, there should be no more than one new observer on any given survey flight. Pilots should understand the survey methods, as described in **SOP 7**, particularly the double-observer methods. Pilots should be briefed on the methods in the pre-flight briefing.

Maintaining Independence

It takes self-discipline to refrain from calling out or indicating to others when you see an elk group. That, however, is what you must do to allow all observers to have a fair chance to independently see each elk group. Experienced observers should teach new observers how to recognize when it is all right to speak about an observed elk group. Observers should not speak out or make any motion that would indicate the presence of an elk group, until that elk group is slightly past perpendicular to the helicopter's line of travel (see **SOP 7: Conducting Helicopter Surveys**, Figures 7.8 and 7.9).

Identifying Covariates

All observers should read or review the description of age and sex categories, and of all the covariates in **SOP 7: Conducting Helicopter Surveys**. All observers should review the schematic diagrams of percent concealing forest vegetation in Figures 7.6 and 7.7, and the example photographs in Appendix D. New observers should review and discuss these photos with one or more experienced observers. When possible, in flight, new observers should have elk of different sex and age categories pointed out to them.

Laptop and GPS Operation

There are no specific guidelines for training the observer who will be handling the laptop in flight. Each tribe or agency uses its own configuration of laptop and GPS unit(s). Hardware and software are expected to vary among MORA survey participants, and to change over time. Prior to the flight, the observer who will be handling the laptop should be thoroughly familiar with the devices, and have training and practice so that he or she can confirm that the laptop will display the flight line and survey unit boundaries correctly, and that GPS units are collecting point locations to form the flight path data (see **SOP 4: GPS Use**). NPS staff can receive more specific instruction on the current steps involved with laptop use from the GIS Specialist.

Literature Cited

National Interagency Aviation Council (NIAC). 2009. Interagency Helicopter Operations Guide. Department of the Interior and Department of Agriculture, Boise, Idaho.

SOP 4: GPS Use

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides background and guidelines for GPS use in this project. More detailed instructions for operating and building background maps for specific GPS models and software are available from NCCN GIS staff.

Introduction

GPS receivers are used to navigate among and within survey polygons, map helicopter flight paths, and map animal observation locations. GPS receivers will help flight crews increase survey efficiency, determine whether or not survey polygons are surveyed adequately, and estimate flight times. Documenting flight times required to ferry to and from survey units and to survey individual survey polygons helps determine future planning and costs for helicopter use.

GPS receivers with customized background map data provide flight crews with geographic references throughout each flight. Background map data, such as survey polygons and waypoints, allow for more accurate flight following with park dispatch and enable better communications with other aircraft in the area. The combination of hardcopy or image file maps distributed to dispatch and the helibase and GPS receivers in aircraft is critical for crew safety. This is particularly important when two helicopters are conducting elk surveys during the same evening.

The helicopter survey crew and the pilot should not allow GPS receiver display to interfere with their situational awareness. Helicopter crews and pilots should not be distracted by GPS receivers. The pilot's priority is safely flying the helicopter, not looking for elk or determining what is or is not adequate flight coverage within a survey polygon.

One helicopter crewmember should be the designated navigator. The navigator, not the pilot, should check survey flight coverage and direct the pilot where to fly for further coverage if necessary, and direct the pilot to the next survey polygon. The GPS displays will help the navigator and pilot more efficiently communicate about survey flight coverage needs, but the GPS receivers should not ever be the pilot's main focal point.

The navigator should have paper maps in addition to GPS receivers and electronic maps. These maps will serve as navigational safety back-up in the event of electronic equipment failure or lack of satellite availability.

Specific methods and equipment configurations will change as equipment and software changes. The **Directions for GPS Use** that follow are general steps. More detailed instructions for operating and building background maps for specific GPS models and software are available from NCCN GIS staff.

In general the necessary GPS and mapping equipment per helicopter includes:

- One handheld GPS receiver (internal or external antenna) and a customized background map for elk survey data collection; receiver must be capable of storing flight lines (tracks) and waypoints
- One helicopter GPS with customized background map data to help the pilot navigate within and among survey polygons, and to communicate current locations to dispatch and other aircraft
- One laptop (optional) for additional mapping and data collection capabilities
- Hardcopy maps, or image file maps (.pdf, .jpg), with customized GPS background map information distributed to each helicopter manager and to park dispatch offices

Directions for GPS Use

I. Specific equipment needed
   a. One or more handheld GPS receivers
   b. Spare batteries or means of connecting handheld GPS receiver to external power source
   c. Helicopter GPS receiver (comes with the helicopter)
   d. GPS model-specific formatted files for upload into helicopter GPS (such as Garmin .gpx files or DNRGarmin .txt files)
   e. Firmware and software necessary to operate GPS receivers and customized data files (such as Garmin’s MapSource, Magellan’s MobileMapper Office, Trimble’s Pathfinder Office, or DNRGarmin (Minnesota DNR freeware)
   f. Laptop computer (optional; one or more GPS receivers with background map capability can be used with or without a connected laptop)
   g. Cable and software connections from laptop to GPS receivers
   h. Laptop mapping software (ESRI’s ArcGIS, Garmin’s MapSource, other)
   i. GIS and GPS intermediary software (DNRGarmin, MapWel, other) for background map file creation
   j. Paper map showing survey polygons to use as back-up if GPS set-up fails
   k. Means of securing lose equipment. For example, use Velcro to attach antennas to helicopter dashboards, use Velcro strips to consolidate antenna cables and tuck them out of the pilot’s way, have laptops and GPS receivers accessible, but secure (such as lying near the top of an equipment bag), secure paper (datasheets, maps, etc.) to clipboards.

II. Handheld GPS set-up
   a. Depending on GPS receiver display capability and software, create a background map in a software program that is compatible with the GPS receiver. Background maps should show the survey polygon boundaries, survey polygon name label, and waypoints desired for navigation (such as place-names or well-known landscape features)

b. See the project's geodatabase, MAa12_Elk_Aerial.mdb for spatial data that can be used to build GPS background maps
    i. many navigation points can be found in the Navigation feature dataset
    ii. survey polygon boundaries are in the Survey_Areas feature dataset
c. If desired, add national park boundaries, rivers, streams, etc.
d. Set the receiver to store a coordinate location every one or two seconds
e. Connect an external antenna to the GPS receiver to maximize satellite signal reception and make sure the antenna has a clear view of the sky (helicopter dashboard is a good place)
f. Make sure the clock is current and displaying local time
g. Set timers or watches to GPS time if time will not be recorded directly from the GPS display screen

III. Helicopter GPS set-up
a. Survey polygon boundaries may also be loaded into the helicopter's GPS receiver. This greatly increases pilots' abilities to navigate based on elk survey specific locations, such as a survey polygon, and it helps pilots see flight coverage within a polygon
b. Files representing survey polygons and waypoint locations need to be prepared prior to fieldwork and be ready for upload at the helispot
c. Transfer survey polygon boundaries and waypoints into helicopter GPS receivers prior to flights
d. Adjust helicopter uploaded data display, such as flight path color, label text size, and polygon boundary color, to pilot's specifications

IV. Laptop set-up
a. Laptop computers can be connected to GPS receivers and used for navigation, flight path recording, and animal observation data entry
b. Set laptop power settings so that the laptop does not shut down if the lid is closed, sleep mode is off, system stand-by is off, and any other settings to keep the computer from going dark during a survey
c. Create a background map in a laptop computer that receives data from a GPS receiver to show current location relative to survey polygons and other desired geographic locations or place-names
d. Load into the laptop whatever data entry program being used to store animal observation data
e. Connect GPS receivers to laptops and make sure communications work. Cabling, drivers, and software will be dependent on software and hardware manufacturers and models.

V. Flight line mapping
a. Begin recording GPS data a few minutes prior to take-off
    i. Begin an active log file
    ii. Or open a data file (use a simple name that can be quickly typed such as elk1)
b. If using a laptop, open the connection between the laptop and the GPS receiver
c. View GPS location via GPS receiver display screen or laptop screen running mapping software
d. If using ArcGIS with the GPS extension, begin writing GPS locations to a simply named log file (GPSLog_flt_xx.shp); this produces redundant data with a GPS file,

but provides nice back-up and some additional flight data fields such as speed and heading

e. After a flight, save the GPS data
   i. close the GPS file
   ii. or save the active track log to a saved track log and then clear the active track to get ready for mapping the next flight
f. Open a new file or begin a new active track log for each flight (one flight equals one take-off and one landing)

VI. Observation mapping
a. After an elk group has been located, the data recorder will record the time, to the nearest second, on the datasheet at which the helicopter is over the main part of the elk group
b. In addition, the GPS receiver operator can mark a waypoint in the GPS or in the laptop mapping program at the time which the helicopter is over the main part of the elk group
   i. Mark the location at the time the helicopter is over the main part of the elk group before the group begins to move
   ii. It is helpful, if there is time, to label the GPS waypoint or the laptop's GIS map with the elk group's observation number being entered onto the datasheets
c. Marking elk observations in GPS receivers and/or laptops often helps reduce double-counting instances
   i. previously marked elk group locations can help determine if another elk group observation has been previously recorded by viewing the helicopter's current flight path relative to the previously marked elk group
   ii. a marked location and it's observation number label can be cross-referenced to the datasheet to help determine if an elk group in question was previously observed by comparing the composition and number of currently observed elk to the composition and number of previously observed elk
d. Non-elk observations may be audio recorded (where the audio recorder time is set to GPS time) or marked on a datasheet with a GPS time to the nearest second

VII. Daily post-survey GPS data download
a. Download GPS data onto a laptop computer or onto a park service computer network after each day's flights
b. Rename GPS and GIS files with standard names
   i. GPS = GPSRec_AgencyCode_flt_xx.csv
   ii. GIS = GPSLog_AgencyCode_flt_xx.shp
c. Back-up GPS and GIS files on a flash drive or a computer network
d. Clear or delete files from the GPS receiver to make memory space for next day's flights

VIII. Recharge or replace GPS and laptop batteries

SOP 5: Summer Survey Weather

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP outlines weather conditions under which summer surveys should or should not take place, as well as several logistical considerations used in planning. This SOP lists recommended weather conditions for effective surveys.

Introduction

Weather strongly influences elk behavior and habitat selection, affecting the proportion of the elk population using the survey frame. Weather can also directly affect viewing conditions.

Summer surveys are conducted between August 15 and September 15. In summer, helicopters and pilots may become unavailable if they are hired to suppress fires. Because weather can be unpredictable, it is advisable to schedule survey as soon as possible after August 15. At OLYM, because there are no planned replicate counts, it is advisable for cost savings to choose a good weather window and try to complete all flights on consecutive days

Whenever possible, summer surveys should be conducted when weather conditions are optimal for elk detection. Optimal conditions for summer survey are cool (i.e., temperatures of 4° – 20° C at ~1800 m (6000 feet) above sea level), with no snow on the ground (other than in customary late-season or permanent snowfields), no ground fog, mist or precipitation obscuring the survey units or landing zones. A high cloud layer that causes the light to be uniformly flat also contributes to optimal viewing conditions.

Elk stay in the shade on hot days, and preliminary data from 2008 – 2010 at MORA suggest that elk remain under forested cover later in the evening on days that are notably hot. Although there is currently no temperature cutoff above which surveys are precluded, the park project manager and other participating wildlife biologists may want to consider delaying surveys if temperatures at 5 pm are ~27°C at elevations of 1800 m (i.e., ~80°F at 6000 feet). If temperatures are known at lower elevations, use the dry adiabatic lapse rate of 9.8°C per 1000 m (5.5°F per 1000 feet) to estimate the temperature at 1800 m (6000 feet). Subtract 17°C (31°F) from temperatures measured at Fairchild International Airport, near OLYM. Subtract 10°C (18°F) from temperatures measured at Ranger Creek Airstrip, near MORA. Subtract 15°C (27°F) from temperatures measured at Packwood airport, near MORA.

In practice, helicopters, pilots, and survey crews are not always available when ideal conditions occur. Survey dates and backup survey dates often must be scheduled weeks or months in advance for summer surveys, and the decision facing the park project manager and helicopter manager is whether or not to hire the helicopter for use on that day. This decision can be fraught with uncertainty. If the helicopter is already hired but weather conditions degrade to the point that no survey is conducted on the anticipated day, then the project will lose the cost of any minimum guaranteed flight time and the cost of pilot and fuel truck driver lodging and per diem. On the other hand, if conditions are acceptable but the helicopter was not hired, then one of the few potential survey days is lost. The decision at MORA is more complicated because federal, state, and tribal flights paired on a single evening make up each complete trend count area survey. Our experience has shown that the decision to proceed with a survey is necessarily subjective, based on considerations of cost commitments, future helicopter and crew availability, and, in the case of summer surveys in MORA, coordination with MIT, PTOI, and WDFW.

Conditions that Preclude Summer Survey

The pilot, and any crew member, should direct surveys to stop if conditions are not safe.

Helicopters hired by NPS or with NPS employees on board may not survey if wind speed exceeds 30 knots (55 km/hr or 34 miles/hr) of steady wind or if the wind gust spread exceeds 15 knots (27 km/hr or 17 miles / hr), as per NIAC (2009) guidelines.

Do not survey when rain is falling steadily. A light rain, or drizzle may be acceptable for surveys, but wet windshields and windows could impair the crew's ability to see elk.

There should be little to no ground fog or clinging mountain mists for surveys. Fog and mist can be a safety hazard that also obscures the survey area. Fog is especially opaque in bright light conditions. Ground fog is typically heavy on a morning after a heavy rain.

Surveys at OLYM may be complicated by the development of a marine layer of low-elevation clouds. If such a layer is developing, the Obstruction Point landing zone (at high elevation) or Sweets field (inland) can be used.

The National Weather Service Forecast office provides rainfall probability and wind speed predictions for any given location. Go to www.weather.gov; in the field for 'Local forecast by "City, St" type a location near the survey area, such as "Sunrise, WA" or "Port Angeles, WA." Choose a location for the Detailed Point Forecast in the survey area, using the Google map window at right. Once the forecast is shown for that location, scroll to the bottom of the page and select "Hourly Weather Graph" from the Additional Forecasts & Information menu. The hourly weather forecast graph includes predicted temperatures, wind speeds, and precipitation probability (Figure 5.1).

Be aware of impending storms, and release the helicopter early enough that the helicopter can return to its base before any long storm arrives. Avoid the expenses that come if the pilot and helicopter are forced to stay grounded for several days; in addition to per diem, costs may include three or more hours of flight time per day.

In assessing weather conditions for the immediate future, consult any available webcams. These can be useful, for example, in deciding whether fog or clouds at MORA are too thick for survey.

Weather web-cameras are available for showing current conditions at MORA and OLYM. The webcam pages listed here also include links to views of conditions in the high mountains.

http://www.olym.nps.gov/Ridgecam/main_ridgecam.htm
http://www.mora.nps.gov/dashboard/Webcams.aspx
http://www.wrh.noaa.gov/sew/whitepasscams.php
http://www.nature.nps.gov/air/WebCams/parks/moracam/moracam.cfm

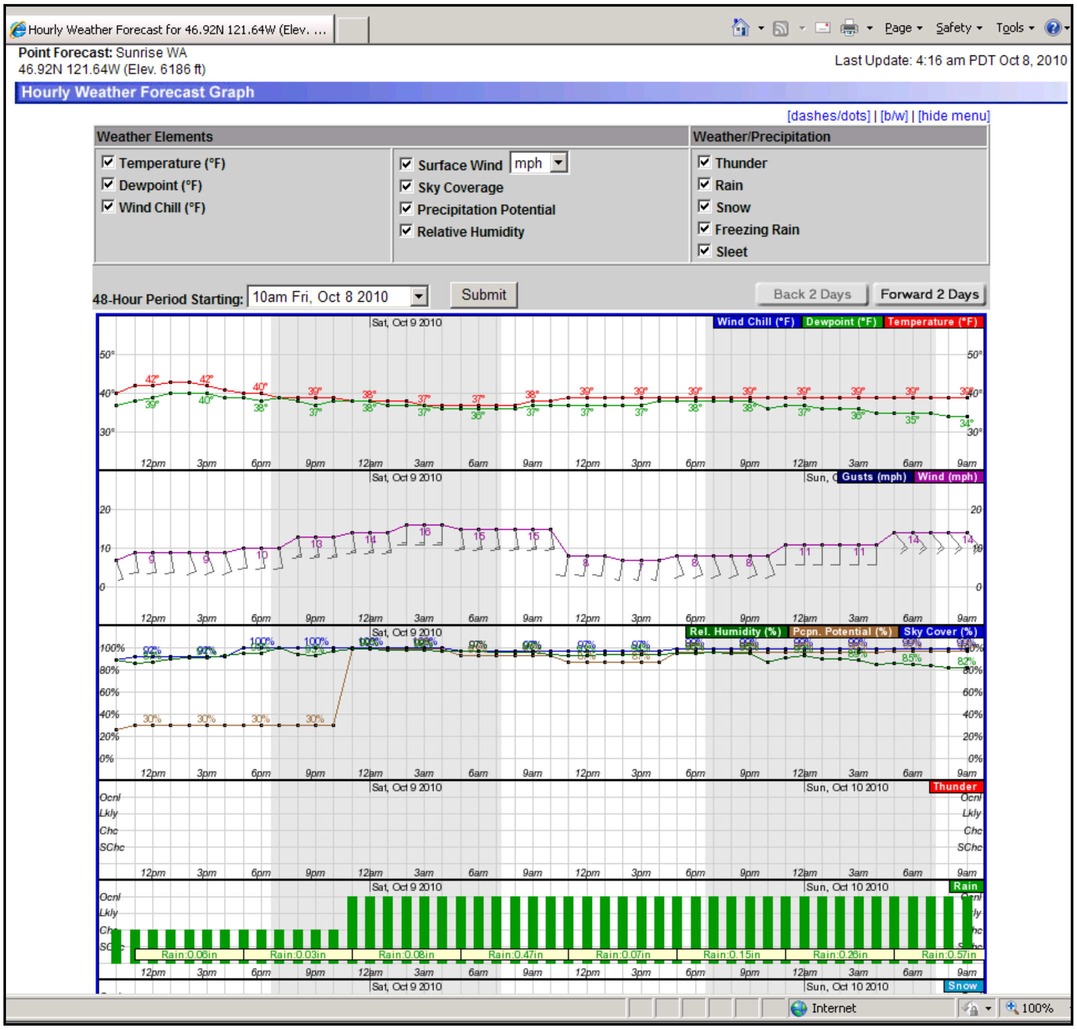

Figure 5.1. Hourly Weather Forecast Graph, available through www.weather.gov. Rainfall probability is shown with bars indicating small chance, chance, likely, or occasional. Total expected rainfall in different time periods is printed across the bottom of the Rain graph. Average windspeed is shown as a line in the graph. Wind barb symbols represent the wind speed and direction; each full barb represents an additional 10 knots (18.5 km/hr), and each half barb represents 5 knots (9 km/hr).

Literature Cited

National Interagency Aviation Council (NIAC). 2009. Interagency Helicopter Operations Guide. Department of the Interior and Department of Agriculture, Boise, Idaho.

SOP 6: Spring Survey Weather

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

For years when supplemental or outside funding allows for spring surveys in OLYM, this SOP outlines environmental conditions under which the spring surveys in OLYM should or should not take place. Conditions for spring surveys have relatively tight prescriptions for plant phenological state, long term weather forecasts, and daily weather. This SOP lists conditions for go/ no go decisions determining when to start planning the flights, when to call the helicopter over to conduct surveys, and the daily decision of whether or not to survey.

Introduction

The spring elk surveys in OLYM take place at a time of year when the weather conditions are often not conducive for aerial operations; there are often extensive periods of precipitation and unpredictable weather. The timing of the surveys is also limited to a narrow phenological window: early spring when herbaceous plants have initiated growth (or green-up) but before deciduous trees have leafed out (and hamper elk sightability). These conditions usually occur for about a month, from mid-March through mid-April, but the timing can change depending on how severe the preceding winter was and the warmth of the spring. The operational window is also currently limited to stopping by 1 April, due to effects of low elevation helicopter flights on Marbled Murrelets (*Brachyramphus marmoratus*) during the early nesting season. These factors, coupled with the fact that the surveys must start at dawn, which necessitates that the helicopter be in place in Forks the night before the survey, makes the logistics of this protocol challenging to conduct while staying within the operational budget.

Plant Phenology in Spring Trend Count Areas

Houston et al. (1987) suggest that surveys should take place when there is a flush of spring growth in floodplain herbaceous vegetation, but before the leaf-out and canopy closure of the deciduous trees. This determination was based on previous radiotelemetry studies indicating that elk focus use in deciduous forests on the river floodplains during early spring (Jenkins 1980). However, as the spring progresses bud burst and leaf-out in mid and top canopy deciduous trees negatively influences elk sightability. The dates on which Houston et al. (1987) conducted their surveys ranged from March 17 to April 12; these flights, however, took place prior to the federal listing of the Marbled Murrelet as a threatened species. Current surveys are restricted to days before 1 April, to limit disturbance of Marbled Murrelets during the early nesting season. In some years, the phenological conditions recommended for spring elk surveys might not materialize before March 30. When that occurs, flights should not be conducted, because many elk will be out of the survey frame, higher on the valley slopes.

There are several ways to evaluate whether or not phenological conditions are correct for surveys:

1. Ask park staff at the Hoh Ranger Station to describe plant phenological conditions and its progression, starting in late February and continuing into March
2. The OLYM project manager can visit the Hoh floodplain to assess the spring green-up conditions, and
3. Incorporate integrated weather data, like the cumulative number of degree-days (in degrees Fahrenheit) above 40° F since February 1, as measured at the Quileute airfield weather station (Figure 6.1). Although there is no definitive cutoff, surveys may tend to be more successful after this index approaches about ~150 degree-days. This index may correlate with the green-up that occurs in floodplain plants after a certain amount of warmth and light have fostered enough spring foliage growth. Houston et al. (1987) hypothesized that this growth attracts elk into the delineated trend count areas. By early March, the OLYM project manager or designated staff person should begin to assess the cumulative number of degree-days since February 1.

Go/ no go decisions:

1. If over 33% of the survey area is under snow and has been that way all winter, do NOT survey
2. If there is no visible herbaceous growth at the Hoh ranger station, do NOT survey.
3. If there is very little herbaceous growth, and willows have not started to leaf out at the Hoh ranger station, it MAY be too early to survey. Phenological conditions in the upper half of the valley are often a week or more behind the lower valley. If phenological conditions are marginal in the lower valley, they may not have progressed adequately in the upper valley where a large proportion of the herds in question reside.
4. If skunk cabbage (*Lysichiton americanus*) is up, graminoids are lush and green, salmonberry (*Rusus spectabilis*) is blooming, and willows (*Salix* spp.) are starting to get a green tinge at the Hoh ranger station, surveys may proceed.
5. If Alder (*Alnus rubra*) catkins start to erupt and willows leaf out at the Hoh ranger station, surveys may proceed, but there may not be much more time until leafout is too great for surveys.
6. If Alder buds are beginning to open and show a green tinge, and willow and salmonberry is leafed out at the Hoh ranger station, survey conditions are marginal, but probably still suitable because phenological conditions will be further behind up valley and elk are still visible.
7. If Alder is ¾ leafed out at the Hoh ranger station, canopy conditions are such that elk will not be visible in most of the deciduous habitats, and any remaining spring surveys for the year should be cancelled.

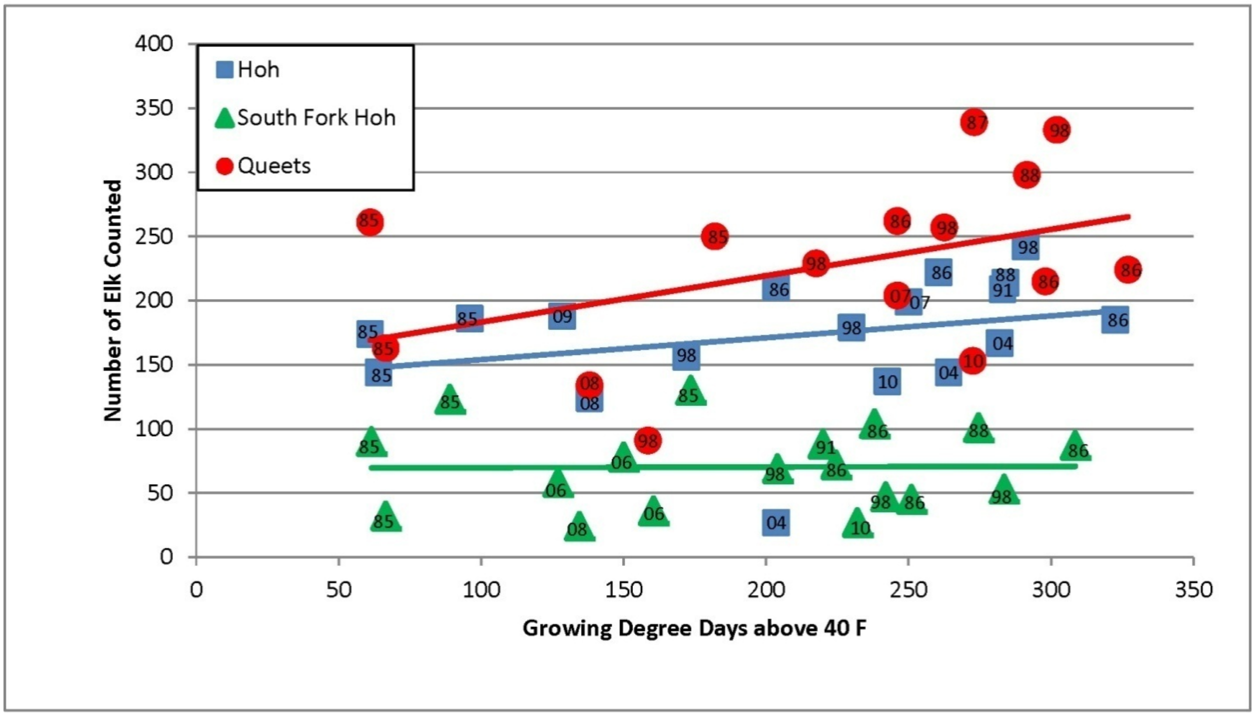

Figure 6.1. Scatterplot of the total number of elk seen (y-axis) in spring surveys over the Hoh (blue squares), South Fork Hoh (green triangles), and Queets (red circles) trend count areas, as a function of the number of cumulative degree-days since February 1 (x-axis, as measured at Quileute airfield, Clallam County). The approximate relationship, based on linear regression, is suggested separately for the Hoh, South Fork Hoh, and Queets trend count areas with a, respectively, blue, green, or red line. Labels on data points are the last two digits of the year of survey.

Weather

Weather conditions have a profound influence on whether or not one should perform an aerial elk survey. Poor weather conditions affect flight safety and elk visibility and can also strongly influence elk behavior and habitat selection. The following are some weather factors to consider:

1) Under conditions of deep snow, or very cold mornings a greater proportion of the elk will be out of the survey frame and remain either up valley or on the warmer side slopes. Counting under these conditions will lead to low counts and greater variability in long term trends.
    a. Consequently, do not conduct counts under these conditions.
2) Valley fog or river mist, a common condition the morning after heavy rains, can obscure significant portions of the survey area, potentially obscuring herds of elk and precluding their detection.
    a. Do not initiate a count if it appears that >10% of the valley is obscured by valley fog. Cease operations if those conditions occur.
3) Incoming storm fronts can cause deterioration of conditions (visibility or winds) during the survey flights, and cause cessation of activities prior to obtaining complete counts.
    a. If possible, plan counts during periods of predicted stable weather.
    b. If there is valley fog and a dropping ceiling, do not initiate a survey, and terminate the survey if these conditions develop mid-flight.

   c. In some conditions, the best lighting conditions (a high overcast layer of clouds) for survey can be on days when the leading edge of a storm front arrives. If a survey is conducted on such a day, it is critical to know before the survey begins that there will be enough clear weather for the survey to be completed, and for the helicopter to return to its company's helibase.

4) Bright sun creates glare on the helicopter window and high contrast in areas of coniferous cover – both of which act synergistically to reduce elk detectability and reduce counts. Bright sun is a greater problem when there is valley fog, because it makes the fog, which is normally somewhat transparent, practically opaque.
   a. Avoid surveying on days that are totally cloudless whenever possible.
   b. If overcast conditions clear during the flight, record that as a covariate.
   c. If there is a chance for a clearing trend, start the survey on the western edge of the survey area, so that shading from the valley wall can mitigate glare in the upper portion of the valley at the end of the survey when the sun rises over Mount Olympus.
   d. If glare develops and there is a significant amount of valley fog, consider aborting the survey. If too much survey time has already been committed to abort, note conditions where it was impossible to survey on the data.

Long Term Weather Go/ No Go Decisions

During March the competition for helicopter resources is not as intense as in the summer months i.e. there are no fires, but there are usually several other groups (state and tribal biologists) that want to fly during this time period. Consequently, it is best to reserve the helicopter for the predicted best window – usually the third week in March – at least a month in advance. Because we are surveying three different valley bottoms only once, it is possible – and preferable - to survey on three consecutive days. Although we need only three days of good flying conditions, these are often infrequent, so by scheduling to start in mid-March there are over 14 days to try to complete three mornings of survey.

As the survey time approaches and if the spring looks to be warmer than average, one could start talking to the helicopter company and see the survey could be moved up a week - although this is rarely necessary. On the other hand, if it is a late winter and phenological conditions are not great, the flights may need to be delayed until the last week of the month.

Weather on the Week of Flights

The week before the flights are scheduled to begin, given that the phenological conditions are within prescription, the park biologist and the helicopter manager should start looking at the long term weather forecast and looking for periods of predicted stable weather with no predicted precipitation and cloudy skies. If things look promising, start communicating with the helicopter provider and confirm the start date. The helicopter will need to come over the night before the survey for check-in (**SOP 7: Conducting Helicopter Surveys**; Survey Flights, Preflight). Whether or not to bring the helicopter over or not is a tricky decision. If the helicopter comes and the weather is bad, that is a waste of funding required to ferry the helicopter and pilot into position for the survey. On the other hand, if the helicopter and pilot are not in position for the survey and the weather is good, that may mean missing one of the few windows of opportunity. Also, if the helicopter is delayed too much beyond a scheduled time period, the helicopter may go to other projects, or the preferred pilot may be no longer available.

Some go/ no go decision points on whether or not to bring over the helicopter:

1) If there is a predicted sunny spell, wait if there will be another opportunity with cloudy skies, but if time is running out or the pilot does not have flexibility in scheduling, it is worth the gamble to bring the helicopter over, because:
    a. It is often less sunny in the west end of the peninsula than predicted.
    b. The South Fork Hoh can be surveyed on a sunny day because it can be completed before the sun rises over the ridge line (it is a smaller survey area than the Hoh or Queets).
2) If the period of good weather follows a time of heavy rain, delay bringing over the helicopter for a day, if possible. Often, following rain a heavy valley fog builds up, precluding surveys.
3) It is often possible to forecast two days in a row of adequate survey weather, if the first is a day with high pressure, and the second is a day when low pressure is beginning to bring clouds over the region. The high pressure day will typically be clear, which is not good for surveys – that day can be used to survey the South Fork Hoh trend count area, though. The second, overcast, morning, can be spent surveying one of the longer trend count areas (Queets or Hoh).

Overcast skies lead to ideal survey conditions. An overcast dawn is most common at the spring trend count areas when there has been a high pressure system over the region for at least a day, and storm or low pressure system is moving in to the area from the west. The high stratus or cirrus layer that is the leading edge of the incoming weather system leads to overcast conditions. These conditions typically last one morning at most, though, because the arrival of a storm prevents survey on the following day.

Weather on the Day of the Flight.

Because surveys begin at the Forks airport, the survey crew must leave Port Angeles at least two hours before the flight (~ 5 am if it is daylight savings time). Because the weather conditions are so different between Port Angeles and the western valleys, it is impossible to make the go/no decision in Port Angeles – the call must be made at the Forks airport in the half-hour before dawn. Often it is hard to make a definitive call, so the crew may need to fly towards the Hoh before making a final decision. In this project we are surveying three different river valleys, each with different logistical considerations.

- The South Fork Hoh is the shortest and is done on only one tank of gas. It is best to save this one for last, if possible, because it is the easiest to do, can be done on a clear weather day. Also, one can wait for weather to improve for 1.5 hours before initiating flight and still get the South Fork Hoh done within the time of day prescriptions.

- The Queets is the hardest to do: it is the furthest away from Forks and the weather is often the worst in the southwest. In addition, arrangements must be made for remote refueling with a fuel truck. However it may be possible to complete the survey with one tank of gas and then just refuel for the trip back to Forks. Plan on doing this valley first – but it often will be the last to get done.

- The Hoh takes the longest to fly, and requires a refueling break in mid survey. It is best to have a fuel truck on site so that there is not too long a break between flights. The Hoh also is the most heavily visited valley, so there must be no surveys there on weekends.

Day of flight go / no decisions:

1) If it is raining, snowing or sleeting, don't fly.
2) If the ceiling is <1000 m (~3000 ft), a survey will probably not be possible, although the conditions may be better in the interior. A good indication is if the ridgeline to the north of the Forks airport is not visible because of a low ceiling, then a survey is probably not possible. It is helpful to arrange with staff in the Hoh Ranger station to call in and check on local conditions (ceiling, precipitation).
3) If, upon flying to a valley to survey, there is >10% valley fog, that probably means that there will be too much fog to conduct the survey. However, if it is near the end of the dates of the survey window, and the fog appears thin and is lifting, then it may be worth conducting the survey. Often, valley fog improves throughout the morning. Only try this on an overcast day, however.
4) If, upon flying to the valley, the ceiling is near the ridge top, then conditions are fine for survey, but:
   a. Start the survey at the upper end of the valley and work towards downstream.
   b. If, at any time the ceiling starts to drop or the weather deteriorates, abort the survey.
5) If one valley looks marginal, but the decision is to not survey, take a look at conditions in another valley, if that is logistically possible. Weather conditions vary throughout the survey area and sometimes one valley may be flyable when others are not.
6) If wind speed is stronger than 30 knots, or if gusts are > 15 knots above the background wind speed, do not fly. If these conditions develop mid survey, abort the survey. The Interagency Helicopter Operations Guide (IHOG; NIAC, 2009) details other safety considerations that must be followed.

Literature Cited

Houston, D. B., B. B. Moorhead, and R. W. Olson. 1987. Roosevelt elk density in old-growth forests of Olympic National Park. Northwest Science 61:220-225.

Jenkins, K. J. 1980. Home ranges and habitat use by Roosevelt elk in Olympic National Park, Washington. M.S. Thesis. Oregon State University, Corvallis.

National Interagency Aviation Council (NIAC). 2009. Interagency Helicopter Operations Guide. Department of the Interior and Department of Agriculture, Boise, Idaho.

SOP 7: Conducting Helicopter Surveys

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides instructions for conducting helicopter surveys, including guidelines for equipment preparation, crew duties and flight conduct, and how to record data.

Introduction

Surveys are conducted to maximize the chance of seeing the largest number of elk present. All surveys are double-observer surveys, where each observer acts independently of other observers in the initial detection of elk groups.

Pre-Survey Planning

MORA and OLYM summer surveys take place between August 15 and September 15. Weekend surveys are precluded in MORA in order to reduce visitor conflicts. OLYM surveys preferentially take place on weekdays, but occasional weekend surveys may be allowed if there is permission from the OLYM superintendent. At least two months before MORA surveys, the MORA project manager should convene an in-person or teleconference meeting, so that project participants can plan for survey schedules and discuss survey procedures. Project participants should coordinate their attempts to contract with helicopter companies, to streamline pilot and helicopter scheduling. Helicopters and experienced pilots should be reserved and scheduled as early as possible following the coordination meeting.

Surveys require three observers and a pilot. NPS surveys also require a helicopter manager who should also be scheduled well in advance. Observers should, as much as possible, be experienced at finding ungulates from helicopters and should read and be familiar with methods in this document (in particular, the **Survey Procedures** section). Preferably, no more than one inexperienced crew member would be on any single survey flight. Similarly, experienced pilots should be contracted as much as possible.

Daily Preparations and Supplies

Safety

Safety is essential for all aspects of all surveys. Any flight with a federal employee on board must follow interagency helicopter operating guidelines ("IHOG", NIAC 2009). Tribal and State flights are not subject to IHOG regulations, however all flights should be coordinated. For NPS flights, the project manager at each park should prepare and secure approval for the Project

Aviation Safety Plan well in advance (**Appendix A: Yearly Project Task List**); this plan should be understood by all flight crew and the helicopter manager. One copy of the Safety Plan, along with maps of the intended survey routes, should be distributed ahead of time to park dispatch, one to the helicopter manager, and one brought on the helicopter.

As members or employees of sovereign nations or a state agency, tribal and state biologists do not need NPS approval of any flight safety plan, but they should communicate and coordinate with the MORA project manager the timing and location of their elk survey flights. The MORA project manager, in turn, must notify the MORA dispatch about the timing and location of tribal and state survey flights, and should confirm that dispatch has maps of the elk survey units. Although MORA personnel do not formally flight follow tribal or state flights, it is a courtesy and an effective safety precaution for the pilot to always call in via radio to the dispatch when entering the park, when entering a new survey unit, and when leaving the park. On any evening in MORA when two helicopters are scheduled to conduct surveys, for safety reasons no helicopter will survey unless both helicopters are in communication with each other and with park dispatch.

Washington state funded surveys must follow WDFW Wildlife Program Aircraft Safety SOP.

Weather and Flight

Many factors influence the go / no-go decisions (**SOP 5: Summer Survey Weather**, and **SOP 6: Spring Survey Weather**). Do not order the helicopter or fly if you do not meet the conditions laid out in the applicable SOP.

Trend Count Areas and Survey Units

Maps and a table of survey unit areas and approximate required survey time are in **Appendix E: Trend Count Areas and Survey Units**. Having trend count areas separated into survey units helps with survey planning and navigation. At MORA, survey crews must coordinate flight plans in advance so there is no question about which tribe or agency is surveying in which survey units. This is critically important if two helicopters are surveying within the park on the same evening.

Summer survey units are named with a letter-number-letter combination. The first letter(s) indicate the trend count area. At MORA, these are North (N) and South (S); at OLYM these are Core (C), Northwest (NW), Elwha (E), Quinault (Q), and Southeast (SE). The number and following letter indicate the survey unit number; for example, C6a, and C6b are two separate survey units. There are three spring OLYM trend count areas in large floodplains (Hoh, HOH; South Fork Hoh, SFH; and Queets, QTS). These are not subdivided into survey units.

The GIS Specialist maintains digital files of survey units (polygon features) in a geodatabase (SOP 11: Geospatial Data Management). The MORA project manager should confirm that all MORA project participants have correct survey unit boundary features loaded into the pilot's GPS unit.

Crews should be very familiar with the survey areas. The helicopter pilot and the crew member operating the GPS-enabled laptop can both identify survey unit boundaries, relative to the helicopter's flight path, in real time during survey. Having paper maps, in addition to the GIS /

GPS enabled laptop, allows for navigation if all electronics should fail. The GIS Specialist should print several sets of survey unit maps (**Appendix E: Trend Count Areas and Survey Units**); one set should be given to park dispatch one week prior to the survey, one set should be brought on the helicopter, and one set should be left with the Helicopter Manager. The MORA project manager should provide sets of these maps to MIT, PTI, and WDFW participants.

Equipment

The project manager for each park, or the state or tribal biologist, should prepare the survey equipment. In addition to a helicopter and pilot, the main items needed include personal protective equipment (PPE), data sheets, clocks, a GPS-enabled laptop and at least one more GPS unit, a digital camera, and (for NPS flights) a digital voice recorder. Detailed lists of required equipment are presented in the Elk Survey Equipment Checklist (page 131).

Helicopter pilots are accustomed to using GPS units for navigation. The GIS specialist, project manager, tribal biologist, or state biologist will upload survey unit boundaries to the pilot's GPS unit before flights. At this time, uploading requires a laptop with the survey unit boundary coordinates saved as a tracklog or shapefile, a working copy of DNRGarmin software (Minnesota Department of Natural Resources 2008), and a USB to Mini-USB cable. Instructions for uploading to the pilot's GPS unit are in **SOP 4: GPS Use**.

On each survey flight, a laptop or other portable computer with mapping software (GIS) should show and record the flight line in reference to survey unit boundaries. Having this laptop is useful for knowing where the helicopter is, for making sure that survey unit coverage is adequate, for logging the flight lines in detail (i.e., one point per 1-2 seconds), recording elk group locations, and to aid in determining whether a group has been recorded previously. The choice of laptop model and software is left to the participating tribe or agency, but it should be connected to a GPS unit, or be otherwise GPS-enabled. WDFW is refining software application for recording elk group location directly within GIS (A. Duff, WDFW, personal communication). If no laptop is available, then the required tasks could be done using a GPS unit if it has adequate display to show flight path within survey unit boundaries and if someone is designated as the person who marks waypoints. However, the larger screen of a laptop makes these tasks easier in a moving helicopter.

At least one additional GPS unit should record the flight, in case the GPS-enabled laptop fails to record the flight path. At MORA, the pilot's GPS unit can serve this purpose if it has enough memory to contain survey units and to record a flight track file.

Survey Procedures

Crew Positions and Duties

The crew consists of one pilot, one front seat observer, and two back seat observers. The pilot's primary duty is to fly the helicopter safely. The pilot may also contribute observations of elk as a secondary function, but the pilot must not let the visual search for elk distract from the focus on safe flight.

The data recorder should not sit directly behind the pilot. One crew member (the navigator) is responsible for operation of the GPS and the GPS-enabled laptop. On NPS flights, one back seat observer records data, and the other manages the GPS-enabled laptop. On NPS flights in both parks the laptop operator will typically be the back seat observer seated directly behind the pilot. At MORA, each participating tribe and agency may determine the specific seating arrangements of their crew.

Defining Age and Sex Categories for Composition Counts

In summer surveys, elk group composition is recorded as the number of cows, calves, yearling bulls, subadult bulls, and mature bulls. All observers should have prior experience judging sex and age-classes of elk, but the enclosed figures are included for training if an inexperienced observer is unavoidable. Calf and cow elk are distinguished from bulls by the absence of antlers (Figures 7.1, 7.2). Calf elk and deer, which could be confused from the air by novices, are easily distinguished by the large cream-colored rump patches on elk (Figures 7.1, 7.2).Deer have smaller bodies and typically a more reddish hue. Calf elk are smaller than cow elk, and calves may have slightly darker fur (Figure 7.1).

Bull elk will be classified and recorded based on three categories (Figure 7.3). Yearling bulls, also known as spikes, typically have only one point to each antler. Subadult bulls, sometimes called 'raghorns,' are small beamed, with 3-5 points per antler. Mature bulls are typically four or more years old; they have large antlers with heavy beams, typically with five or six points on each antler, but sometimes only four in OLYM. Calling a bull mature will be based on overall size of the animal and the apparent heaviness of the antler beams; a broken-antlered bull could correctly be called mature. Binoculars can be helpful in classifying bulls.

Deer observations, along with those of bears, mountain goats, eagles, coyotes, or any other wildlife species are recorded on the Other Species Data Form. That form allows for detailed recording of the number of animals and their immediate surroundings (see below, **Completing the Other Species Data Form**). For summer surveys, recording other species observations may distract from the search for elk, so those observations are transcribed, based on an audio recording of the cockpit conversation.

Figure 7.1. Photos of cow and calf elk (left), and black-tailed deer doe (middle) and black-tailed deer buck (right), seen from the ground. Photo credits: P. Happe, NPS (elk); C&G Photography (deer).

Figure 7.2. Photos of cow and calf elk (left), and deer (right), seen from the air. Photo credit: NPS.

Figure 7.3. Photos of cow and calf elk (above left, photo credit: P. Happe, NPS), yearling bull elk (above right, photo credit: P Happe, NPS), subadult bull elk (below left, photo credit: P. Happe, NPS) and mature bull elk (below right, photo credit: S. McCorquodale, WDFW).

Defining Elk Group Covariate Categories

Covariates are attributes of an elk group that may influence their detection probability, and that are recorded with each observation. It is important for everyone to understand how they are defined, and that all observers collect covariate data in a uniform manner. Group size is the total number of animals in the observed group of elk. A group is defined as any group of one or more elk that move together as part of the same social unit Other covariates to record for every group of elk seen are:

- activity
- cover type
- percent concealing vegetation
- lighting condition

Note that there are numerous possible ways to define how a variable is measured or recorded—for example whether the variable is recorded for the majority of animals or the first animal seen. It is imperative that every observer understands that differences in the way variables are defined is not as important to subsequent model development as is the absolute requirement that all observers record variables in the same manner, using the set of rules described here.

<u>Activity</u>

Choose one of three choices: bedded (lying), standing, or moving (walking or running). The one choice recorded is the one that best describes the majority of the group's activity *at the time the group was first detected*.

<u>Cover Type</u>

Select the cover type category that describes the prevalent vegetation cover where the majority of the elk group is located, when the elk group was first seen. Chose the cover type that best describes the greatest proportion of an area defined by a 10 meter buffer surrounding the *entire elk group at the time it was first detected*. For large groups, observers may first need to assess where the majority of the group was at the time when the group was first detected, then select the cover type describing cover type surrounding the whole group. Cover type categories used for summer surveys (Figure 7.4) include: rock, snow, herbaceous (grasses, forbs and other non-woody plants), shrub, and forest (dominated by trees). After a fire, burned areas should be classified as shrub if shrubs are the predominant vegetation, and as forest if trees that could obscure detection have persisted. For spring surveys in OLYM, the cover types (Figure 7.5) include river, gravel bar (which may have shrubs on it), alder flat, maple forest, grassy meadow, old growth forest, open old growth forest (which includes sizable gap-phase openings between standing trees), and shrub-upland (including slide alder and post-fire shrub regeneration). More photographs of cover type categories are in **Appendix D: Photographs of Covariate Categories**.

<u>Lighting</u>

Lighting condition categorically describes the light under which the elk group was observed. "High contrast" means that there are distinct shadows in the area surrounding the elk group, while "Flat" means that there are no distinct shadows. Figure 7.5 illustrates conditions with high contrast.

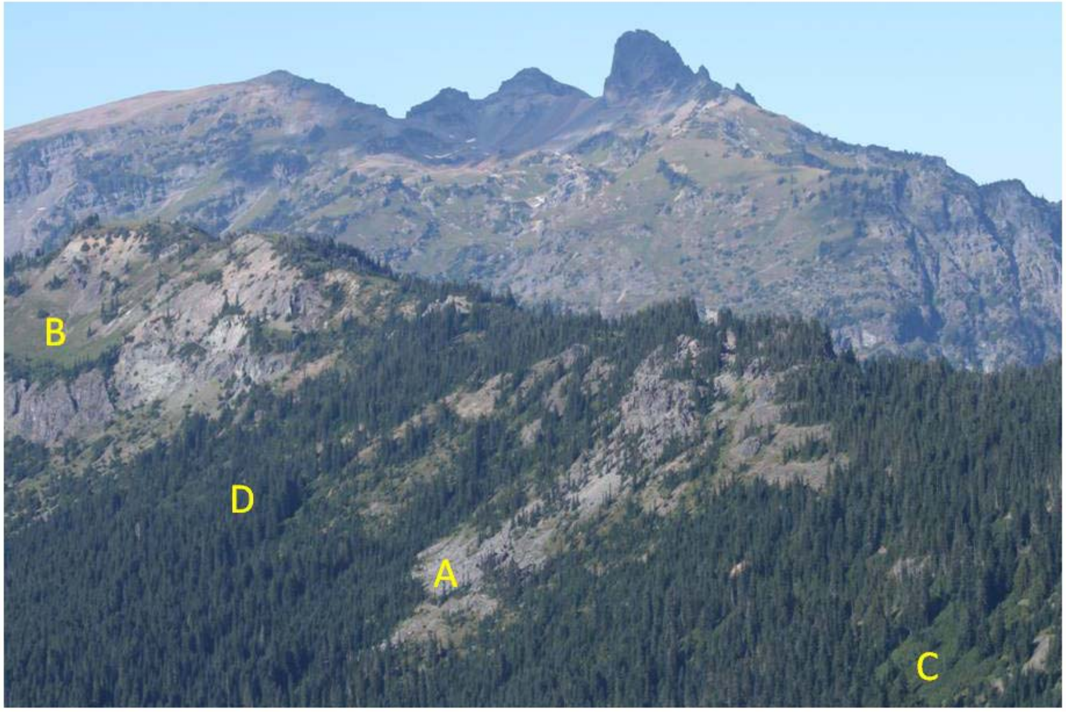

Figure 7.4. Photograph from MORA, showing several of the summer survey cover types: A Rock, B Herbaceous, C Shrub, D Forest. Snow as a cover type is not pictured here.

Figure 7.5. One portion of the Queets trend count area (March 29, 2007), showing several of the spring survey cover types: A. River; B. gravel bar; C. Alder flat; D. Maple forest; E. Grassy meadow; F. Old growth forest. Open old growth forest and Shrub-upland are not pictured here.

Percent Concealing Vegetation

Percent concealing vegetation is a categorical estimate of the percent cover of vegetation that has the potential to completely obstruct observers' view of elk (Unsworth et al. 1999). Percent concealing vegetation will be recorded as one of 5 classes: 0%, 1-25%, 26-50%, 51-75% and ≥76%. Observers should decide which of those categories best describes the percent concealing vegetation, evaluated over two areas (First seen, and Whole group), until model development clarifies the best approach. The value for percent concealing vegetation is estimated by survey crews, with reference to the vegetation near the elk group. The value can include the effect of shrubs and small trees, if that vegetation has the potential to conceal elk. This is not the same as the remotely sensed forest canopy cover value that was used to determine the edges of survey units (see **2.0 C. Sampling Frame, Survey Locations, and Scope of Inference**).

"First seen percent concealing vegetation" is the percentage of obstructing vegetation in an area defined by a 10-m buffer around the elk that were first observed in the group (i.e., Figure 7.6). "Whole group percent concealing vegetation" is the percentage of obstructing vegetation defined by a 10-m buffer surrounding the entire elk group, including those first seen as well as other elk in the group that are seen after closer examination (often under denser cover). For example, in the diagram at right in Figure 7.7, the First seen percent concealing vegetation could be either in the 1-25% category, or in the 75-100% category, depending on which individual or individuals first caught the observer's attention. In the same example, the Whole group percent concealing vegetation is 51-75%, based on the area surrounding the entire group plus a 10-m buffer. **Appendix D** has Whole group percent concealing vegetation values for a selection of elk groups, based on photographs taken from helicopter surveys. The MORA double-observer sightability model (**Appendix C: Analyses of Detection Bias**) uses Whole group percent concealing vegetation.

Photography

Large elk groups seen from the air have a tendency to be undercounted (Cogan and Diefenbach 1998). Photograph elk groups of ~20 or more animals with a high-definition digital camera. Photographs are used after the survey to compare the group size and composition recorded on the datasheets to the animals seen in the photo. If a photo is taken, circle Y in the Photo column on the Census Data Form. The photos are associated with the appropriate elk group observations based on the time the group was observed, and the digital photo file time stamp recorded by camera's internal clock.

The photographer should try to photograph all members of the group in one frame, before they disperse. If that is not possible, the photographer should tell the data recorder how many elk of a group were not included in the photograph; that should be written on the Census Data Form in the comments area for that elk group. In most cases, the photographer should be the front seat observer. In some cases, the pilot's side back seat observer will have the better view.

NPS flights will use Canon digital SLR cameras with image-stabilizing zoom lenses. These should be in sports mode, with the image stabilizer and autofocus turned on. To frame the photograph, zoom manually, push down the shutter release button half way so that the camera automatically focuses, then push the button all the way to take the picture. Capture images at a high enough resolution to classify elk into sex and age categories, yet which reflects consideration of computer memory space limitations. It is not usually feasible to change camera settings quickly, when counting elk, so it may be more efficient to capture all images at the same resolution initially. A recommended minimum resolution is 1600 x 1200 pixels (~2 megapixels).

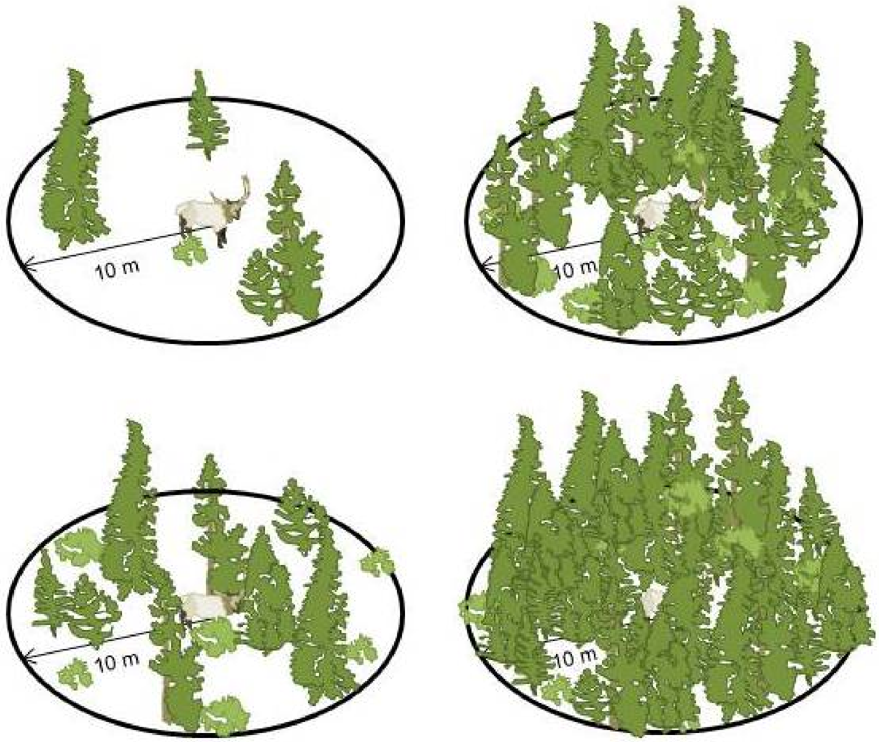

Figure 7.6. Four examples of percent concealing vegetation, illustrated for a single elk, taken from Unsworth et al. (1999). The value of 'percent concealing vegetation' for the 10 m radius area around this elk is chosen from categories defined in the text. The value for the elk in these examples is: 1-25% (upper left); 26-50% (lower left); 51-75% (upper right); and 76-100% (lower right). Illustrations are based on Unsworth et al. (1999).

Figure 7.7. Two examples of percent concealing vegetation, illustrated in each case for a group of five elk, The 'Whole group percent concealing vegetation,' is evaluated for the area occupied by the whole elk group, plus a 10 m radius. The whole group percent concealing vegetation values are chosen from categories in the text; these groups would have a value of: 26-50% (left); and 51-75% (right). For the group at right, the value of 'First seen percent concealing vegetation' would depend on which animal or animals are first seen. Illustrations are based on Unsworth et al (1999).

During OLYM flights, the front seat observer is responsible for taking pictures of the vegetation at designated phenology photo point locations. For spring surveys, these are the upper and lower boundaries of the trend count areas. For summer OLYM surveys, these points are identified by their UTM coordinates. The name codes for these photo points, and the associated coordinates, are stored in the geodatabase, and in the relational database table tbl_Locations. During flight, the navigator managing the GPS-enabled laptop guides the pilot to the phenology point, and alerts the front seat observer when the helicopter is at that location. The camera should be aimed at the phenology point location, with the photograph framed to capture as wide a field of view as possible.

Survey Flights

Preflight

Elk tend to use open areas at times of day closest to sunset or sunrise (MIT, unpublished data). Survey timing coincides with these times of day. MORA surveys start no earlier than four hours before sunset. OLYM summer surveys may end up to four hours after dawn or begin four hours before sunset, but they are typically done in the morning. The differences in summer survey timing at the two parks reflect historical legacies of past survey methods at MORA (Bradley 1982) and OLYM (Houston et al.1987). OLYM spring surveys take place between March 1 – March 31; they may continue up to four hours after sunrise. NPS contracted helicopters may not fly more than 30 minutes after sunset or before sunrise.

Before flight, the crew must consider the amount of fuel the helicopter is holding, and plan the timing of surveys so that all of the targeted survey units will be completely surveyed. The table of expected survey times in **Appendix E: Trend Count Areas and Survey Units** may help in planning. Extra time will be needed, depending on the number of collared elk, if a survey will also include radio telemetry for sightability data collection.

For NPS surveys, the helicopter and crew should arrive at the airport or helispot at least one hour before takeoff to allow for check-in by the helicopter manager, prepare the flight manifest and load calculations, radio frequency checks, and conduct mission and safety briefings. This is also the time for refueling, electronic equipment installation, a group review of age, sex, and covariate categories, and window cleaning. The GIS Specialist or another crew member may need to upload outlines of the survey units onto the pilot's GPS unit (**SOP 4: GPS Use**). The GIS Specialist should install GPS antennas (**SOP 4: GPS Use**), laptop, and the audio recorder (**SOP 8: Digital Audio Recorder Use**).

Before takeoff, the data recorder fills in the Flight Information Form, including the flight number, descriptions of environmental conditions (see below, ***Completing the Flight Information Form***) and the starting Hobbs meter number. The pilot calls dispatch immediately after becoming airborne to relay the helicopter's destination, the number of people onboard, the estimated hours of fuel, and to confirm if AFF is operational. The pilot calls dispatch at the time of arrival to the designated survey unit and then any time the helicopter enters a new survey unit.

The data recorder enters the Survey Start time on the Flight Information Form, writes that same time next to the survey unit number on the Census Data Form, and announces the time so that it is audio recorded.

Flight Pattern

For summer surveys, the pilot flies the helicopter on a systematic flight path in such a way that the survey unit is completely surveyed. Typically, parallel flight lines within a large survey unit are spaced at ~ 300 m – 700 m (0.16 – 0.38 nautical miles), depending on the openness of the habitat. In irregularly shaped survey units, achieving complete survey coverage is informed by awareness of the pilot and front-seat observer, and by the real-time map of the flight path within the survey unit, as seen on the pilot's GPS unit and on the laptop. The topography of summer trend count areas in OLYM includes more ridgelines and less subalpine parklands than in MORA, so summer survey units in OLYM can typically be searched by flying along one or two elevation contours, i.e., at ~1360 m (4500 ft) and ~1575 m (5200 ft). Ground speed will vary, but should average ~83 km / hr (~45 knots); the front seat observer, or the person with the GPS and laptop, should periodically check flight airspeed and suggest changes if needed. This groundspeed and flight pattern yields a search intensity of ~0.35 km^2 / minute, but that may vary depending on topography and forest canopy density.

The OLYM spring surveys are limited to the valley floodplain. Surveys will typically start on the west end of the trend count area valleys. The flight crew may decide to begin surveying from the eastern boundary when weather concerns make such a flight plan safer. Parallel flight lines cross the axis of the river valley and are spaced 150-300 m (0.08 – 0.16 nautical miles) apart, with turns being made at the slope break between the valley wall and the flood plain. Flight groundspeed should be ~55 km/hr (30 knots) but may be increased over open gravel bars, where elk are plainly visible. This groundspeed and flight pattern yields a search intensity of ~0.25 km^2 / minute or less.

Finding Elk Groups

Where to search

Surveyed trend count areas must be consistent over time. Crews should search for elk within the designated survey units. Elk groups that are found outside of a survey unit may also be recorded, but must also be noted in the comments field of the Census Data Form. Elk groups observed outside of survey units will be included in composition estimates, but not in abundance estimates for trend count areas (**SOP 13: Data Summary, Analysis, and Reporting**).

How to Search: Maintaining Observer Independence for Initial Detection

Data are collected in a way that allows for computation of detection biases based on the independent observations of individual crew members (Schoenecker et al. 2006). Each crew member should be given the independent opportunity to detect each elk group. Each observer allows other observers to have an adequate opportunity to independently detect each elk group, and observers who detected the groups independently are recorded as "Who Saw" the elk group (see below, **Completing the Census Data Form**).

When any observer (including the pilot) sees an elk or an elk group, she or he starts to observe attributes of that group, and may note them on paper. That observer should not, however, alert others until the helicopter has moved past where the elk is perpendicular to the flight path (i.e., when an imaginary line from the elk to the helicopter is past perpendicular to the flight path, i.e., ~120 degrees relative to the nose of the ship). At that time, anyone who has seen the animal(s) says so and provides 'clock directions' to the pilot to obtain the best possible view of the elk group (i.e., “single bull at 3 o’clock.”). Clock directions are based on the directions pointed by hands of a clock, as if it were oriented with 12 o’clock straight ahead (0 degrees) of the helicopter and 3 and 9 o’clock perpendicular (90 degrees) to the right and left of the flight path, respectively. The pilot then maneuvers the ship to the animal(s) and the flight crew works together to count the group and record covariates. The data recorder fills in the time, count, composition, and covariates (see below, **Completing the Census Data Form**) and announces the observation number.

To illustrate, in Figures 7.8 and 7.9, the fields of view for the four observers are suggested by colored shading: yellow for the observer in the right back seat, red for the observer in the right front seat, blue for the observer in the left front seat, and purple for the observer in the left back seat. The black line suggests an axis that is perpendicular to the helicopter flight path. When elk are behind this axis, they are said to be ‘past perpendicular,’ or ‘abeam’ of the flight path.

In Figure 7.8, the elk group is in front of the helicopter; it is not yet abeam. At the time represented in Figure 7.8, no one should mention the elk group. At the time represented in Figure 7.9, however, all of the elk in the group are abeam or behind the helicopter; the group is ‘past perpendicular.’ At the time represented in Figure 7.9, anyone who has seen the elk group should say so, and should help guide the pilot to the group, so that the entire crew can then work together to count the group size and record other covariates.

On occasion the front seat observer (or pilot) may see an elk group as the elk are rapidly moving into vegetation or terrain where they will be very difficult to count. The observer (or pilot) may decide to alert the rest of the crew about that elk group immediately, to increase the accuracy of the count of the elk in that group. If this happens, the data recorder should indicate that the back seat observers did not have an adequate opportunity to detect the elk group (by circling “D” in the Back-Front I/D column; see **Completing the Census Data Form**). Such data are useful in estimates of abundance and composition, though they cannot be used as double-observer data points (**Appendix C: Analyses of Detection Bias**).

Counting Elk after Detection is Announced

The helicopter should be flown to maximize the chances of fully counting the elk group without causing undue stress to the animals. When the crew is counting group size and composition, the pilot should not fly directly over a large group, as the elk may scatter. Often elk will bunch up or form a line after the helicopter hovers nearby; this is the best time to get a complete count and a photo if necessary. A hand counter is commonly useful for larger groups.

Summer survey crew members should decide before take-off what strategy will be used to obtain accurate composition counts in large groups. In relatively open habitats, the best strategy may be to orbit the group so that the front seat observer and data recorder have the best view of the group. Often a decision is made for the front seat observer to count and classify bulls, while the back seat observer counts cows and calves. Alternately, the front seat observer may photograph large herds while the back seat observer obtains a preliminary count. The pilot’s attention should remain on safe flight. The back seat observer who is not facing the elk group still plays an important role looking for additional elk outside the helicopter’s orbit, and looking for flight hazards.

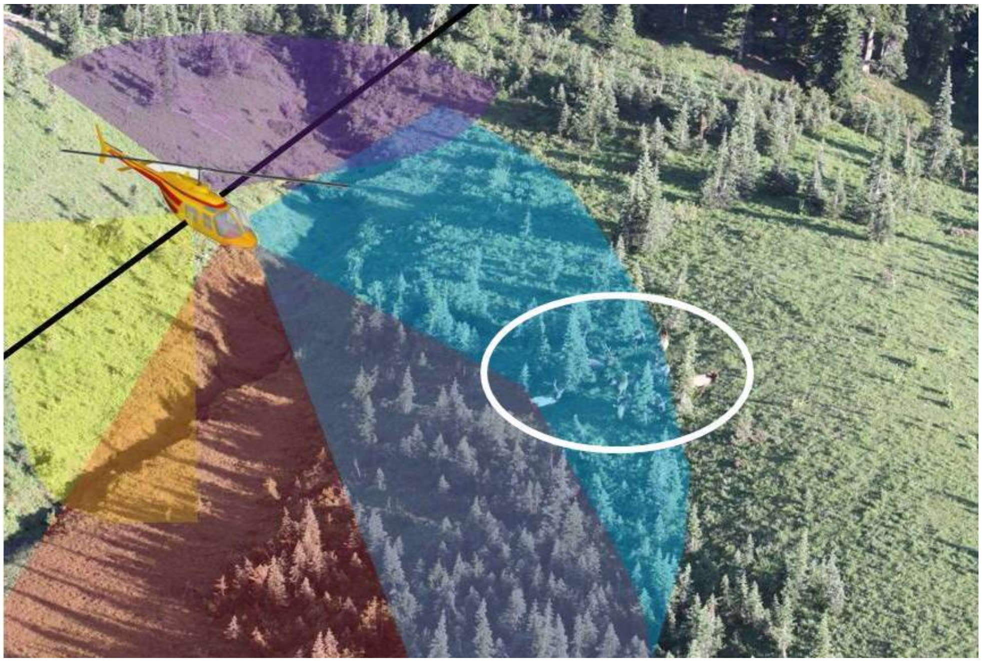

Figure 7.8. Cartoon of survey helicopter's initial approach near an elk group, circled in white. Coloration of each observer's field of view, and the heavy black line that is perpendicular to the helicopter's flight path are explained under the text section heading: **How to Search**. Even though the elk group is visible to front seat observers, back seat observers may not yet have had a chance to detect the elk group.

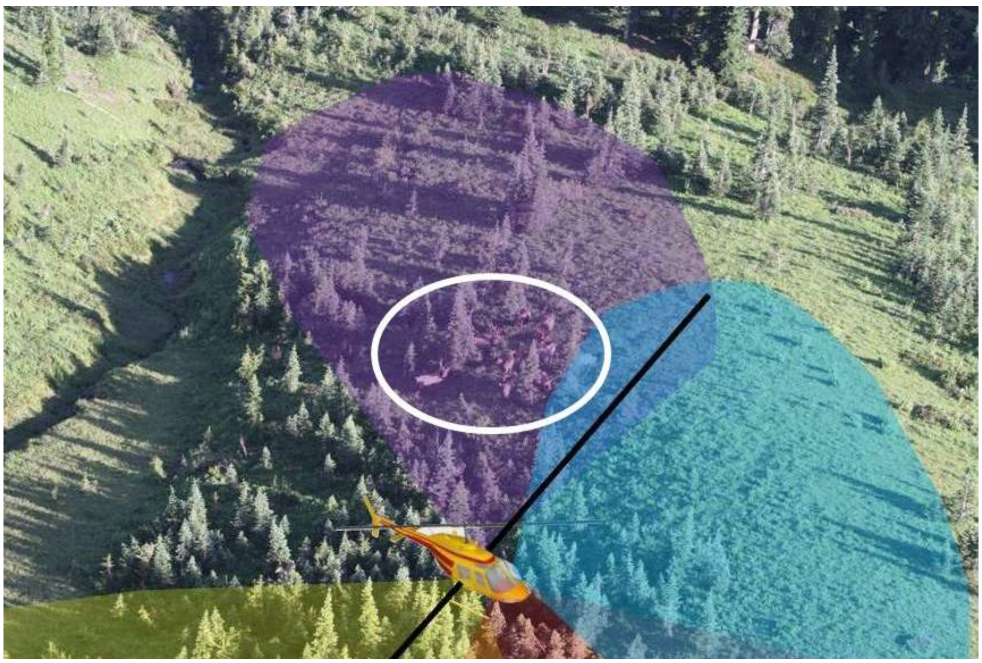

Figure 7.9. Cartoon of survey helicopter's continued flight past an elk group, circled in white. As with Figure 7.8, coloration of each observer's field of view, and the heavy black line that is perpendicular to the helicopter's flight path are explained under the text section heading: **How to Search**. At this time, the elk group is abeam or past perpendicular. At least one of the back seat observers has had a good chance to detect this group. Any crew members who have seen this elk group should speak up.

For spring surveys, and when elk groups are in tall timber, the most complete counts are often obtained when the elk are visible to the pilot. If the elk group is first seen on the front seat observer's side, after an initial count of elk the pilot should then fly so that the elk group is on the pilot's side. Observers on the side of the helicopter opposite the group of elk should continue to search for associated elk, and watch for safety hazards. If the elk are already moving into heavier canopy cover, any observer with the best view of the elk group should ask the pilot to try to hold the position, and that observer should get as complete a count as possible. It may also be worthwhile to make one more orbit of the immediate area, to look for more elk that may become visible.

Recording Location

Elk group locations are important for long-term analysis of spatial distribution. Crews must use one of the several possible ways to record elk group locations. First, the time, to the nearest second, is recorded when the helicopter is closest to each elk group sighted, so that the group's coordinates can be derived from the GPS-recorded flight path. Second, the location can be marked directly with a GPS waypoint or on the GPS-enabled laptop. The resulting coordinates are associated with each elk group in the database. For locations recorded in a laptop, groups should be marked with the Observation number. If a GPS waypoint is used, the waypoint number should be written in the comments area for that group on the Census Data Form.

Recording Covariate Data, and Who Saw the Elk Group

As soon as possible after each group of elk is observed, the data recorder should fill in values for the covariates. Recorded covariate values should be based on the consensus opinion of all the crew that observed the elk group (see **Defining Elk Group Covariate Categories**).

It is also imperative to record exactly which observers detected the elk group independently, by circling up to four choices in the "Who Saw" column. The data recorder should ask out loud to clarify who independently saw each group, before the time that the group was announced to the crew as a whole. Alternately, at OLYM only, the pattern of "Who Saw" may be recorded by having all observers use forms to record the observation numbers of elk groups they saw independently (see below, **Completing Front Seat Observer and Back Seat Observer Form (OLYM Only)**); accurately completing the "Who Saw" records requires careful comparison of these sheets immediately after the completion of the flight (see below, **Reconciling the Census Data Form, Front Seat Observer Form, and Back Seat Observer Form (OLYM Only)**).

If any observer who has seen an elk group during the survey alerts any other observers (e.g. by speaking or pointing) before they have had the chance to see the group independently, the data recorder notes that loss of independence for that observation. The recorder notes whether the loss of independent sighting opportunity was only between the front seat observer and pilot, or whether it influenced both front and back seat crew members. For example, if the pilot were to nudge the front seat observer by way of pointing out an elk group then the front seat passenger might not have had an independent opportunity to observe the elk, but the back seat observers may not have been alerted and their detections may have been independent of the front seat observers. It is important to tell the data recorder if any of the crew members did not have independent chances to detect elk, because an observation that lacks independence can still have a sightability correction factor applied to them based on the group size and covariates. Such a group cannot, however, be included in data sets that are used to develop double observer sightability models.

After all covariates for an elk group have been recorded, the data recorder should read the covariate values out loud, as a final opportunity for others to offer corrections.

What to do when Other Species are Seen

A digital audio recorder will be used to record cockpit conversations during each NPS flight. Recordings are often difficult to understand except for the voice of the one person whose headset is plugged in line with the audio recorder (**SOP 8: Digital Audio Recorder Use**). Hence, that person should clearly repeat any observations of other species, noting the exact time, the species, the number of animals, and who in the helicopter saw those animals. For example, if the pilot says that he sees three goats out in the open, on rocks, the person whose headset is in line with the audio recorder should key the avionics microphone and say, “Seven seventeen and twelve seconds. The pilot saw three goats, rocks, zero cover.” Note that the person with the audio recorder should repeat any covariates that are stated. In the event that a voice recorder is not used, it is appropriate for the data recorder to document other species occurrence on the Other Species Data Form.

After Surveys

The pilot needs to tell park dispatch when the helicopter is finished surveying for the day. If it is an NPS flight, the pilot also notifies dispatch when the helicopter has landed and concluded operations for the day. The pilot or helicopter manager should notify park dispatch whether or not the helicopter will return to the helicopter’s home base that day. The pilot needs to communicate with park dispatch when leaving the helibase and en route to the helicopter’s home base.

The data recorder fills in the description of the environmental conditions at the time of Survey Stop on the Flight Information Form. Upon landing, the data recorder fills in the arrival time on the Flight Information Form and the ending Hobbs meter number.

For NPS flights, the helicopter manager fills out forms required by the Department of Interior’s Aviation Management Directorate (AMD-23) to record billable services. The crew and pilot confer and debrief, discussing the flight. The project manager records any relevant notes that will go into the flight report. The project manager should confer with the helicopter manager to assess ongoing weather conditions and the status of the project budget. A determination is made daily whether to keep the helicopter for survey the following day, or to release it.

Immediately at the end of every survey flight, the MORA project manager, or the wildlife biologist from MIT, PTOI, or WDFW, oversees checking all data sheets for legibility and completeness. The crew flags any missing data and attempts to fill in the missing data based on the best information possible. At OLYM, the project manager compares the Census Data Form, Front Seat Observer Form, and Back Seat Observer Data Form and the crew fixes discrepancies or missing data.

For NPS sponsored flights, the project manager or another crew member downloads and files photo images (**SOP 10: Processing Digital Photographs**) and downloads audio recordings

(**SOP 8: Digital Audio Recorder Use**) within a day after the flight. The project manager ensures that the data are entered into the project database within a week after the flights (**SOP 9: Data Entry and Verification**). The project manager writes the daily flight report (**SOP 13: Data Summary, Analysis, and Reporting**) within a week of the flight. The GIS specialist downloads and processes the GPS flight line and animal location data, (**SOP 11: Geospatial Data Management**), prepares daily flight maps, and gets mapping equipment ready for the next flight. The laptop and GPS unit (or units) are recharged overnight.

MIT, PTI, and WDFW biologists send digital copies of their Census Data Forms, shapefiles of the flight path, recorded GPS waypoint files, digital photographs, and other notes to the MORA project manager. The MORA project manager ensures that the Census Data Forms from those flights are entered into the database. Spatial data are forwarded to the GIS Specialist for incorporation into the project geodatabase. The MORA project manager should solicit and compile feedback from other project participants about what worked well, what did not work well, and what could be improved in future surveys.

The MORA data will be entered and archived on the NPS-administered database (**Appendix B: Elk Aerial Survey Database Documentation**). Once the data have gone through quality assurance and certification (**SOP 12: Data Quality Review and Certification**), copies will be made available to all MORA project participants. As soon as possible after the completion of the survey season (i.e., in mid-October), the MORA project manager should distribute preliminary results from all MORA surveys to the project participants, including the number of elk seen and the composition counted in each evening of surveys, and a summary of the flight times and survey units surveyed on each flight.

In-Flight Data Recording

Several field forms are used to record helicopter survey data. Data collection at OLYM entails more forms, because MORA participants chose to have a single person write down data on the flight. Slightly different data recording methods were required in MORA and OLYM in order to accommodate the views of diverse project participants.

- At both parks, a Flight Information Form is used to describe crew members and conditions of each aerial survey flight.
- The Census Data Form is the primary data sheet used by the data recorder at each park, but different forms are required for MORA, OLYM summer, and OLYM spring surveys.
- In addition to the Census Data Form, OLYM uses Front and Back Seat Observer Forms so that all observers (except the pilot) record written data
- A Telemetry Form is used in OLYM to record data about missed radio collared animals, whereas that data is recorded on the Census Data Form in MORA surveys.

Completing the Flight Information Form

The data recorder should fill in one Flight Information Form (Figure 7.10) for each time that the helicopter takes off. The first set of data fields are for information about the flight:

Year: Fill in the year (yyyy format)
Park: Circle OLYM or MORA

Flight #: Fill in the flight number. Flights are numbered sequentially within a season; the MORA project manager should tell other participants what flight number they will use. There should be a new flight number for each occasion of lifting off. After refueling, the second takeoff should be given a new flight number, and the data recorder should fill out a new Flight Information Form.
For flights initiated, but when conditions in the survey area did not permit a survey to be conducted, label the flight number "XXXX."
Date: Date (mm/dd/yyyy)
GPS File: GPS file name if available.
Aircraft Model: Fill in the helicopter type, i.e., "Jet Ranger" or "Hughes 500"
Tail #: Fill in the helicopter tail number, i.e., "N91TA."
Company: Helicopter company name
Heli Manager: Helicopter manager name (NPS surveys) (last name, first name)
Departure Time: Time (hh:mm) when the helicopter lifted off
Departure Location: Name of the location where the flight started
Arrival Time: Time (hh:mm) when the helicopter touched down
Arrival Location: Name of the location name where flight ended
Participants, names: Fill in the names of the pilot and three other observers (last name, first name)
Participants, where seated, and duties: For each person on the helicopter, circle lf, rf, lb, or rb to indicate where that person was sitting (left front, right front, left back, right back). Fill in each crew member's duties; note who is the data recorder.
Comments: Use this space for notes about the flight.
Overall Count Conditions: Circle one of these categories after the flight based on the consensus of all the crew.
Entered by, Verified by, Updated by, and Date: Leave these blank. These fields, written in small font, are only for use at the data entry stage (**SOP 9: Data Entry and Verification**).
Hobbs Start: Write the number on the Hobbs meter at the time of helicopter take-off (to the nearest tenth of an hour). This is needed for accounting.
Hobbs Stop: Write the number on the Hobbs meter at the time of helicopter landing (to the nearest tenth of an hour). This is needed for accounting.

Environmental conditions at the time of **Survey Start** (start of the first surveyed unit) and of the **Survey Stop** (end of the last surveyed unit) for a given flight number are recorded on the Flight Information Form.

Survey Start time: Fill in the time (hh:mm:ss) when the helicopter entered the first survey unit
Cloud Cover: Fill in a value for overhead cloud cover (at and above flight elevations), to the nearest one percent.
Mist: Fill in a value for the percentage of the ground that is obscured by mist or fog, to the nearest one percent.
Wind: Circle the one best description (calm, light, moderate, high, gusty)
Precipitation: Circle the one best description (none, mist, light rain, heavy rain, snow)
Temp: Fill in the outside air temperature and circle the proper scale °C or °F.
at elev: Fill in the elevation (feet) at which the temperature was measured.

Light Conditions: Circle high contrast if there are visible shadows. Circle flat if there are no visible shadows.
Survey Stop time: Fill in the time when you exited the last survey unit of the flight, then fill in all of the environmental conditions at that time.

Below the space for environmental conditions is a space for general comments about the flight, including whether all of the intended survey units were completely surveyed.

Comments: Write any comments about conditions of flight or the survey area that seem notable.
Survey Completed?: Write "yes" if all of the intended survey units were surveyed. Write "no" if a survey unit that ought to have been surveyed was not, or if a survey unit was only partially surveyed.
If not…comments: Explain which intended survey units were not completely surveyed, and why not.

The data recorder at OLYM should also record the following information about photographs taken at the phenology photo points.

Description of location: Describe the location, with the name code of the photo point i.e., "SFH E1" for photo point at the eastern edge of the South fork Hoh trend count area.
GPS Time: Fill in the time (hh:mm:ss) when each photo was taken.
Photo Numbers: Note the frame numbers of photos taken at each photo point.
Comments: Write comments about the photos.

Completing the Census Data Form

On the Census Data Form the data recorder records information about the time spent in each survey unit, and one row of data for each elk group. Different versions of the Census Data Form should be used for MORA surveys (Figures 7.11, and 7.12), OLYM summer surveys (Figures 7.13, and 7.14), and OLYM spring surveys (Figures 7.15, and 7.16). The data recorder should fill in the following on the top of each sheet of Census Data Form that is used.

Flight#: Fill in the specific flight number; this should match the flight number from the Flight Information Form.
Date: Fill in the date (mm/dd/yyyy)**.**
Survey Unit(s): Enter all the survey unit numbers surveyed. On the first page of census data forms that are filled out on a given flight, write down all the survey unit numbers that are surveyed on that flight. This summary can be done either during or after the flight.
Recorder Name: Fill in the data recorder's last name.
Position: Circle the data recorder's position in the helicopter, as either left back seat (lb) or right back seat (rb).
Page: Fill in the page number of the Census Data Form; at the end of survey, fill in the total number of sheets, i.e., page 1 of 3.
Comments: Write comments about the survey here. Note which survey units, if any, were started but not completely surveyed.

The Census Data Form has a box for recording the Survey Unit Numbers visited, and the start and stop time of survey within each survey unit. The entry and exit time only need to be noted on one sheet; typically this will be on the same sheet on which elk observations for the corresponding survey unit are also recorded. On the MORA form, this boxed area is at the upper right of the page, and at the top of the continuation pages. On the OLYM form this is on the lower right of the first page, and the top of the continuation pages. Use as many lines of this box as you need to record the timing of survey in each survey unit. If you entered and exited a survey unit more than once, use more than one of these data lines. Below an example is demonstrated in which unit S16 was entered twice in completing the survey of that unit:

Unit# S16__ Start 17:37:10 Stop 17:41:13
Unit# S15__ Start 17:41:15 Stop 17:49:20
Unit# S16__ Start 17:49:21 Stop 17:54:01

Each elk group observed has data recorded on a single row. Observation by crew, and discussion about the group, should lead to the recorded values for count, composition, and covariates (see **Defining Age and Sex Categories**, and **Defining Elk Group Covariate Categories**). For each elk group, the data columns at the far right of the data row have one choice in bold font. The bold font choice is the default value; unless the other value is circled, the person entering data will enter the default value.

Obs #: Starting with one (1) for the first elk group seen, give each elk group a new observation number. Continue to increase the numbering throughout the morning / evening of survey, even if the survey breaks to refuel and start a new flight. Start again at one on each new day of survey.
Time: Fill in the time (hh:mm:ss) For summer surveys, use Pacific daylight time. For spring surveys, use Pacific Standard Time. Record time to the nearest second.
Activ: Circle the activity category that best describes what the majority of the group was doing at the time it was first detected: bedded (B), standing (S), or moving (M).
Cover type: Circle the cover type category that best describes what cover type was surrounding the majority of the group, plus a 10 m buffer, when the group was first detected:
First Seen % Concealing Veg: Circle the one categorical value of approximate concealing vegetation that best describes the amount of vegetative cover around the first elk that were seen in the group, plus a 10 m buffer around those individuals. The categories are zero (0); 1-25% concealing veg (1+); 25-50% concealing veg (25+); 51-75% concealing veg (50+); and 76-100% concealing veg (76+). Refer to Figure 7.5 and Figure 7.6 for examples.
Whole Group % Concealing Veg: Circle the concealing vegetation value that best describes the amount of vegetative cover around the entire elk group, plus a 10 m buffer. The categories are: zero (0); 1-25% concealing veg (1+); 25-50% concealing veg (25+); 51-75% concealing veg (50+); and 76-100% concealing veg (76+).Refer to Figure 7.6 for examples.
Light: Circle high contrast (HiCont) if there are visible shadows near the elk group. Circle flat if there are no visible shadows.

Snow (this column is only for spring surveys at OLYM)**:** Circle yes (Y) if snow was present on the ground at the location where the group was detected. Circle no (N) if there was no snow on the ground where the group was detected.
Total # Elk: Fill in the total number of elk that were counted in the elk group.
Complete Count?: Circle yes (Y) if the crew is confident that no elk were missed in the count. Yes is printed in bold font because it is the default value here; if neither Y nor N is circled, the person entering this data will assume that the count was complete. If there were more elk in the group than the number written in for Total # Elk, circle N here, and note in the comments any guess about the approximate number of elk that were not counted.
Cow: Fill in the total number of cows that were counted in the group.
Calf: Fill in the total number of calves that were counted in the group.
Yearl Bull: Fill in the total number of yearling bulls that were counted in the group.
SubAd Bull: Fill in the total number of subadult bulls that were counted in the group.
Mature Bull: Fill in the total number of mature bulls that were counted in the group.
Unkn Animal: Fill in the total number of unknown category elk that were counted in the group. These would be elk that were counted, but were not clearly classified into any of the other categories.
Who Saw?: Circle the two-letter codes for each of the crew members who independently saw the elk group. This will require one or more circles. For example, if the pilot, front seat observer, and the observer in the left back seat saw an elk group, circle LF, RF, and LB, but not RB.
Side of Ship: Circle whether the elk group was initially on the left side of the helicopter's flight path, or on the right side. *You may circle both L and R*, if the elk group could have been seen on both sides. Most importantly, though, you should only circle C if the elk group was only ever visible to the pilot and front seat observer. That would only happen if the elk group was always directly under the helicopter flight path until it was announced to the whole crew. C should only be circled if the elk group was within the field of view defined at its edges by the helicopter's two landing skids.
Back-Front I/D: Circle independent (I) if the front seat observers did not prevent the back seat observers from having an independent chance to detect the elk group, and vice versa. Only circle D_{bf} if the back (or front) seat observers did not have a chance to independently detect the elk group, i.e. because they were clued in to the existence of the group by the front (or back) observers before the elk group was abeam, relative to the flight path. I is printed in bold font because independent it is the default value here; if neither I nor D_{bf} is circled, the person entering this data will assume that both the front and back seat observers had independent opportunities to detect the elk group.
Front-Front I/D: Circle independent (I) if both of the front seat observers did not prevent each other from having an independent chance to detect the elk group. Only circle D_{FF} if one of the front seat observers clued the other one about the existence of the elk group before the elk group was abeam, relative to the flight path. I is printed in bold font because it is the default value here; if neither I nor D_{FF} is circled, the person entering this data will assume that both of the front seat observers had independent opportunities to detect the elk group.
Missed Group with radio?: Circle one choice: no (N) means that the elk group was seen during surveys; yes (Y) means that the group was missed during surveys, but was later

found by means of telemetry because one or more of the elk in the group had a radio collar.
Circling N means that the group was seen during the survey without any assistance from telemetry. N is printed in bold font because it is the default value here; if neither Y nor N is circled, the person entering this data will assume that the elk group was not missed during the survey. If N is circled here, and the elk group contained a radioed animal, it means that the group was seen during the survey, regardless of whether the radio collared animal itself was seen within the group.
Circling Y means that the group was missed during the visual survey, but was later found by means of telemetry. In OLYM surveys, any group that was missed during the visual survey but later found via telemetry is only recorded on the Radio Telemetry Form.
Elk IDs, or Freq Codes: Fill in the ElkID number or frequency code of any radio collared elk that were in the group. Radio collar frequencies are coded to prevent their public release; radio frequencies are proprietary information owned by tribes at MORA. Also, public release of frequencies could endanger collared elk to poaching.
In the same box, circle whether the elk group was inside a survey unit that was already surveyed (In-Unit) or was outside of the previously surveyed units (Out). For sightability data collection, this is important to know, because elk groups are only counted as seen or missed if they were inside a surveyed unit.
Photo?: Circle Y if a photo of the elk group was taken. N is printed in bold font because it is the default value here; if neither Y nor N is circled, the person entering this data will assume that no photo was taken. If photos are taken, they should be processed after the flight, so that group size and / or composition can be updated (**SOP 10: Processing Digital Photographs**).
Comments: Fill in any comments about the elk group here. On the left side of the Comments line you must write the Obs# of the elk group to which the comments refer.

Only on the OLYM Census Data Form is there a "Data Recorder's Own Observations" area at the bottom of the form, where the Data Recorder fills in values for elk groups that he or she independently detected before being alerted by any other flight crew. This space is analogous to the Front Seat Observer Form and the Back Seat Observer Form. At OLYM, the important columns for the Data Recorder to complete for any observed elk group that he or she independently detected are: Time and Obs#. These represent the time when the data recorder saw the group, and the observation number of the elk group seen. The covariate values noted here represent the data recorder's "notes to self."

Completing Front Seat Observer Form & Back Seat Observer Form (OLYM Only)

OLYM uses two additional forms not used at MORA. The Front Seat Observer Form (Figure 7.17 for summer surveys; Figure 7.19 for spring surveys) is for observations made by the front seat observer and/ or the pilot. The Back Seat Observer Form (Figure 7.18 for summer surveys; Figure 7.20 for spring surveys) is for the back seat observer who is not the data recorder. The forms are similar except that the Front Seat Observer Form has one data column to note who independently saw the elk (only the observer, only the pilot, or both observer and pilot) and one data column to note the side of the helicopter on which the elk group was seen (left, right, or center).

In OLYM surveys the Front Seat Observer Form and the Back Seat Observer Form are used to record the individual patterns of which observer saw each elk group. The same information is contained in the "Who Saw" and "Side of Ship" Columns of the Census Data Form, which the data recorder fills in based on discussion at the time each elk group is observed. At OLYM, the Front Seat Observer Form and Back Seat Observer Form at OLYM serve as a written record of those independent observations. Any discrepancies between these forms and the Census Data Form must be identified and resolved immediately after the flight, because the Census Data Form is the only one of the three that is used during data entry.

The observer should fill in the following on the top of each sheet that is used:

> **Flight #** Fill in the flight number; this number should match the flight number from the Flight Information Form.
> **Date:** Fill in the date (mm/dd/yyyy).
> **Park:** Circle Rainier or Olympic.
> **Observer:** Enter your last name.
> **Position:** Circle your position: right front (rf) or left front (lf) for the Front Seat Observer Form; left back (lb) or right back (rb) for the Back Seat observer Form.
> **Comments:** Write comments about the flight.

For each elk group that the observer detects independently, the observer at OLYM must fill in the following in one row of data. The front seat observer records data t reflect the pilot's independent observations as well.

> **Time:** Fill in the time (hh:mm:ss) you saw the elk group
> **Obs#:** Enter the Obs# of the elk group based on numbering from the data recorder.
> **Obs/Pilot/ Both** (Front Seat Observer Form only): Circle one of these choices, to show who independently saw the elk group: just the front seat observer (O), just the pilot (P), or both (B).
> **Side of Ship** (Front Seat Observer Form only): Circle whether the elk group was initially on the left side of the helicopter's flight path, or on the right side. You may circle both L and R, which would indicate that the elk group was located on both sides. Most importantly, though, you should only circle C if the elk group was only ever visible to the pilot and front seat observer. That would only happen if the elk group was always directly under the helicopter flight path until it was announced to the whole crew. C should only be circled if the elk group was within the field of view that was not available to the back seat observers.

The observer using this form is not required to fill in other columns. Data for Activity, Cover type, First Seen % Concealing Veg, Whole Group % Concealing Veg, and Comments may be noted here. The values for these data columns that represent the crew's consensus should be recorded on the Census data Form. Descriptions of count, compositions, and covariates are already explained (see sections **Defining Age and Sex Categories for Composition Counts**, and **Defining Elk Group Covariate Categories**), but there are two fields on the Front Seat and Back Seat Observer Forms that are not:

Front-Front (I/D) (on Front Seat Observer Form), or **Back-Front (I/D)** (on Back Seat Observer Form): This column is for noting any breach of the methods that are meant to give each observer an independent chance to detect the elk group. For the front seat, independent (I) here means that the front seat observer and the pilot did not give each other clues about the elk group until the group was abeam. Dependent (D) here means that one of the front seat observers did tip off the other, before each had an independent chance to detect the elk group.

For the back seat, independent (I) here means that the front seat observers did not prevent the back seat observer from having an independent chance to see the elk group. Dependent (D) here means that somehow the front seat observer(s) did tip off the existence of the elk group before the elk group was abeam.

For both forms, I is printed in bold font because independent it is the default value; if neither I nor D is circled, that indicates that the observers had independent opportunities to detect the elk group.

Count & Composition Notes: This space is for making notes about the number of elk in each category. The Census Data Form will have the final numbers that reflect the consensus of the crew.

Reconciling the Census Data Form, Front Seat Observer Form, and Back Seat Observer Form (OLYM only)

After each flight at OLYM, observers must immediately reconcile any differences that appear between the Census Data Form, Front Seat Observer Form, and Back Seat Observer Form. Ultimately, the Census Data Form must reflect the consensus record of observations made during the flight. The first item to cross-check for each observation is the record of “Who Saw?” The Census Data Form should be updated, if necessary, to account for observations that the front seat observers or other back seat observer noted on their form as having been seen independently. The Data Recorder should next check for completeness in the recording of covariates and composition counts. If there are any missing values, the notes made on the Front Seat Observer Form or Back Seat Observer Form can be used to fill in blanks. In the event of a discrepancy between data forms, crew members can discuss the observation in question to come to a conclusion, and / or may refer to the audio recording of the flight.

Completing the Telemetry Form (OLYM only)

Survey crews will continue to record sightability trial data during the OLYM surveys for a time after this protocol is completed. We will complete testing the MORA model for application in OLYM before we are due to prepare a second four-year report (**SOP 13: Data Summary and Analysis**). The Radio Telemetry Form (Figure 7.19 for OLYM summer surveys; Figure 7.20 for spring surveys) at OLYM is intended to record data from elk groups that have one or more radio collared elk, but which were not detected (either the whole group was missed, or the collar was not observed but the group was seen) during surveys. The Census Data Form is used for this purpose at MORA. The data recorder should fill in Flight #, Date, Name, and Page as described for the Census Data Form. The following fields at the top of the sheet are different:

Time Start Telem (1, 2, 3, 4 or 5): Fill in the time (hh:mm:ss) for the start of each period of radio telemetry search. Only note sustained periods of search with telemetry; do not include quick scans using the receiver.

Time Stop Telem (1, 2, 3, 4 or 5): Fill in the time (hh:mm:ss) for the end of each period of radio telemetry search.

One row of data is filled for each elk group that was missed during survey but was later found with radio telemetry. The following fields should be completed, based on instructions for **Completing the Census Data Form**: Obs#, Time, Activity, Cover type, First Seen % Concealing Veg, Whole Group % Concealing Veg, Light, Total Count, Cow, Calf, Yearl Bull, SubAd Bull, Mature Bull, Unknown Animal, and Photo. Also complete the following fields for each elk group found with telemetry:

Freq Code(s) (Collar#): Fill in the frequency code or collar number for any radio collared elk that are in the elk group.
When was the group seen?: Circle only one choice. 1) If the elk group was not seen during survey, but was only found afterwards via telemetry, circle Missed – this elk group should be given a new Obs#. 2) If the elk group was seen during survey, but the radio collared elk was not detected at that time, circle "Group Seen"; in this case, the group will be counted as having been seen – use the Obs # for that group on this form. 3) If , upon finding the radio collared animal, it turns out that the collared cow elk itself *and* its group were actually detected already in the survey, circle "Cow seen"; in this case, the group will also be counted as having been seen – use the Obs # for that group on this form. The need to circle "Cow seen" is expected to be very rare.
In or Out of Survey Unit?: If the elk group was in a survey unit, circle In; this will mean it was missed during survey. If it was outside of any surveyed unit, circle Out; this will mean it was not missed during survey, because it was outside of any surveyed area.

Completing the Other Species Data Form

Other wildlife species are seen during elk surveys, especially in summer. These observations may be recorded on the Other Species Data Form. The location of a given observation can be recorded in one of two ways: either by writing down the Clock time when it was seen, and matching that time to the helicopter's coordinates, based on the GPS record of the flight (**SOP 11: Geospatial Data Management**); or by using a handheld GPS unit to record a waypoint at the time the group was seen, and writing the waypoint number down on the comments field of the data sheet. Each Other Species observation should have one line of data in the main table, with data filled in for the following fields:

Clock time hh:mm:ss: Fill in the time of day when the observation was noted in flight, unless the location is being recorded by writing down a GPS waypoint number.
Incidental Obs I#: Fill in the incidental species observation number. It is preceded by I to distinguish it from the elk group observations. Starting with 1 for the first incidental species seen, give each one a new observation number. Continue to increase the numbering throughout the morning / evening of survey, even if the survey breaks to refuel and start a new flight.
Species: Circle one species: bear (B), deer (D), goat (G), eagle (Ea), or other (O). If it is another species, write what species it is in the Comments column.
Number in Group: Fill in the number of individuals of the species seen.
Comments: Write down any other comments that the crew made about the animal here. If location is recorded based on a GPS unit waypoint, note the waypoint number here.

In addition to those data fields, the following four fields should be filled out at OLYM.

Cover type: Circle one cover type.
Activity: Circle one description of the animal's activity, or the activity of the majority of the group if it is a group of animals.
% Concealing Veg: Circle one description of the percent concealing vegetation near the animal, or the majority of the group if it is a group of animals.

Using the Audio Recording to Note Other Species

A digital audio recorder will be used during NPS summer surveys (**SOP 8: Digital Audio Recorder Use**). The audio recording of the conversation is primarily used as a way to record other species observed during elk surveys. This measure may be adopted to minimize note taking aboard the helicopter and enhance searching efficiency for elk. As described in SOP 8, voice recordings may be later transcribed to an Other Species Data Form (Figure 7.21 for summer surveys; Figure 7.22 for spring surveys). During spring surveys, the Other Species Data Form may be filled out in flight, because there tend to be few other species seen during spring surveys.

During NPS summer surveys, crew members should speak loudly and clearly. The data recorder should announce the exact time at a point early in the flight. If another wildlife species is seen, the observer should at a minimum say what species it is and how many there are. At OLYM, the observer should also say what cover type the animal is in, its activity, and the percent concealing vegetation near it.

Following each flight, the project manager for each park designates someone to listen to the entire cockpit recording and transcribe data on the Other Species Data Form. The transcriber fills in the Flight #, Date (of the flight), and Park data fields at the top of the sheet. The transcriber also fills in the digital recording file name, and the transcriber's name. The following three items are taken from a combination of file properties and information taken from listening to the recording. If the other species data are recorded directly in flight, without the need to transcribe an audio recording, then these three fields should be left blank.

Audio recording start time: This is either taken from the digital file's properties, or is based on the time announced early in the flight. It is important to find the exact time when the audio recording file begins, to the nearest second. Use the hh:mm:ss format, with 24-hour time.
Audio recording end time: This is the time when the recording ends. Use hh:mm:ss format.
Total Audio recording length: This is the file length, in hh:mm:ss format.
Running time hh:mm:ss: Fill in the time since the beginning of the audio recording, in hh:mm:ss. If the observation is recorded directly on the field form in flight, then this field should be left blank.
Clock time hh:mm:ss: Fill in the time of day when the observation was noted in flight. To fill in this time, add the Audio recording start time to the Running time.

Checklists and Field Forms

The following checklists and figures are useful and / or required for surveys. The census sheet field instructions (Figures 7.12, 7.14, and 7.16) are a one page set of reminders about how to collect and record data; they include a definition of abbreviations (the data dictionary). Other forms have data dictionaries on the data form page.

Checklists

Field forms and abbreviated field instructions

The following forms are saved as .docx and .pdf files in the project workspace folder, under \MAa12_Elk_Aerial\Documents\Field_Forms.

Literature Cited

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National Interagency Aviation Council (NIAC). 2009. Interagency Helicopter Operations Guide. Department of the Interior and Department of Agriculture, Boise, Idaho.

Schoenecker, K., B. Lubow, L. Ziegenfuss, and J. Mao. 2006. 2005 Annual progress report: elk and bison gazing ecology in the Great Sand Dunes complex of lands. USGS Open File report 2006-1267. US Department of Interior.

Elk Survey Equipment Checklist

For Pilot's GPS unit

- ☐ Survey unit boundary files and navigation waypoints for transfer to helicopter GPS; use MapSource or DNR Garmin or other compatible software if the GPS is a Garmin
- ☐ Laptop that can transfer background map data files to pilot's GPS unit (DNRGarmin or other software loaded and ready)
- ☐ Data transfer cable (USB to mini-USB)

Each Crew Member

- ☐ PPE: Nomex flight suit, Nomex gloves, leather boots, helmet, earplugs
- ☐ 10 Essentials: food & water, knife, matches, fire starter, map & compass, extra warm clothes, raingear, space blanket, first aid kit, flashlight
- ☐ Personal locator beacon (optional)
- ☐ Clipboard, field form, pencil, clock, cheat sheet of covariate categories

In the Helicopter

- ☐ List of park radio frequencies and map of repeaters
- ☐ Survey unit maps (one for front seat, one for back seat)
- ☐ List of approximate times to fly each survey unit
- ☐ Field forms
    - o Pencils – for each observer
    - o Clipboards – 1 per observer. Data recorder's clipboard should be legal-sized
    - o Rubber bands to hold down papers on clipboard
    - o 2 Flight Information Forms
    - o Census Data Forms. For each day of survey, 2 first pages, 10 continuation pages
    - o 5 Front Seat Observer Forms
    - o 5 Back Seat Observer Forms
    - o 2 Radio Telemetry Forms (OLYM)
    - o 2 Other Species Data Forms (OLYM spring)
    - o Binoculars – front seat observer
- ☐ GPS-enabled laptop computer
    - o Fully charged laptop, with survey units visible in GIS
    - o External GPS unit or antenna, and connections, with communications tested and operating
    - o Map file used to display and record the flight path, while in flight
    - o Spare laptop battery, fully charged
    - o Cloth, to wipe screen
    - o AC power adapter for use in helicopter (optional)
    - o Memory key / thumb drive, for data backup or transfer after flight (optional)
    - o Carrying case (optional)
    - o GIS security key attached to laptop (if necessary)
- ☐ Separate GPS unit, to record the flight path independent of laptop
    - o External GPS antenna and cables
    - o Spare batteries
    - o the helicopter GPS may be used for this, if it records tracks
- ☐ 3 timing clocks or large-faced digital watches -- one for each observer
    - o Use GPS unit to synchronize all clocks every day

- ☐ Digital camera, synchronized to the GPS unit, on sports mode setting
  - o Spare batteries
  - o Spare compact flash memory card
- ☐ Duct tape (and/ or zip ties or velcro strips) to secure loose cables
- ☐ Telemetry gear, if needed
  - o Scanning VHF Receiver and antenna
  - o UHF Terminal and antenna, if needed
  - o Spare batteries
  - o Ear pieces
  - o Adapters for helicopter avionics
  - o Coaxial cables (10 ft)
  - o Individual elk radio frequency list, with collar colors and Elk ID or other codes
- ☐ Aviation safety plan (NPS flights)
- ☐ Digital audio recorder (NPS flights), synchronized to GPS time
  - o Olympus DS-30 digital voice recorder and user's guide
  - o CellSet 5000H adapter
  - o 1/8" male to 3/32" female stereo adapter
  - o 2 extra AAA batteries
- ☐ Printed copy of in-flight methods (**SOP 7: Conducting Helicopter Surveys**)
- ☐ Handheld park radio (NPS flights)
- ☐ Cell phone (optional)
- ☐ Satellite phone (optional)
- ☐ Equipment bag (optional)
- ☐ Scissors (optional)

At the Landing Zone (NPS flights)

- ☐ Helicopter manager (if this person is not an observer)
- ☐ Helispot safety items:
  - o Park radio; fire extinguisher; wind indicator; crash kit; traffic control equipment, dust abatement, if needed
- ☐ Aviation safety plan
- ☐ Appropriate account numbers for AMD-23 forms
- ☐ Survey unit maps
- ☐ Scale
- ☐ Load calculation book
- ☐ Passenger manifest pages
- ☐ Safety briefing cards
- ☐ Extra helmet and Nomex flight suit

At park dispatch

- ☐ Aviation safety plan (NPS flights)
- ☐ Survey unit maps
- ☐ Coordinate list (this can be coordinates for the center of each survey unit; to be used for quick location reference in the event of an emergency)
- ☐ Confirm AFF capability

Action Checklist for Elk Surveys

Before Flights

- ☐ Give copies of maps to dispatch (days in advance), crew, and helicopter manager.
- ☐ On the day before pilot leaves the company's base: Double check equipment requests with helicopter company (antennas, cables, auxiliary power sources, etc.).
- ☐ Get the list of collared elk frequencies and last known locations, if telemetry applies to your survey.
- ☐ Plan which survey units you are going to survey and in which order. Double-check your plan and confirm whether or not there is going to be another helicopter in the air at the same time. Communicate with any other aircraft.
- ☐ Review flight objectives, crew responsibilities
- ☐ Review the Data Sheets (Flight Information, Flight Census) and directions for Flight Census sheet with all flight crew.
- ☐ Synchronize watches, clocks, camera, and audio recorder with GPS unit
- ☐ Prepare the laptop and its own associated GPS to record the track of the flight.
- ☐ Upload Survey unit boundaries file into helicopter GPS unit.
- ☐ Distribute data sheets, pencils, clipboards
- ☐ Go over the covariate measures with all crew and pilot, especially definitions of % concealing vegetation.
- ☐ Review fuel load to meet flight objectives
- ☐ Make sure pilot has proper radio frequencies
- ☐ Test radio reception with park dispatch before survey flight
    - o Requirement for NPS flights: Do not survey if the helicopter radio cannot talk with park dispatch.
    - o Guideline for MIT, PTOI, and WDFW flights, to comply with park aviation safety protocols: if there is a second helicopter involved with concurrent surveys and radio communications on either helicopter are not working, the NPS helicopter will not attempt the survey. Single-helicopter surveys are also not recommended if the helicopter cannot talk by radio with park dispatch.
- ☐ Wash the windows
- ☐ Conduct mission and safety briefing
- ☐ Test communications among crew; replace malfunctioning helmets if needed
- ☐ Test telemetry receiver and antennas
- ☐ Test communications among crew
- ☐ Record backup track log of entire flight on second GPS unit, using either additional handheld unit or helicopter GPS. If using helicopter GPS, ensure the track log can be either downloaded after the flight, or received via email.

Flight Guidelines

- ☐ Stay within survey units except when finding radio-collared elk that may be slightly out.
- ☐ Speed should average 45 knots in summer, 30 knots in spring; actual speed will vary.
- ☐ Contact NPS dispatch upon take-off, to confirm that AFF is operational, flight follow at appointed times (i.e., when moving to a new survey unit), contact dispatch at landings
- ☐ Communicate with any other aircraft in the area regarding aircraft locations
- ☐ Confirm if AFF is operational immediately after take-off

DATA RECORDER:

- ☐ State the exact time early in the flight, so that it's on the audio recorder (NPS flights).
- ☐ Start a new Flight Information Form at each take-off.
- ☐ Fill in the survey Start / Stop conditions just at the start of / end of the survey (not ferry).
- ☐ Write in the start and stop times for each survey unit.

<u>In-Flight Methods</u>

- ☐ Pilot calls dispatch when entering or leaving any survey unit.

EVERYONE:

- ☐ Stay quiet about any elk group you see until it is perpendicular to the ship's path.
- ☐ Wait until the group is just past perpendicular, then speak up! For every group observed, tell the data recorder whether you saw the group before it was called out (that's the definition of seeing it 'independently').
- ☐ If someone spoke up before the group was past perpendicular, tell the recorder you didn't have an independent chance to detect that elk group.

<u>In-Flight Methods, continued</u>

- ☐ Work together to count and determine composition (Cows, Calves, Yearling bull (spike), subadult bull (raghorn), mature bull, unknown). Tell the pilot to not split up the group, if possible.
- ☐ Help the Recorder by *calling out* the covariates: Activity (Bedded / Standing / Moving), Substrate (Rock, Snow, Herbaceous, Shrub, Forest), Concealing vegetation when first seen (0, 1+, 26+, 51+, 76+), Concealing vegetation for whole group (0, 1+, 26+, 51+, 76+), and Light (Flat or HiContrast).
- ☐ Take photos for groups larger than 20 elk.
- ☐ OLYM: Take photos at Phenology photo points.

DATA RECORDER

- ☐ Be sure that all data are completed for each elk group detected, especially Obs # and time (to the second), which are critical pieces of information as elk group location is tied to time.

<u>At end of Flight</u>

- ☐ Data recorder fills in environmental conditions at survey stop time, then arrival time when the helicopter lands.
- ☐ Check over flight data forms in detail
- ☐ Recharge laptop batteries; re-supply batteries for GPS unit, camera, voice recorder.
- ☐ Confer and note what worked and what didn't on this survey
- ☐ Send data forms, digital files to project manager

Elk Monitoring – Flight Information Form

Spring (Standard Time) Summer Survey (Daylight Savings Time) Year ________ Park (circle one): OLYM MORA

Individual Flight (#sequentially within a single year; new Flight # after each refueling)

Flight #________________ Date (mm/dd/yyyy)____________ GPS File ______________________

Aircraft Model____________________ Tail #___________ Company ___________________ Heli Manager _________________

Departure time (hh:mm, 24hr)_________________ Departure Location__________________

Arrival time (hh:mm, 24hr)____________________ Arrival Location____________________

Participants: *Last name, first name* | *Assignment* | *Comments: where seated & duties*

_________________________ pilot ____________________________________ | lf | rf |

_________________________ navigator/observer ____________________________________ | lf | rf || lb | rb

_________________________ observer/recorder ____________________________________ | lf | rf || lb | rb

_________________________ observer ____________________________________ | lf | rf || lb | rb

Survey Start time (hh:mm:ss, 24hr) : : **Cloud Cover** (%)____ **Mist** (%) _____ **Wind** *(circle one)* calm, light, moderate, high, gusty

Precipitation*(circle)* none, mist, light rain, heavy rain, snow **Temp** _______(*circle* C or F) at elev (ft)__________ **Light** *(circle)* Flat HiContrast

Survey Stop time (hh:mm:ss, 24hr) : : **Cloud Cover** (%)____ **Mist** (%) _____ **Wind** *(circle one)* calm, light, moderate, high, gusty

Precipitation*(circle)* none, mist, light rain, heavy rain, snow **Temp** _______(*circle* C or F) at elev (ft)__________ **Light** *(circle)* Flat HiContrast

Cloud cover= overhead, to nearest 5% **Mist** = % of ground in survey units obscured by fog (nearest 5%) **Light** = Flat if no shadows, HiCont if shadows present

Comments (*include snow cover, phenology, scenescence etc.*)

____

____

____

Survey completed? Y / N If not…comments (which survey units only partial?): ________________________________

Overall Count Conditions: Excellent | Very Good | Good | Fair | Poor

Phenology Photo Point Location (Olympic NP)	GPS Time (hh:mm:ss)	Photo Numbers	Comments
	: :		
	: :		
	: :		

AS #_____________ Account________________ Hobbs Start______ Hobbs Stop______

Entered by________ Date______
Verified by_______ Date______
Updated by_______ Date______
Maa12_Field_Forms_2011 V1.0 1/30/11

Figure 7.10. Flight Information Form.

Elk Monitoring – Mt Rainier Census Data Form

Flight #____ Date (mm/dd/yyyy) ____________ **Survey Unit(s)** ________________________ Recorder Name:_________________ Recorder Position: LeftBack / RightBack Page ___of __

Comments____

Unit#______ Start ___:___:___ Stop___:___:___		Unit#______ Start ___:___:___ Stop___:___:___		Unit#______ Start ___:___:___ Stop___:___:___	
Unit#______ Start ___:___:___ Stop___:___:___		Unit#______ Start ___:___:___ Stop___:___:___		Unit#______ Start ___:___:___ Stop___:___:___	

Elk Observation Data

Obs #	Time hh:mm:ss	Activ	Cover type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Total # Elk	Complete Count?	Group Composition, # of each: Cow	Calf	Yearl Bull	SubAd Bull	Mature Bull	Unkn Animal	Who Saw?	Side of Ship	Back-Front I/D	Front-Front I/D	Missed group with radio?	Elk ID, or Freq Codes	Photo
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF RF LB RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF RF LB RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF RF LB RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF RF LB RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF RF LB RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF RF LB RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N

Comments. Note collar color here, if any seen, and any other comments.

Obs #______:____

Obs #______:____

Obs #______:____

Obs #________:____

Obs #________:____

Obs #________:____

Entered by______Date______; Verified by_______Date________; Updated______Date_____
MORA Summer Elk Survey Forms 2011.doc 6/29/2011 11:13:00 AM6/29/11

Figure 7.11. MORA Census Data Form. This form is to be printed on legal sized (8 ½" x 14") paper.

DATA FIELDS DESCRIPTION FOR MT. RAINIER NP ELK MONITORING, FLIGHT INFORMATION FORM AND CENSUS DATA FORM

Please fill out a new Flight Information Form AND a new Census Data Form first page each time you take off.

Survey Start time and **Start Conditions** is for when you arrive at the survey unit. **Survey Stop time** and **Stop Conditions is** for the time when you have finished the last survey unit.

As you proceed through surveys, write the **Unit** #, **Start** time, and **Stop** time for each unit, in the box above the observations data. If GPS fails, this is a record of where you surveyed.

Time saver: if two units are adjacent and surveyed in order, you may write the start time of the second, and that will be entered as the stop time of the first.

After the flight, be sure that the first page of the Census Data Form has all the units visited on that flight written in the **Survey Unit(s)**, on the top line of the form.

Data to record for each elk group

Obs#: The data recorder should announce this clearly to everyone before and after each group. Keep increasing numbers sequentially all evening, even after refueling breaks.

Time: Write down the time when the helicopter was closest to group. Be sure that your watch or clock is synchronized to the GPS (Pacific daylight Time) before the flight begins.

The data recorder should call out the covariates that get recorded for each group, so others can comment

Activity: (majority of group, when 1st seen): B=bedded S=standing, M=moving **Cover type** (majority of group): Ro=rock, Sn=snow, H=herbaceous, SH=shrub, F=forest.

First Seen % Conceal Veg: % concealing vegetation of trees & shrubs / screening vegetation for the elk that were first detected in this group. This refers to how much conceling vegetation there was near those animals only; the type of cover is not relevant; i.e. if cover was 85% near those animals, circle 75+

Whole group % Conceal Veg: % concealing vegetation of trees & shrubs / screening vegetation for the areas surrounding the whole group of elk plus a 10 meter buffer around that. This refers to how much concealing vegetation there was over the whole area

Note: if only one value is recorded for % Conceal Veg, it will be entered for both columns of % Conceal Veg in the database.

Light Flat=low contrast lighting at this group; no distinct shadows seen. HiCont=High contrast; distinct shadows of objects visible here.

Total # Elk: Enter the best estimate of total group size. **Complete Count?:** the default answer is in bold…yes it was complete. Only circle "N" here if you think some elk in the group were missed.

Composition: Fill in numbers seen in each category. Yearling Bull = usually a spike, but may have 2 points. Subadult Bull= usually 3-5 points, but with light beams. Mature Bull = heavy, large beamed, typically with 6 points at Mt. Rainier (5 at Olympic). **Include the number of unknown / unclassified animals!**

Who Saw: Circle the letter codes for each person that saw this elk group independently, i.e. not based on cues from other people in ship. LF=Left Front RF=Right Front (usually this is the pilot); LB= Left Back seat; RB=Right Back seat.

Side of Ship: Circle whether group was on the Left (L) or Right (R) side of the helicopter, i.e., before the pilot turned for counting. Circle L and R if group was visible on both sides. **Circle Center (C) ONLY if the group was always directly under the helicopter's flight path – i.e. it was not visible from the back seats **

If nothing is circled in the last five columns, default values are in bold: "I", "I", "N", (blank), "N": independent detections, not missed, (no radio), no photo.

Back-Front Ind Dep: I=Front and back seats had independent chances to detect the group, at least until the group was past perpendicular; D_{bf} =Back seat observers had no independent chance to detect the group, because they were somehow alerted by the front seat observers (or vice-versa) before the group was past perpendicular.

Front-Front Ind Dep: I=Pilot and the front seat observer had independent chance to detect group until the group was past perpendicular. D_{FF} = some communication between pilot and front seat passenger happened before each had an independent chance to detect the group.

Any Obs with a 'D_{bf}' circled here can not be used in double-observer analysis. Any Obs with a "D_{FF}" circled here can not be used in analyses of pilot acuity.

Missed group w. radio? Circle Yes ONLY if the group was missed during the non-telemetry survey time, but was later found with the use of radio telemetry.

Elk ID, or Freq. Codes: Note the Elk ID / or Frequency code of any animals with working radio collars that were detected in this group, if any.

****For any group found via telemetry**, be sure to circle In-Unit if the group was inside a surveyed unit, Out if it was outside of any surveyed unit, or ? if you don't know.

Photo: Circle Yes if a photo was taken – be sure your camera has the correct GPS time and date before take-off.

Comments: Write the Obs# to which the comments refer. Note if the group was outside a survey unit, and any other notes of interest about that elk group, including collar colors.

Figure 7.12. MORA Abbreviated Instructions for Flight Information Form and Census Data Form. This form is to be printed on legal sized (8 ½" x 14") paper.

Elk Monitoring – OLYMPIC NP Census Data Form

Flight #____ Date (mm/dd/yyyy) ____________ **Survey Unit(s)** _________________________ Recorder Name:_________________ Position: LeftBack / RightBack Page ___of __

Comments____

Elk Observation Data

Obs #	Time hh:mm:ss	Activ	Cover type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Total # Elk	Complete Count?	Cow	Calf	Yearl Bull	SubAd Bull	Mature Bull	Unkn Animal	Who Saw?	Side of Ship	Back-Front I/D	Front-Front I/D	Missed group with radio?	Elk ID, or Freq Codes	Photo
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF | RF LB | RB	L R C	I D_{bf}	I D_{FF}	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF | RF LB | RB	L R C	I D_{bf}	I D_{FF}	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF | RF LB | RB	L R C	I D_{bf}	I D_{FF}	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF | RF LB | RB	L R C	I D_{bf}	I D_{FF}	Y N	In-Unit ? Out	Y N
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N							LF | RF LB | RB	L R C	I D_{bf}	I D_{FF}	Y N	In-Unit ? Out	Y N

Comments. Note Collar color here, if any seen, and any other comments.

Obs #______:_______________________________________ **Obs #**_______:_______________________________________

Obs #______:_______________________________________ **Obs #**_______:_______________________________________

Obs #______:_______________________________________ **Obs #**_______:_______________________________________

Unit#_____ Start ___:___:___ Stop___:___:__
Unit#_____ Start ___:___:___ Stop___:___:__
Unit#_____ Start ___:___:___ Stop___:___:__
Unit#_____ Start ___:___:___ Stop___:___:__
Unit# Start : : Stop : :

Data Recorder's Own Observations. Record Time and Obs# for all groups you saw independently. In table below, I/D is just for the data recorder's own self.

Time	Obs #	Indep	Count and composition Notes	Activity	Cover type	1st seen% Conceal Veg	Whole group Conceal Veg	Comments
: :		I D		B S M	R Sn H Sh F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Sn H Sh F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Sn H Sh F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Sn H Sh F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Sn H Sh F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	

Entered by________ Date______
Verified by_______ Date______
Updated by_______ Date______
OLYM Summer Elk Survey Forms_2011.doc
10/28/11

Figure 7.13. OLYM summer survey Census Data Form. This form is to be printed on legal sized (8 ½" x 14") paper.

DATA FIELDS DESCRIPTIONS FOR OLYMPIC NP SUMMER ELK MONITORING, FLIGHT INFORMATION AND CENSUS DATA FORMS

Fill out a new Flight Information Form once per take-off. This has data about the helicopter, participants, weather & flight conditions, and phenology photos.

There, write **Survey Start time** and **Start Conditions** for the time when you are starting survey; **Survey Stop time** and **Stop Conditions** after finishing the last survey unit of the flight.

As you surveys, write the **Unit #**, **Start** time, and **Stop** time for each unit, in the box at upper right (top of page on other sheets).

After the flight, be sure that the first page of the Census Data Form has all the units visited on that flight written in the **Survey Unit(s)**, on the top line of the form.

Time saver: if two units are adjacent and surveyed in order, you may write the start time of the second, and that will be entered as the stop time of the first.

Data to record for each elk group

Obs#: The data recorder should announce this clearly to everyone before and after each group.

Time: Write down the time when the helicopter was closest to group. Be sure that your watch or clock is synchronized to the GPS (Pacific Daylight Time) before the flight begins.

The data recorder should call out the covariates that get recorded for each group, so others can comment

Activity: (majority of group, when 1st seen): B=bedded S=standing, M=moving

Cover type (majority of group): Ro=rock, Sn=snow, H=herbaceous, SH=shrub, F=forest.

First Seen % Conceal Veg: % concealing vegetation of trees & shrubs / screening vegetation for the elk that were first detected in this group. This refers to how much concealing vegetation there was near those animals only; the type of vegetation is not relevant; i.e. if vegetative cover was 85% near those animals, circle 75+

Whole group % Conceal Veg: % concealing vegetation of trees & shrubs / screening vegetation for the areas surrounding the whole group of elk plus a 10 meter buffer around that. This refers to how much concealing vegetation there was over the whole area **Note: if only one value is recorded for % Conceal Veg, it will be entered for both columns of % Conceal Veg in the database.**

Light Flat=low contrast lighting at this group; no distinct shadows seen. HiCont=High contrast; distinct shadows of objects visible here.

Total # Elk: Enter the best estimate of total group size. **Complete Count?:** the default answer is in bold, yes it was complete. Only circle "N" here if you think some elk in the group were missed.

Composition: Fill in numbers seen in each category. Yearling Bull = usually a spike, but may have 2 points. Subadult Bull= usually 3-5 points, but with light beams. Mature Bull = heavy, large beamed, typically with 5 points at Olympic (6 at Mt Rainier). **Include the number of unknown / unclassified animals!**

Who Saw: Circle the letter codes for each person that saw this elk group independently, i.e. not based on cues from other people in ship. LF=Left Front RF=Right Front (usually this is the pilot); LB= Left Back seat; RB=Right Back seat.

Side of Ship: Circle whether group was on the Left (L) or Right (R) side of the helicopter, i.e., before the pilot turned for counting. Circle L and R if group was visible on both sides. **Circle Center (C) ONLY if the group was always directly under the helicopter's flight path – i.e. it was not visible from the back seats **

In the last 5 columns, default values are in bold (or blank), but MAKE SURE THAT ALL DATA COLUMNS ARE FILLED IN / CIRCLED AT THE END OF THE FLIGHT.

Back-Front Ind Dep: I=Front and back seats had independent chances to detect the group, at least until the group was past perpendicular; D_{bf} =Back seat observers had no independent chance to detect the group, because they were somehow alerted by the front seat observers (or vice-versa) before the group was past perpendicular.

Front-Front Ind Dep: I=Pilot and the front seat observer had independent chance to detect group until the group was past perpendicular. D_{FF} = some communication between pilot and front seat passenger happened before each had an independent chance to detect the group.

Any Obs with a 'D_{bf}' circled here can not be used in double-observer analysis. Any Obs with a "D_{FF}" circled here can not be used in analyses of pilot acuity.

Missed group w. radio? Circle Yes ONLY if the group was missed during visual surveys…For each group with a missed collar, complete a row of data on the Radio Telemetry Form.

Elk ID or Freq. Codes: Note the ID# of collared animals detected in this group, if any. If there are collared animals, circle whether the group is IN-UNIT (inside any survey unit), OUT, or circle **?** if you don't know. (If "Out" is circled, it means the group was not in any survey unit; it won't be included in abundance, but will be included in comp counts if it's within 300 m of a survey unit.)

If nothing is circled in the last five columns, default values are in bold.

Photo: Circle Yes if a photo was taken – be sure your camera has the correct GPS time and date before take-off.

Comments: Write the Obs# to which the comments refer. Note if the group was outside any survey unit, and any other notes of interest about that elk group, including collar colors, if seen.

Data Recorder's Own Observations. Record **Time** and **Obs#** for all groups you saw independent of any cues. Use the spaces at right for notes about your observations.

Figure 7.14. OLYM summer surveys abbreviated Instructions for Flight Information Form and Census Data Form, OLYM summer surveys. This form is to be printed on legal sized (8 ½" x 14") paper.

Olympic N.P. Elk Monitoring – Spring Survey — Flight Census Data Form

Flight #______ Date(mm/dd/yyyy)______________ **Survey Unit:**__________________Recorder name:________________ Position: LeftBack / RightBack Page _____of _____

Comments ____

Obs #	Time hh:mm:ss	Activ	Cover Type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Snow	Total # Elk	Complete Count?	Notes: Count & Composition	Bulls	Who Saw?	Side of Ship	Back-Front I/D	Front-Front I/D	Missed group with radio?	Elk ID, or Freq Codes	Photo
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N			LF | RF LB | RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N			LF | RF LB | RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N			LF | RF LB | RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N			LF | RF LB | RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N			LF | RF LB | RB	L R C	I Dbf	I DFF	Y N	In-Unit ? Out	Y N

Comments. Note collar color here, if any seen, and any other comments.

Obs #________:____

Obs #______:____ **Obs #**________:____

Obs #______:____ **Obs #**________:____

Data Recorder's Own Observations. Record Time and Obs# for all groups you saw independently. I/D is just for the data recorder.

Time	Obs #	Indep	Count and composition Notes	Activity	Cover Type	1st seen% Conceal Veg	Whole group % Conceal Veg	Comments
: :		I D		B S M	R Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		I D		B S M	R Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	

Entered by________ Date______ Verified by_______ Date______ Updated by_______ Date______

Maa03_Field_Forms_2011 V1.0.doc 10/28/11

Figure 7.15. OLYM spring surveys Census Data Form. This form is to be printed on legal sized (8 ½" x 14") paper.

DATA FIELDS DESCRIPTION FOR OLYMPIC NP SPRING ELK MONITORING, FLIGHT CENSUS FORM

Fill out a new Flight Information Form once per take-off. This has data about the helicopter, participants, weather & flight conditions, and phenology photos.
On that form, write **Survey Start time** and **Start Conditions** for the time when you are starting survey. Increase flight number by 1 after each refueling.
Write the **Survey Stop time** and **Stop Conditions** when you have finished the last survey unit of the flight, and are starting the ferry back, or the final round of telemetry.
Start a new Census Data Form after each refueling. Record the Flight #, Date, and Survey Area on the Census forms. Spring **Survey Areas** are Hoh, SFHoh, or Queets.

Data to record for each elk group

Obs#: The data recorder should announce this clearly to everyone before and after each group. Continue to increase numbering, even after refueling (one set of Obs numbers per day).
Time: Write down the time when the helicopter was closest to group. Be sure that your watch or clock is synchronized to GPS time before the flight begins.

The data recorder should call out the covariates that get recorded for each group, so others can comment

Activity: (majority of group, when 1st seen): B=bedded S=standing, M=moving
Cover Type (majority of group): Ri=river, Gb=gravel bar (can have shrubs), Af=alder flat, M=maple, Gr=grassy meadow, OGO=open old growth, OG=old growth. Sup=Shrub-Upland.
First Seen % Conceal Veg: % concealing vegetation…trees & shrubs / screening vegetation for the elk that were first detected in this group. This refers to how much concealing vegetation there was near those animals only; the type of vegetation is not relevant; i.e. if concealing vegetation was 85% near those animals, circle 75+
Whole group % Conceal Veg: % concealing vegetation…trees & shrubs / screening vegetation for the areas surrounding the whole group of elk plus a 10 meter buffer around that. This refers to how much concealing vegetation there was over the whole area **Note: if only one value is recorded for % Conceal Veg, it will be entered for both columns of % Conceal Veg in the database.**
Light Flat=low contrast lighting at this group; no distinct shadows seen. HiCont=High contrast; distinct shadows of objects visible here.
Snow: yes or no for snow present at group location
Total # Elk: Enter the best estimate of total group size. **Complete Count?:** the default answer is “Yes” it was complete. Only circle “N” here if you think some elk in the group were missed.
Notes: Count & Composition: This space for notes, while initial counts are still being made / spoken out loud.
Bulls: This is a subset of “Total # Elk.” At this time of year, some bulls have dropped antlers, and some have not. Write the number of bulls here, if any are noted.
Who Saw: Circle the letter codes for each person that saw this elk group independently, i.e. not based on cues from other people in ship. LF=Left Front RF=Right Front (usually this is the pilot); LB= Left Back seat; RB=Right Back seat. It’s most reliable to do this in the air, but the record can be reconstructed from ‘double-observer’ sheets.
Side of Ship: Circle whether group was on the Left (L) or Right (R) side of the helicopter, i.e., before the pilot turned for counting. Circle L and R if group was visible on both sides.
*Circle Center (C) only if the group was always under the flight path – i.e. it was not visible from the back seats * REVIEW ALL COVARIATES AND ‘WHO SAW' AFTER EACH GROUP.
If nothing is circled in the last five columns, default values are in bold: “I”, “I”, “N”, (blank)“N”, meaning: independent detections, group was not missed, (no radio), no photo, but…
Back-Front Ind Dep: I=Front and back seats had independent chances to detect the group, at least until the group was past perpendicular; D_{bf} =Back seat observers had no independent chance to detect the group, because they were somehow alerted by the front seat observers (or vice-versa) before the group was past perpendicular.
Front-Front Ind Dep: I=Pilot and the front seat observer had independent chance to detect group until the group was past perpendicular. D_{FF} = some communication between pilot and front seat passenger happened before each had an independent chance to detect the group.
Any Obs with a ‘D_{bf}’ circled here can not be used in double-observer analysis. Any Obs with a “D_{FF}” circled here can not be used in analyses of pilot acuity.
Missed group w. radio? Circle Yes ONLY if the group was missed during visual surveys…For each group with a missed collar, complete a row of data on the Radio Telemetry Form.
Elk ID or Freq. Codes: Note the ID# of collared animals detected in this group, if any. If there are collared animals, circle whether the group is IN-UNIT (inside any survey unit), OUT, or circle **?** if you don’t know. (If “Out” is circled, it means the group was not in any survey unit; it won’t be included in abundance, but will be included in comp counts if it’s within 300 m of a survey unit.)
Photo: Circle Yes if a photo was taken – be sure your camera has the correct GPS time and date before take-off.
Comments: Write the Obs# to which the comments refer. Note if the group was outside any survey unit, and any other notes of interest about that elk group, including collar colors if seen.
Data Recorder’s Own Observations. Record **Time** and **Obs#** for all groups you saw independent of any cues. Use the spaces at right for notes about your observations.

ENSURE THAT ALL DATA ARE FILLED IN / CIRCLED DURING REFUELING / AFTER THE END OF THE FLIGHT.

Figure 7.16. OLYM spring surveys abbreviated Instructions for Flight Information Form and Census Data Form. This form is to be printed on legal sized (8 ½” x 14”) paper.

Elk Monitoring –**FRONT SEAT OBSERVER FORM**

Flight #____ **Date**_________ **Park** Rainier Olympic **Observer**________ **Position**: rf, lf **Pilot** __________ **Comments**__________ Page __of ___

At Olympic NP: Only record Obs# and time for groups that you and / or the Pilot saw before being told by other crew.

At Mt. Rainier NP: This page is for notes; no fields are required

Time hh:mm:ss	Obs #	Obs/Pilot/ Both	Side of ship	Front-Front (I/D)	Count & Composition Notes	Activity	Cover type	First Seen % Conceal Veg	Whole group % Conceal Veg	Comments, collar color
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**O P** Both	L R C	**I** D		**B** S **M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	

Flight#:same # as on flight census data sheet **Date** (mm/dd/yyyy) **Park**: circle one **Observer**: your name **Position**: left front or right front seat **Comments**:other notes in general

At Olympic: Fill in Time, Obs#, Obs/Pilot/Both, and Side of Ship for every group you and/or the pilot see independent of rear seat crew…other columns are for notes.

At Olympic: Only note observations made independently by you and/ or pilot…Do not record Obs# for any elk that you saw only after back seat observer(s) mentioned it.

Time: 24-hour time when over group **Obs#:** observation # on Census data sheet (Get this from data Recorder) **O**bserver / **Pilot**/ Both: **P** if pilot saw independently, **O** if front seat observer only, **B** if both. **Side of Ship**: circle "C" (center) if the elk group was at center at all times, and passed only under skids (not available for rear seat to have seen)

Front-Front Ind Dep I/D: I=There was no cue between the front seat observer and pilot. D=One of the people in the front seats alerted the other by word or action before the other one had a chance to see or not see the elk. Default is Independent. **Tell data recorder if the observation was Front-Front Dependent.**

Count and Composition notes: This space is for jotting notes. The data recorder records the consensus of total count and composition, based on what you and others see.

Activity: (Pick this based on the majority of the group, when they were 1st seen): B=bedded S=standing, M=moving

Cover type (majority of the group): Ro=rock, Sn=snow, H=herbaceous, SH=shrub, F=forest.

First Seen % Conceal Veg = % concealing vegetation of trees & shrubs / screening vegetation for the elk when first detected in the group.

Entire Group %Forest cover =% concealing vegetation of trees & shrubs / screening veg in the area of the entire elk group +10m buffer.

Entered by________ Date______
Verified by_______ Date______
Updated by_______ Date______
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1/30/11

Figure 7.17. Front Seat Observer Form for summer surveys.

Elk Monitoring – **BACK SEAT OBSERVER FORM (for the observer who is not the main data recorder)**

Flight #____ **Date**_________ **Park** Rainier Olympic **Observer**_____________ **Position**: lb, rb **Comments**______________________ Page __of ___

At Olympic NP: Only record Obs# and time for groups that you saw before being told by other crew.

At Mt. Rainier NP: This page is for notes; no fields are required

Time **hh:mm:ss**	Obs #	Back-Front **(I/D)**	Count and Composition Notes	Activity (B S M)	Cover type (R/Sn/H /Sh /F)	First Seen % Conceal Veg	Whole group % Conceal Veg	Comments, Collar color
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	
: :		**I** D		**B S M**	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	

Flight#:same # as on flight census data sheet **Date** (mm/dd/yyyy) **Park**: circle one **Observer**: your name **Position**: left front or right front seat **Comments**:other notes in general

At Olympic: Fill in Time and **Obs# for every group you personally see independent of front seat crew…other columns are for notes.**

At Olympic: Only note independent observations…Do not record time or obs # for any elk group that you saw only after front seat observer(s) mentioned it.

Time: 24-hour time when over group **Obs#**: observation # on Census data sheet (Get this from data Recorder)

Back-Front I/D: I=back seat observer was not cued in to presence of the elk group before he/she had a chance to see it. D=Some cue prevented back or front seat from having a fair chance to see the elk group independently. Default is Independent. **Tell data recorder if you did not have a fair chance to see that group (i.e., it was not an independent observation)**

Count and Composition notes: This space is for jotting notes. The data recorder records the consensus of total count and composition, based on what you and others see.

Activity: (Pick this based on the majority of the group, when they were 1st seen): B=bedded S=standing, M=moving

Cover type (majority of the group): Ro=rock, Sn=snow, H=herbaceous, SH=shrub, F=forest.

First Seen %Conceal Veg = % concealing vegetation of trees & shrubs / screening vegetation for the elk when first detected in the group.

Entire Group %Conceal Veg =% concealing vegetation of trees & shrubs / screening veg in the area of the entire elk group +10m buffer

Entered by________ Date______
Verified by_______ Date______
Updated by_______ Date______
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1/30/11

Figure 7.18. Back Seat Observer Form for summer surveys

Olympic NP Spring Elk Monitoring –**FRONT SEAT OBSERVER FORM**

Flight #____ **Date**__________ **Observer**_____________ **Position**: rf, lf **Pilot**____________ **Comments**______________ Page __of ___

Only record groups that you or the Pilot saw before being told by other crew.

Time hh:mm:ss	Obs #	Obs/Pilot/ Both	Side of ship	Front-Front I/D	Count & Composition Notes	Activity	Cover Type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Snow	Comments, collar color
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		O P Both	L R C	I D		B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	

Flight#:same # as on flight census data sheet **Date** (mm/dd/yyyy) **Observer**: your name **Position**: left front or right front seat **Comments**:other notes in general

Fill in Time, Obs#, Obs/Pilot/Both, and Side of Ship for every group you and/or the pilot see independent of rear seat crew…other columns are for notes.

DO NOT RECORD TIME OR OBS # FOR ANY ELK GROUP THAT YOU SAW ONLY AFTER REAR OBSERVER(S) MENTIONED IT.

Time: 24-hour time when over group **Obs#:** observation # on Census data sheet (Get this from data Recorder) Observer / **Pilot**/ Both: **P** if pilot saw independently, **O** if front seat observer only, **B** if both. **Side of Ship**: circle "C" (center) if the elk group was at center at all times, and passed only under skids (not available for rear seat to have seen)

At Mt. Rainier, the rest of each row is for notes purposes; not required. At Olympic, each observer should fill in Activity, Substrate, and Veg Cover.

Front-Front Ind Dep I/D: I=There was no cue between the front seat observer and pilot. D=One of the people in the front seats alerted the other by word or action before the other one had a chance to see or not see the elk. Default is Independent. **Tell data recorder if the observation was Front-Front Dependent.**

Count and Composition notes: This space is for jotting notes. The data recorder records the consensus of total count and composition, based on what you and others see.

Activity: (Pick this based on the majority of the group, when they were 1st seen): B=bedded S=standing, M=moving

Cover type (majority of the group): Ri=river, Gb=gravel bar, Af=alder flat, M=maple, Gr=grassy meadow, OGO=open old growth, OG=old growth. Sup=Shrub-Upland

First Seen % Conceal Veg = % concealing / screening vegetation of trees & shrubs; for the elk when first detected in the group.

Entire Group % Conceal Veg =% concealing / screening vegetation of trees & shrubs; in the area of the entire elk group +10m buffer.

Light: Flat if no shadows; High if shadows present. **Snow:** Y is snow present at group.

Entered by________ Date______
Verified by_______ Date______
Updated by_______ Date______
Maa12_Field_Forms_2011 V1.0 1/30/11

Figure 7.19. Front Seat Observer Form for spring surveys.

Olympic NP Spring Elk Monitoring – **BACK SEAT OBSERVER FORM (for the observer who is not the main data recorder)**

Flight #____ **Date**_________ Olympic NP Spring **Observer**____________ **Position**: lb, rb **Comments**______________________ Page __of ___

Only record groups that you saw before being told by other crew.

Time hh:mm:ss	Obs #	Back-Front (I/D)	Count & Composition Notes	Activity	Cover type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Snow	Comments, Collar color
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :		**I** **D**		**B S M**	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N	

Flight#:same # as on flight census data sheet **Date** (mm/dd/yyyy) **Observer**: your name **Position**: left front or right front seat **Comments**:other notes in general

Fill in Time and Obs# for every group you personally see independent of front seat crew…other columns are for notes.

DO NOT RECORD TIME OR OBS # FOR ANY ELK GROUP THAT YOU SAW ONLY AFTER FRONT OBSERVER(S) MENTIONED IT.

At Mt. Rainier, the rest of each row is for notes purposes; not required. At Olympic, each observer should fill in Activity, Substrate, and Veg Cover.

Time: 24-hour time when over group **Obs#**: observation # on Census data sheet (Get this from data Recorder)

Back-Front I/D: I=back seat observer was not cued in to presence of the elk group before he/she had a chance to see it. D=Some cue prevented back or front seat from having a fair chance to see the elk group independently. Default is Independent. **Tell data recorder if you did not have a fair chance to see that group (i.e., it was not an independent observation)**

Count and Composition notes: This space is for jotting notes. The data recorder records the consensus of total count and composition, based on what you and others see.

Activity: (Pick this based on the majority of the group, when they were 1st seen): B=bedded S=standing, M=moving

Cover type (majority of the group): Ri=river, Gb=gravel bar, Af=alder flat, M=maple, Gr=grassy meadow, OGO=open old growth, OG=old growth. Sup=Shrub-Upland

First Seen % Conceal Veg = % concealing / screening vegetation of trees & shrubs; for the elk when first detected in the group.

Entire Group % Conceal Veg =% concealing / screening vegetation of trees & shrubs; in the area of the entire elk group +10m buffer.

Light: Flat if no shadows; High if shadows present. **Snow:** Y is snow present at group.

Entered by________ Date______
Verified by_______ Date______
Updated by_______ Date______
Maa12_Field_Forms_2011 V1.0 1/30/11

Figure 7.20. Back Seat Observer Form for spring surveys.

Olympic NP Elk Monitoring – **RADIO TELEMETRY FORM** **Flight #**____ **Date**_________ **Survey Units**________________________ **Recorder name**____________ Page __of __

Time Start Telem 1__________	Time Start Telem 2__________	Time Start Telem 3__________	Time Start Telem 4__________	Time Start Telem 5__________
Time Stop Telem 1__________	Time Stop Telem 2__________	Time Stop Telem 3__________	Time Stop Telem 4__________	Time Stop Telem 5__________

Comments about telemetry

Obs #	Time hh:mm:ss	Activ	Cover type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Total # Elk	Complete Count?	Group Composition, # of each: Cow	Calf	Yearl Bull	SubAd Bull	Mature Bull	Unkn Animal	Freq Code(s) (Collar#)	When was the group seen?	In or Out of Survey Unit?	Photo
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N								Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.																		
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N								Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.																		
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N								Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.																		
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N								Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.																		
	: :	B S M	Ro Sn H SH F	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat HiCont		Y N								Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.																		

Use this form for when a radio-collared animal is not detected during aerial survey. Record time spent on the overall telemetry effort, noting time start and stop for each period of telemetry.

Obs#: if elk was in a group previously detected during the survey, write down that Obs#. Otherwise give it a new Obs#. Record Covariates and composition for elk group with collar as you would for any group seen during the survey.

Time: when over collared animal; **Frequency Code**: animal#...3 or 4 digits – you can write the radio frequency in comments;

"When was the group seen" "Cow seen" = it turns out this was a group seen during survey, and also, the collared cow was seen then, too…it should be an Obs on the main census sheet. This will count as detected in survey;

"Group seen" = it turns out that the group was seen in survey although the collared animal was not detected at that time. It should be an Obs on the main census sheet. This will also count as detected in survey;

"Missed" = the group that this (or these) collared cow(s) was in was not seen during survey. Any Missed group should be copied over to the main census sheet after the flight, with Missed group with radio circled as "YES"

In or Out of Survey Unit?: In = inside a surveyed unit. Out = outside any surveyed unit. ? = observers aren't sure if it was in or out of any surveyed unit.

Entered by________ Date______ Verified by_______ Date______ Updated by_______ Date______OLYM Summer Elk Survey Forms_2011.doc 10/28/11

Figure 7.21. Radio Telemetry Form for OLYM summer surveys. This form is used to record data about radio collared elk groups that were missed during surveys. This form is to be printed on legal sized (8 ½" x 14") paper.

Olympic NP SPRING Elk Monitoring – **RADIO TELEMETRY FORM** **Flight #____ Date_________ Survey Unit__________________ Recorder name_____________** Page __of __

Time Start Telem 1___________ | Time Start Telem 2___________ | Time Start Telem 3___________ | Time Start Telem 4___________ | Time Start Telem 5___________
Time Stop Telem 1___________ | Time Stop Telem 2___________ | Time Stop Telem 3___________ | Time Stop Telem 4___________ | Time Stop Telem 5___________

Use this form for when a radio-collared animal is not detected during aerial survey.

Obs #	Time hh:mm:ss	Activ	Cover Type	First Seen % Conceal Veg	Whole group % Conceal Veg	Light	Snow	Total # Elk	Complete Count?	Notes: Count & Composition	Bulls	Elk IDs, or Freq Code(s)	When was the group seen?	In or Out of Survey Area?	Photo
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N				Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.															
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N				Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.															
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N				Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.															
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N				Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.															
	: :	B S M	Ri Gb Af M Gr OGO OG Sup	0 1+ 26+ 51+ 76+	0 1+ 26+ 51+ 76+	Flat Hi	Y N		Y N				Cow seen Group seen Missed	In ? Out	Y N
Comments for the above. Note collar color, if seen.															

Record time spent on the overall telemetry effort, noting time start and stop for each period of telemetry.
Obs#: if elk was in a group previously detected during the survey, write down that Obs#. Otherwise give it a new Obs#. Record Covariates and composition for elk group with collar as you would for any group seen during the survey.
Time: when over collared animal; **Frequency Code**: animal#...3 or 4 digits – you can write the radio frequency in comments;
"When was the group seen" "Cow seen" = it turns out this was a group seen during survey, and also, the collared cow was seen then, too…it should be an Obs on the main census sheet. This will count as detected in survey;
"Group seen" = it turns out that the group was seen in survey although the collared animal was not detected at that time. It should be an Obs on the main census sheet. This will also count as detected in survey;
"Missed" = the group that this (or these) collared cow(s) was in was not seen during survey. Any Missed group should be copied over to the main census sheet after the flight, with Missed group with radio circled as "YES"
In or Out of Survey Unit?: In = inside a surveyed unit. Out = outside any surveyed unit. ? = observers aren't sure if it was in or out of any surveyed unit.

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Figure 7.22. Radio Telemetry Form for OLYM spring surveys. This form is used to record data about radio collared elk groups that were missed during surveys. This form is to be printed on legal sized (8 ½" x 14") paper.

Elk Monitoring – Other Species Data form – Based on Audio Recording – Complete this in the office

Flight #____ **Date**______ **Park** Rainier Olympic **Comments**____ Page __of ___

Audio recording File Name____ NAME OF LISTENER transcribing the tape____________________

Audio recording Start Time___________ Audio Recording End Time__________________ Total Audio recording Length____________________

Running Time **hh:mm:ss**	Clock Time **hh:mm:ss**	Incidental Obs I#	Species	Number in group	Substr. **(R/Sn/H /Sh /F)**	Activity B / S / M	% Concealing Vegetation	Comments, light
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	
: :	: :	I_____	B D G Ea O		Ro Sn H SH F	B S M	0 1+ 26+ 51+ 76+	

Flight#:same # as on flight census data sheet **Date** (mm/dd/yyyy) **Park:** pick one **Comments**: comments
Start Time: exact time of day when the audio recording began. If only End Time is known, you may need to subtract Total Length from End Time to get Start Time.
Running Time: Time since beginning of audio recording, when this observation is heard.
Clock Time: thisis the time of day that the observation was noted. Clock time = Running Time + Start Time…. You may need to calculate this, i.e. in a spreadsheet program
Incidental Obs I#: observation # for this animal (or group of animals). Number them sequentially, starting at 1 for each flight.
Survey Unit: Number of the survey unit that corresponds to this clock time….enter it if you know, based on the census data sheet record of where the flight was at that time.
Species: Bear, Deer, Goat, Eagle, Other. If other, note what species it was, in comments
Number in group: Number of animals noted by flight crew. Leave blank if not specified
Cover type (when 1st seen): Ro=rock, Sn=snow, H=herbaceous, SH=shrub, F=forest. Activity: B=Bedded, S=Standing, M=Moving… if observer says "feeding," write Standing
%Conceal Veg = % concealing vegetation, including tall shrubs / screening vegetation, in the area of the animal(s) + a 10m buffer

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Verified by_______ Date______
Updated by_______ Date______
OLYM Summer Elk Survey Forms_2011.doc
1/30/11

Figure 7.23. Other Species Data Form for summer surveys.

Olympic NP Spring Elk Monitoring – Other Species Data form – Based on Audio Recording – Complete this in the office

Flight #____ **Date**______ **Park** Olympic **Survey Unit** ___________**Comments**____ Page __of ___

Audio recording File Name____ NAME OF LISTENER transcribing the tape_______________________

Audio recording Start Time_____________ Audio Recording End Time___________________ Total Audio recording Length_____________________

Running Time **hh:mm:ss**	Clock Time **hh:mm:ss**	Incident Obs I#	Species	Number in group	Cover type	Activity B / S / M	% Conceal Veg	Light	Snow	Comments
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	
: :	: :	I____	B D G Ea O		Ri Gb Af M Gr OGO OG Sup	B S M	0 1+ 26+ 51+ 76+	Flat Hi	Y N	

Flight#:same # as on flight census data sheet **Date** (dd/mm/yyyy) **Survey Unit:** Hoh, SFHoh, or Queets **Comments**: comments
Start Time: exact time of day when the audio recording began. If only End Time is known, you may need to subtract Total Length from End Time to get Start Time.
Running Time: Time since beginning of audio recording, when this observation is heard.
Clock Time: thisis the time of day that the observation was noted. Clock time = Running Time + Start Time…. You may need to calculate this, i.e. in a spreadsheet program
Incidental Obs I#: observation # for this animal (or group of animals). Number them sequentially, starting at 1 for each flight.
Survey Unit: Number of the survey unit that corresponds to this clock time….enter it if you know, based on the census data sheet record of where the flight was at that time.
Species: Bear, Deer, Goat, Eagle, Other. If other, note what species it was, in comments. **Number in group**: Number of animals noted by flight crew. Leave blank if not specified
Cover type (majority of the group): Ri=river, Gb=gravel bar, Af=alder flat, M=maple, Gr=grassy meadow, OGO=open old growth, OG=old growth. Sup=Shrub-Upland
if observer says "feeding," write Standing **% Conceal Veg**: % concealing / screening vegetation of trees & shrubs;
in the area of the entire animal(s) group +10m buffer. **Light:** Flat if no shadows; High if shadows present. **Snow:** Y is snow present at group.

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Verified by_______ Date______
Updated by_______ Date______
Maa12_Field_Forms_2011 V1.0 1/30/11

Figure 7.24. Other Species Data Form for spring OLYM surveys.

SOP 8: Digital Audio Recorder Use

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview
This SOP gives instructions for digital audio recorder setup, recording, and playback. Recordings of the cockpit conversation are valuable for several reasons. First, recordings can be used to clarify ambiguously recorded data on data sheets. Second, recordings can be used to locate sightings of other species (e.g., mountain goat, deer, black bear, eagle, marmots, etc.), because the crew members can simply state their observations verbally, and the time of the recording is associated with location by means of the GPS record of the flight path. Recording quality is scratchy with the current equipment, but the conversation is generally intelligible if crew members speak clearly.

Introduction
Elk surveys are the most successful when crew members can maximize the amount of time they spend searching for elk. With that in mind, this protocol calls for audio recording of the cockpit conversation of elk surveys conducted by MORA or OLYM staffs. So long as the exact time is noted at least once on the audio recording, the time of any other part of the recording, and the helicopter's associated location can be known. In theory, all elk-related and other data could simply be spoken during the flight, then later transcribed; we do not, however, advocate so much reliance on the audio recording technology. Rather, the audio recording may be used to note observations of other species. The recording can also be used for clarification, in the event that there are questions about the data recorded on paper.

In addition to the guidelines here, field instructions for equipment preparation and use in the helicopter are provide on the "Field Instructions for Using the DS-30 Digital Audio Recorder" at the end of this SOP (Figure 8.3).

Effectively managing audio recordings requires a consistent method for downloading, naming, and documenting. The general process for managing audio recordings proceeds as follows:

A. File Structure Setup – Set up the file organization for recordings prior to acquisition
B. Prepare equipment
C. Record audio during surveys
D. Download, process, and transcribe
    a. Download and rename the files from the digital audio recorder
    b. Copy and store original, unedited versions
    c. Transcribe 'Other Species' data onto data forms
E. Deliver audio files for final storage

File Structure Setup

Prior to data collection for any given year, project staff will need to set up new folders under the Audio_recordings folder in the project workspace as follows:

[Year]	The appropriate year – 2011, 2012, etc.
[Park code]	Name of park – MORA or OLYM
[Season]	The season of survey – Spring or Summer
Originals	Renamed, but otherwise unedited audio file copies
Processing	Processing workspace

This folder structure provides separate space for processing and storage of original recordings. Note: For additional information about the project workspace, refer to **SOP 1: Project Workspace and Records Management**.

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- No spaces or special characters in the folder name
- Use the underbar ("_") character to separate words in folder names
- Try to limit folder names to 30 characters or fewer
- Use full year (i.e., 2013)
- Use full season name (i.e., Spring, Summer)

Example folder name:

2014_OLYM_Summer_Originals	The folder containing original files from 2014 OLYM summer surveys

Prepare Equipment for Recordings

At present, the surveys use an Olympus DS-30 digital audio recorder. This is plugged into the helicopter's internal audio system through an adapter (CellSet model H-5000-2, Kennedy Technology Group, Rose Hill, Kansas). The audio recorder should be configured so that sound quality is as clear as possible (Table 8.1). The audio recorder must have adequate memory storage space available to record the flight. Recordings from previous flights should be copied to a computer and erased before new flights take place.

Table 8.1. Olympus DS-30 audio recorder settings to use for helicopter survey. These settings are selected via the menu on the audio recorder.

Record Mode:	HQ	Play mode:	File	Beep:	On
Variable Control Voice Actuator (VCVA):	Off	Alarm:	Off	Lock:	On
Timer Rec:	Off	Backlight:	On	Format:	DO NOT REFORMAT!
LowCut Filter:	On	LED:	On	USB Setting	Storage
Noise Cancel:	Off	Contrast:	5 or 6	Power Save:	Off
Voice Filter:	On	Voice Guide:	Off	Time & Date:	Set this to GPS time

Plug the audio recorder into the helicopter's communication system. In a Bell 206BIII JetRanger, plug the CellSet into the audio jack for the center back passenger; this jack is not used by any crew member on the surveys, so the recorder is in a circuit that is connected in parallel to the other headsets. In a Hughes 500D, plug the CellSet into the data recorder's audio jack. There are only two back seat audio jacks in a Hughes 500D, so the CellSet is connected in series with the data recorder's headset. In either case, turn the volume control knob on the helicopter's push-to-talk connection all the way to its maximum setting (all the way to the clockwise).

In-flight Recording Methods

If the DS-30 is connected serially with the data recorder's headset (as is the case in a Hughes 500D helicopter), then the sound quality is consistently best for recording the data recorder's voice.

Within the first few minutes of the audio recording, the Data Recorder should clearly speak the time to the nearest second, as a clear indicator of the exact time. For example, that person could state, "When I say now, the time will be 16:30 and 25 seconds…Now." It is also useful for the Data Recorder to say out loud what the exact time is at the moment when the helicopter enters a new survey unit.

Whenever a crewmember (including the pilot) remarks about seeing a wildlife species other than elk, the data recorder should clearly repeat that information, including a statement of species, number of animals, and the person who noted it. Having the data recorder repeat these observations makes transcription unambiguous.

File Download, Processing, and Transcription

a. Immediately after surveys, download the audio recording from the flight(s) to the \Audio_recordings\1_Originals folder. Rename the recordings according to the ***Audio File Naming Standards*** section.
b. Copy the renamed recordings to the 'Processing' folder, then set the contents in the 'Originals' folder to be read-only by right clicking in Windows Explorer and checking the appropriate box. The originals are the recording backup in case of unintended file alterations (e.g., file deletion).
c. Transcribe 'Other Species' data, as described in the ***Transcription*** section.

Audio File Naming Standards

In all cases, audio recording file names should follow these guidelines:

- No spaces or special characters in the file name
- Use the underbar ("_") character to separate file name components
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters
- Park code, year, season, and flight number should be included in the file name

The audio file name should consist of the following parts:

- Audio_
- Park (MORA or OLYM)
- Year (2011, 2012, etc.)
- Season (Spr or Sum)
- Flight number (_f##)
- Optional: a sequential letter if multiple recordings were made (a, b, c, etc.)

Example file names:

• Audio_OLYM_2014_Sum_f2.wma	The recording of flight 2, in OLYM summer surveys of 2014
• Audio_MORA_2012_Sum_f6.wma	The recording of flight 6, in MORA summer surveys of 2012

Transcription

The purpose of transcription is to write down, on the Other Species Data Form, 'Other Species' data that were spoken during flight. There is no need to transcribe the audio file if Other Species data were written directly onto a field form, during flight. The person listening to the audio file (the transcriber) uses the copy of the recording file in the "Processing" folder. The transcriber can use any applicable software for audio playback, but it is vital that the software have a feature so that the running time is visible – this is the time in hours, minutes, and seconds, since the start of the recording. The Olympus DSS Player software that comes with the DS-30 audio recorder has useful features that can limit background noise.

<u>Determining Audio Recording Start Time</u>

The guidelines for completing the Other Species Data Form are in **SOP 7: Conducting Helicopter Surveys**. The Clock time column on that form signifies the time when the observation was made – this time is a key link that is used to locate that observation (**SOP 11: Geospatial Data Management**). If the Other Species Data Form is filled out based on transcription of an audio file, the Clock time cannot be written down directly; it must be determined by referring to the clock time when the audio recording began (the Audio recording start time) and the time duration after that start time when the observation was noted (the Running time).

Find the Audio recording end time. To do this, use Windows Explorer to open the Audio_recording folder with the audio file in question. Select the file by left clicking on it. Right click over the selected file, and then left click "Properties" at the bottom of the list that appears. Within the file properties window that appears, the end time for the file is listed on the line saying "Modified" (Figure 8.1). The transcriber should write down that time as the Audio recording end time.

Next, the transcriber should refer to the audio playback software to determine the Total audio recording length. On the DSS Player software, this time is shown as "Length" (Figure 8.3). The Audio recording start time is found by subtracting the Total audio recording length from the Audio recording end time. For the example file shown in Figures 8.2 and 8.3, the start time is

(8:15:44 pm) – (1:28:33), which is the same as 6:47:11 pm. This should be recorded in 24-hour time, as 18:47:11.

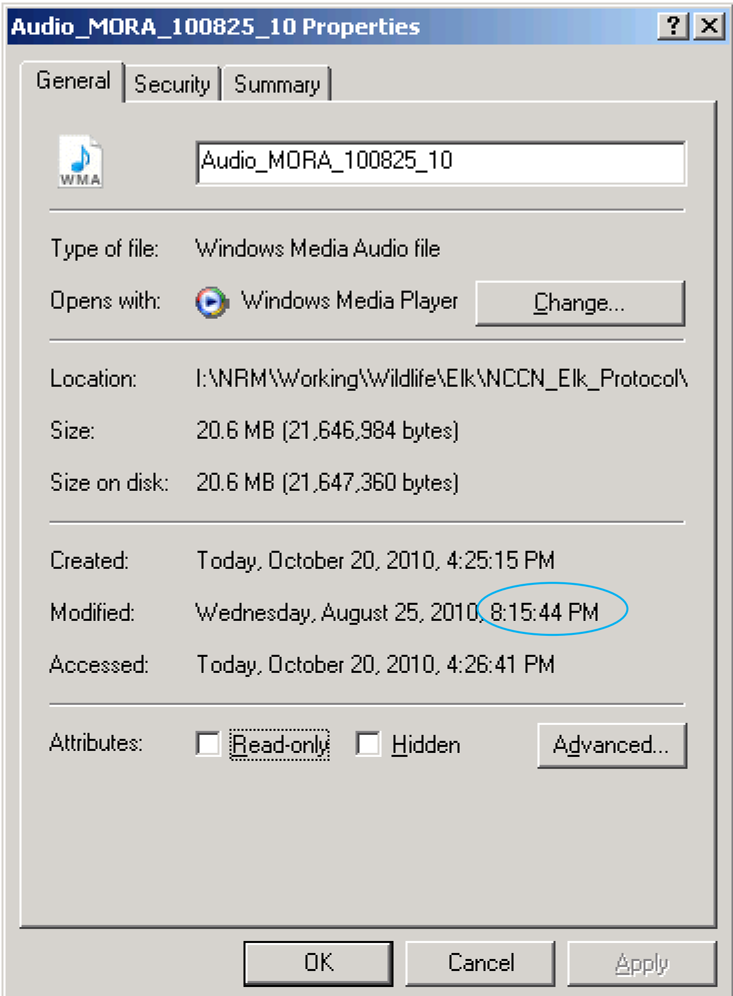


Figure 8.1. File Properties window for a digital audio recording. The Audio recording end time is circled in blue; it is the time when the file was modified.

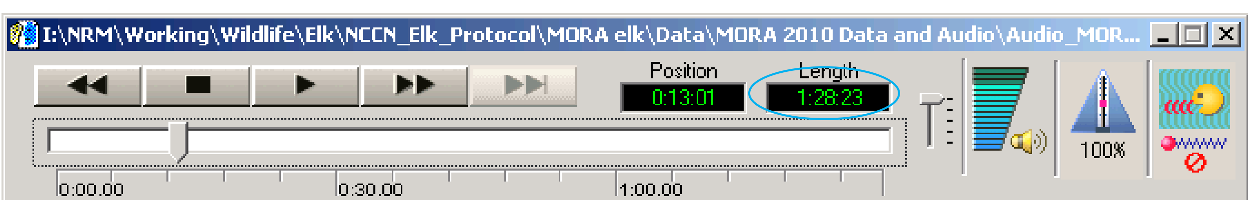


Figure 8.2. DSS Player playback window, showing where Total audio recording time can be found. In this software that duration is called “length.” Total audio recording time for this file is circled in blue.

Recording Other Species Data, while Transcribing

The transcriber should listen to the entire audio recording of the flight. To record observations from the audio recording, the transcriber should fill in the Running time, Incidental Obs #, Survey Unit (if known), Species, Number in group, Cover type, Activity, % Concealing Veg, and Comments, as described in **SOP 7: Conducting Helicopter Surveys** (Completing the Other Species Data Form section). Those data can subsequently be entered into the project database.

So long as there is a valid Audio recording start time, and a running time for each observation, the database will associate a Clock time with that observation when the data are entered. From the Clock time and the record of the helicopter's flight path, the observation will be associated with a location, including attribution within a survey unit, if appropriate.

Deliver Recordings for Final Storage

At the end of the season, and once the year's data are certified, audio recordings for the year may be delivered along with the working copy of the database to the Data Manager on a CD or DVD. To do this, simply copy the folder for the appropriate year(s) and all associated subfolders and images onto the disk. Prior to delivery, make sure that the 'Processing' folder is empty. Upon delivery, the delivered folders should be made read-only to prevent unintended changes.

Every year, the Project Lead and Data Manager should evaluate whether or not archived digital audio recordings are stored on media and using software that will be supported by future computer hardware and software, and should take any necessary measures to ensure that stored recordings will be usable in the future.

Field Instructions for Using the Olympus DS-30 Digital Voice Recorder
Bring to Helispot

- ☐ Olympus DS-30 Recorder
- ☐ 2 AAA batteries and 1 9V battery
- ☐ 1/8" male to 3/32" female stereo adapter (Radio Shack)
- ☐ CellSet H-5000 with fresh 9V battery inside

Batteries: Use 2 fresh AAA batteries once per 2 flights / once per 8 hours recording.
Put a fresh 9V battery in the CellSet at least once per 4 flights.

Power: Slide Power bar down once to turn on the DS-30.

Memory: Capacity on the settings specified here is ~ 15 hours. Be sure to download past recordings to a laptop or desktop computer, and clear the recorder's memory before a series of flights are expected. For example, if you know you will have two or three evenings of survey in a row, clear the recorder's memory before the first of those evenings.

Settings: Before flight, confirm that the recorder has following settings:

- On the left side of the recorder, slide the "MIC SENSE" switch to "CONF"
- LowCut filter ON: At bottom right of the screen you should see a symbol that looks like 4 fan blades
- Record Mode should be HQ (high quality, monoaural). Symbol is a black box on 2nd line
- Voice Filter ON: There should be a "V" above the battery indicator
- DO NOT turn on the VCVA (variable control voice actuator)
- DO record the whole flight.
- Set the Time and Date to same time as a GPS unit: From the main (record) screen, press and hold Menu for 1+ second. This gives you the settings menu. Press + 4 times to get to Time & Date. Press OK. Set time and date. Press the minute adjustment so that it starts the minute exactly when the GPS unit starts the minute. Use << and >> to choose what you're adjusting. Use + or – to adjust. Press OK when time is set. Use the << button to get back to the main (record) screen.

Connect the Voice Recorder to the Helicopter Audio System:

- Plug the helicopter avionics plug of the CellSet 5000 into the passenger audio jack.
  In a Bell 206BIII JetRanger, plug the CellSet into the audio jack for the center back passenger; this jack is not used by any crew member, so the recorder is in a circuit that is connected in parallel to the other headsets.
  In a Hughes 500D, plug the CellSet into the data recorder's audio jack. There are only two back seat audio jacks in a Hughes 500D, so the CellSet is connected in series with the data recorder's headset.
- Plug the 1/8" to 3/32" adapter into the TOP (mic) jack of the voice recorder. Plug the smaller of the two CellSet plugs into the 3/32" side of the stereo adapter, so it's connected to the recorder. Duct tape those connections.
- Place the CellSet and audio recorder in a Ziploc or other small bag, to minimize jostling.

Figure 8.3. Field Instructions for digital audio recorder. Print double-sided on one page.

Record flight conversation:

- ☐ Turn on the power for the audio recorder. This should bring you to the main (recording) screen.
- ☐ Confirm that the MIC SENSE button is on CONF.
- ☐ Press the REC button on the right of the unit.
- ☐ Slide the power switch to "HOLD" until the end of the flight. This prevents any stop.
- ☐ Check that voice is being recorded: Before takeoff, but while the audio intercom system is on, look at LCD display and confirm that the "audio input level" display is moving from left to right. You may repeat this several times during the flight, i.e. to be sure connections work.
- ☐ Early in the flight, at least once, state the exact GPS time, to the second.
- ☐ During flight, the data recorder must repeat sightings of other species that other crewmembers call out, as in the following example:
    - Pilot says "Three goats down there."
    - Data recorder says "The pilot saw three mountain goats, along the ridge."
    - The data recorder should only make this kind of statement once for each sighting of non-elk species. In this way, the data recorder's comments about other species form a record of what other species were seen.
- ☐ At the end of the flight, slide the power switch out of hold, to the middle setting
- ☐ Press Stop, then turn off unit.

DO NOT ERASE FILES until they have been downloaded to a computer!

After each flight:

- Connection to a computer, for downloading, requires a USB to mini-USB cable.
- Download files to the NCCN server, in the folder called Audio_recordings/1_Originals.
- Rename the audio file with the format "Audio_park_yyyy_ season_f##.wmv" where park is either MORA or OLYM, yyyy is year, season is spring or summer, and ## is flight number.
- Copy the file to the folder called Audio_recordings/2_Processing
- Use "Olympus DSS Player" software (that comes with the DS-30), or another audio playback software (such as Windows Media Player) to listen to files. Transcribe data to Other Species Data Forms; see **SOP 7: Conducting Helicopter Surveys**, Figure 7.23 for summer survey forms or 7.24 for spring survey forms

Figure 8.3. Field Instructions for digital audio recorder (continued). Print double-sided on one page.

SOP 9: Data Entry and Verification

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP describes the general procedures for entry and verification of field data in the project database application. For related guidance, refer to **Section 4C, Overview of Database Design**, and **Section 4D, Data Entry and Processing**. The following are general guidelines:

1. Data should be entered as soon after data collection as possible so that field crews remain current with data entry tasks, and identify any errors or problems as close to the time of data collection as possible.
2. The front-end database application is a Microsoft Access file maintained in the project workspace (see **SOP 1: Project Workspace and Records Management**). This front-end copy may be considered "disposable" because it does not contain any data, but rather acts as an interface with data residing in the back-end database. It contains the forms, queries, and formatted report objects for interacting with the data in the back-end.
3. The back-end database for this project is implemented in Microsoft SQL Server to take advantage of the automated backup and transaction logging capabilities of this enterprise database software.
4. Each data entry form is patterned after the layout of the field form, and has built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged only to use the pre-built forms as a way of ensuring the maximum level of quality assurance.
5. As data are being entered, the person entering the data should visually review each data form to make sure that the data on screen match the field forms. This should either be done for each record prior to moving to the next form for data entry, or preferably as a separate step after all of the data for a sampling trip has been entered. Important: It is a requirement that all events must be entered and verified at the end of the field season.

At regular intervals and at the end of the field season the Crew Lead should inspect the data that have been entered to check for completeness and perhaps identify avoidable errors. The Crew Lead may also periodically run the Quality Assurance Tools that are built into the front-end application to check for logical inconsistencies and data outliers (this step is described in greater detail in **Section 4E, Data Quality Review** and also in **SOP 12: Data Quality Review and Certification**).

Database Instructions

Getting Started

The first action to be taken is to make sure the project workspace is set up properly on a networked drive. Refer to **SOP 1: Project Workspace and Records Management** for instructions on how to set up and access the project workspace.

Important Reminders for Daily Database Use

- If accessing the database from a remote park (i.e., other than OLYM), do not open and use the front-end application outside the remote desktop environment as it will run very slowly and likely stall. Instead, refer to the following instructions on remote access before using the application.
- If accessing the database from OLYM, do not open and use the front-end application on the network as this makes it run more slowly. Instead, copy the front-end file from the project workspace to your local desktop and open it there. This copy can be replaced with new versions as they are released.
- New versions of the front-end application may be released as needed through the course of the field season. When this happens, you may see a notification about a new release when opening the current or older versions of the front-end. Copies of the outdated version of the front-end file should be deleted and replaced with the new version, which will be named in a manner reflecting the update (e.g., Elk_Aerial_2012_v2.mdb).
- Upon opening the front-end application for the first time, there may be a need to reconnect the front-end to the back-end, depending on how the project workspace is mapped on your computer. This database connection update should only need to be done once for each new release of the front-end database.

Remote Connections for Data Entry and Database Access

Most of our project databases are hosted on a server at OLYM. Due to bandwidth limitations, project database users accessing these databases from other parks (or from remote locations at OLYM) may encounter slow performance or application errors when accessing the database directly via a networked drive or a local front-end file. Therefore, to make data entry as smooth and efficient as possible, such users will typically need to use a remote desktop connection each time they need to access the database.

Remote desktop connections access what is called a "terminal server" at OLYM. In doing so, all of the processing is occurring on a server collocated with the database server, thus minimizing the negative effects of bandwidth on application performance. Through such a connection, the remote user is essentially sending mouse moves and keystrokes to the terminal server, and receiving screen updates in return. There may be some noticeable lag time in mouse moves and screen updates, but the performance is often much better than when accessing the data through other means.

Instructions for Using Remote Desktop

1. From the Start menu, go to: All Programs > Accessories > Communications > Remote Desktop Connection. You may wish to create a desktop shortcut by right clicking on the Remote Desktop Connection icon in the menu and selecting Send To > Desktop.

2. With the Remote Desktop window open, type in the terminal server name: "inpolymts1".

3. Click on the Connect button.
4. Enter your NPS login and password. Note that the login must be preceded by "NPS\", for example: "NPS\gwashington".
5. The remote desktop session will open and you will see a blank desktop that represents what you would see if you were sitting at the computer at OLYM. The first time you use it you may need to map network drives you use frequently and create other useful shortcuts (e.g., to the project workspace), and you will need to use the Access 2010 first-time setup instructions (see the following section) so that the project database functions properly. These initial setup steps should only need to be done once, however.
6. You may switch back and forth between your remote session and your local session (i.e., on your local workstation) using the connection bar across the top of the remote desktop screen.
7. When using the project database, you may need to make a copy of the front-end application if someone else is already using the file (evidenced by a ".ldb" lock file with the same name and in the same folder as the front-end file). You may also want to create your own subfolder in the project workspace for your own front-end copy to avoid these conflicts with other users.
8. When you are finished with your remote session, log off by clicking on Start > Log Off.

The first time you use Remote Desktop, you may wish to select Options from the first Remote Desktop Connection screen to enter more specific information for your frequent remote desktop sessions (e.g., enter "inpolymts1" for the computer, your NPS login, and "NPS" for the domain so you don't have to enter "NPS\" in front of your login each time). Do NOT enter your password or check the box to save your password, as this may present a security risk.

Special Instructions for Access 2010

If you are going to be using Access 2010, make sure the security settings will allow the database to function properly. This is necessary because Access 2010 may have been installed in a very restrictive security mode that disables the functionality built into the project database. Note: This setting change should only need to be performed once. However, if you move to a different workstation, these steps may need to be repeated to allow the database to perform properly. You will know the difference if none of the buttons or form functions on the main database switchboard form work properly, or if you get the following warning message across the top of the window:

To enable the database content to run properly on a consistent basis, do the following:

- Prior to using the front-end database, open Access 2010 from the Start menu.
- Go to Start > All Programs > Microsoft Office > Microsoft Office Access 2010.
- In the upper left corner, click on the Office Button.
- At the bottom of the menu page, click the Access Options button.
- Select the Trust Center category on the left panel.
- In the lower right, click the Trust Center Settings button.
- Select the Macro Settings category on the left panel.
- Select the option “Enable all macros”. Then hit OK, and exit Access.
- From this point forward the project database application should function properly on that computer.

User Roles and Privileges

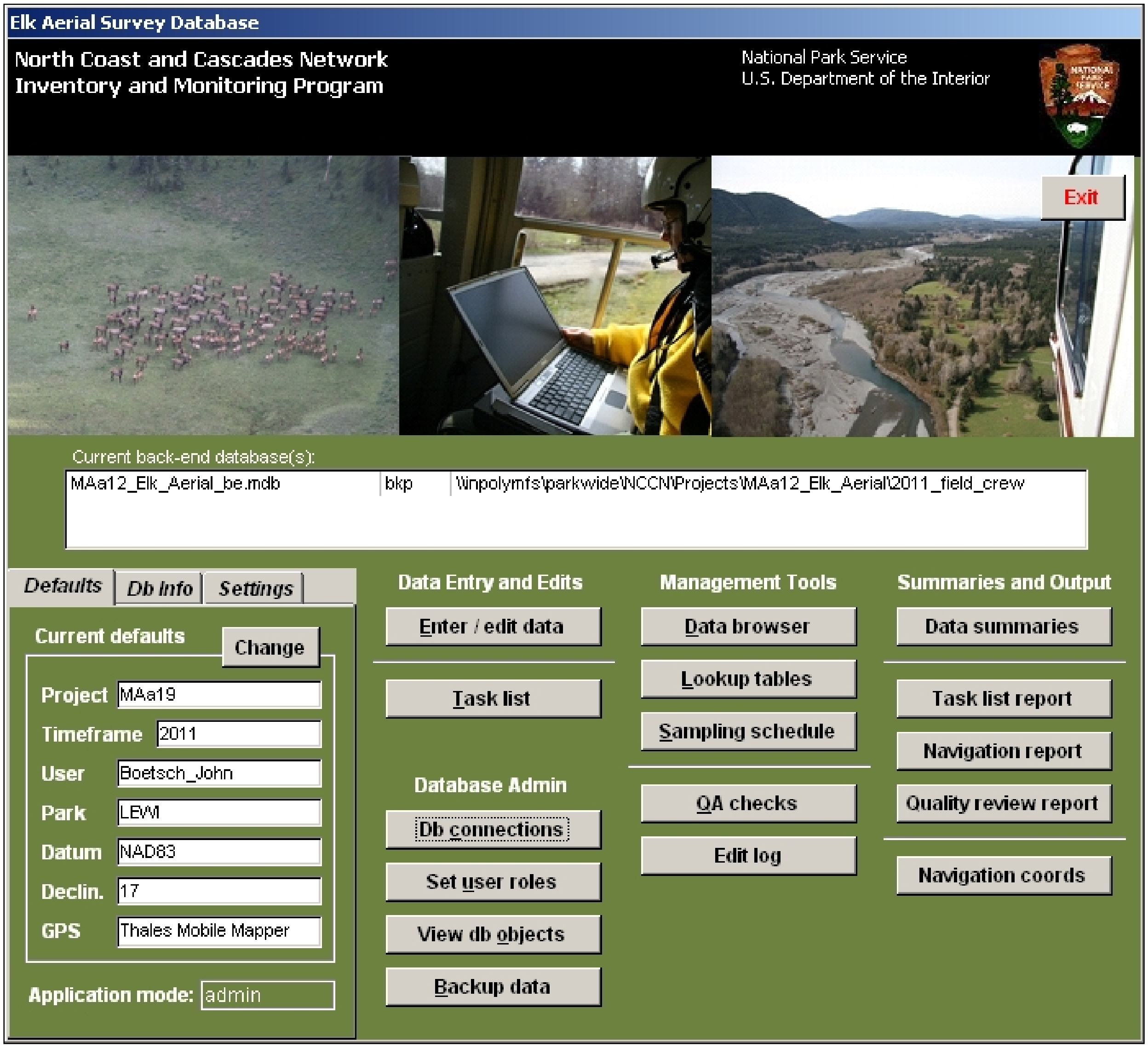
The database application provides different levels of access privileges: read-only, data entry, power user, and administrator. These privileges are assigned based on user login by the Project Lead or a designee at the beginning of each field season. Most field crew users will be granted "data entry" rights, which allow one to enter and edit data for the current field season only. Certified data and lookup domains may only be edited by users with power user or administrator privileges. If a user name is not granted explicit rights to the database, the application will open in "read-only" mode.

Overview of Database Components

The front-end application has multiple functional components, which are accessed from the main application switchboard form that opens automatically when the application starts. Several buttons are found on the form to provide access to different components of the application, and are arranged in functional categories:

- Data Entry and Edits
  - Enter / edit data – Opens a form to confirm default settings (e.g., park, coordinate datum) prior to continuing to the project-specific data entry screens.
  - Task list – Keeps track of unfinished tasks associated with sample locations (for example, forgotten equipment, unfinished data collection) that one field crew can use to communicate with a future field crew.
- Database Admin
  - Db connections – Manage and update the connections to the back-end database(s).
  - Set user roles – Manage the list of users who may view, enter and edit the database. Provides four levels of access: read-only, data entry, power user, and admin. This button is only enabled for power users and administrators.
  - View db objects – Allows the user to view and edit database objects (tables, queries and forms). This button is only enabled for power users and administrators.
- Management Tools
  - Data browser – Opens a tabbed form that provides comprehensive access to data arranged by sampling location. This form has headers for filtering by park, location code, location type and status.
  - Lookup tables – Opens a tool for managing the lookup values for the project data set (e.g., species list, list of project personnel).
  - Sampling schedule – Opens a form to view and edit the sampling schedule.
  - QA checks – Opens the data validation and quality review tool, which shows the results of pre-built queries that check for data integrity, missing data, and illogical values, and allows the user to fix these problems and document the fixes. See **SOP 12: Data Quality Review and Certification**.
  - Edit log – Opens a form for documenting edits to certified data records.
- Summaries and Output
  - Data summaries – Opens a form for viewing and exporting summary queries for data exploration, analysis and reporting.
  - Task list report – Generates a report of tasks that need to be accomplished for a specified park or sample location (default is for all locations).
  - Quality review report – Generates the data quality review results for a selected year or all years.
  - Navigation coords – Provides current, best navigation target coordinates for sample locations (i.e., survey unit centroids, and OLYM phenology photo points) so these can be loaded into GPS units for navigation, or GIS for display and map production.

Below is a view of the main startup menu / switchboard form.



The lower left portion of the main startup menu has tabs for user defaults, database version release information, and run-time settings.

- Defaults – Default values for the application. User name, park, datum, declination, and GPS model type can all be changed by the user. To change user defaults, click on the 'Change' button. This will open up a new window where the user can update the default values. This window also appears each time the user selects the path for data entry or review to ensure that the correct user and park are indicated.
- Db Info – Contains the release information, technical support contact information, and buttons for reporting a bug or issue.
- Settings – Contains checkboxes for run-time application settings:
  - Prompt for backup on startup – The user will be prompted to make a data backup when the application opens.

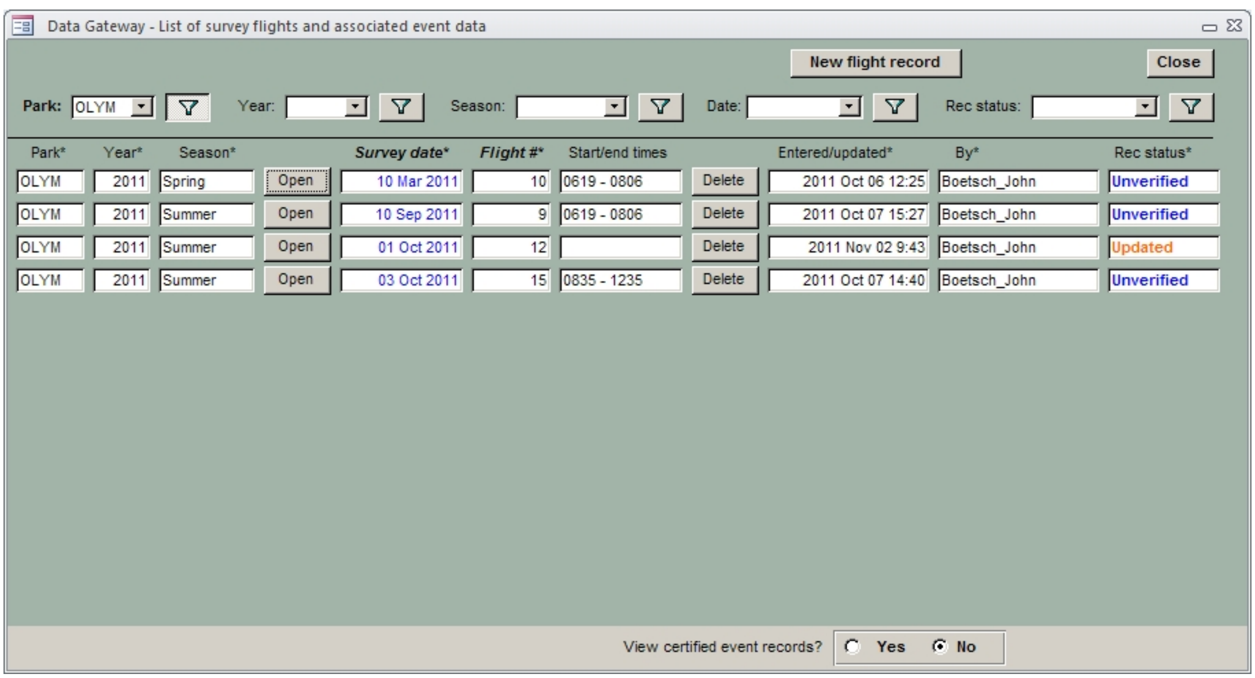
- Prompt for backup on exit – The user will be prompted to make a data backup when the application closes. Default is on, which means that the user will be prompted each time the application closes if there is at least one Access back-end for which backups are specified.
- Compact back-end on exit – Compacts the back-end database when the application closes. This helps to manage the size of the back-end, which improves performance over the network.
- Test all connections on startup – Ensures that each of the back-end tables is linked properly. Default is on, which means that the user will be prompted on startup if there is at least one Access back-end.

Entering and Verifying Event Data

When you select the "Enter / edit data" button, you will have a chance to change the default user name, park, datum, declination, and GPS model. Make sure this information is correct each time you enter data. Note: These defaults are properties of the front-end application, so different users reusing the same front-end file will need to change this information frequently. To avoid this, make copies of the front-end file for each user.

Data Gateway Form

Next you will see the Data Gateway Form, which is where you will see a list of sample locations that are already present in the back-end database. This list is automatically filtered by the selected park (upper left corner), and to show only scheduled sample locations for the current sampling year. There is also the capability to filter by park, sample location, location type (road survey routes vs. pellet points), sampling event year, and record status. Filters can be changed at any time, and records can be sorted by double-clicking on the field label above each column.



At the bottom of the form are radio buttons to allow the user to view certified records from previous seasons (power users only).

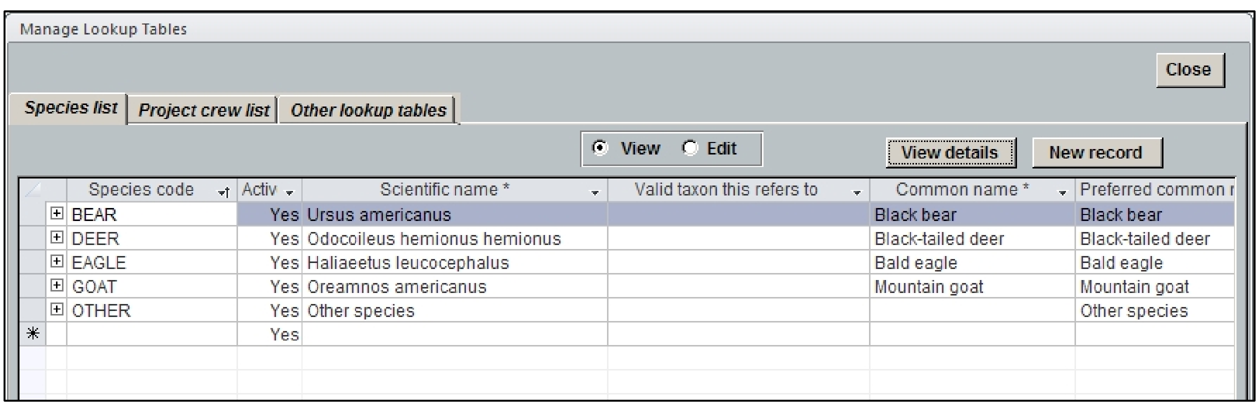
Verifying Data Records

Field crews must verify all sampling events throughout the field season. The recommended approach is for one crew member to do all of the data entry for one sample location, then have another crew member review and verify records for that location. The current record status for each sampling event is shown in the Data Gateway Form. To see all of the sampling events in the database, be sure to turn off the filters to show all of the sampling points and events. By double-clicking on the record status field in the Data Gateway Form, the appropriate data entry form will be opened for verification.

<u>To complete the verification step:</u>
After all data for a given transect have been entered completely, the database entries should be compared against the original field forms. Each of the main data entry screens has a footer containing fields for storing quality assurance information about the event, and information on who created the sampling event record, who last updated it, etc. When all data for the sampling location has been verified, click on the button that says “Verify this sampling event” to indicate that the event record is complete and accurately reflects the field forms. Clicking this button instantly updates the record status in the Data Gateway for that sampling event. Remember that subplot data will need to be verified before clicking the "Verify" button on the main Event Log form.

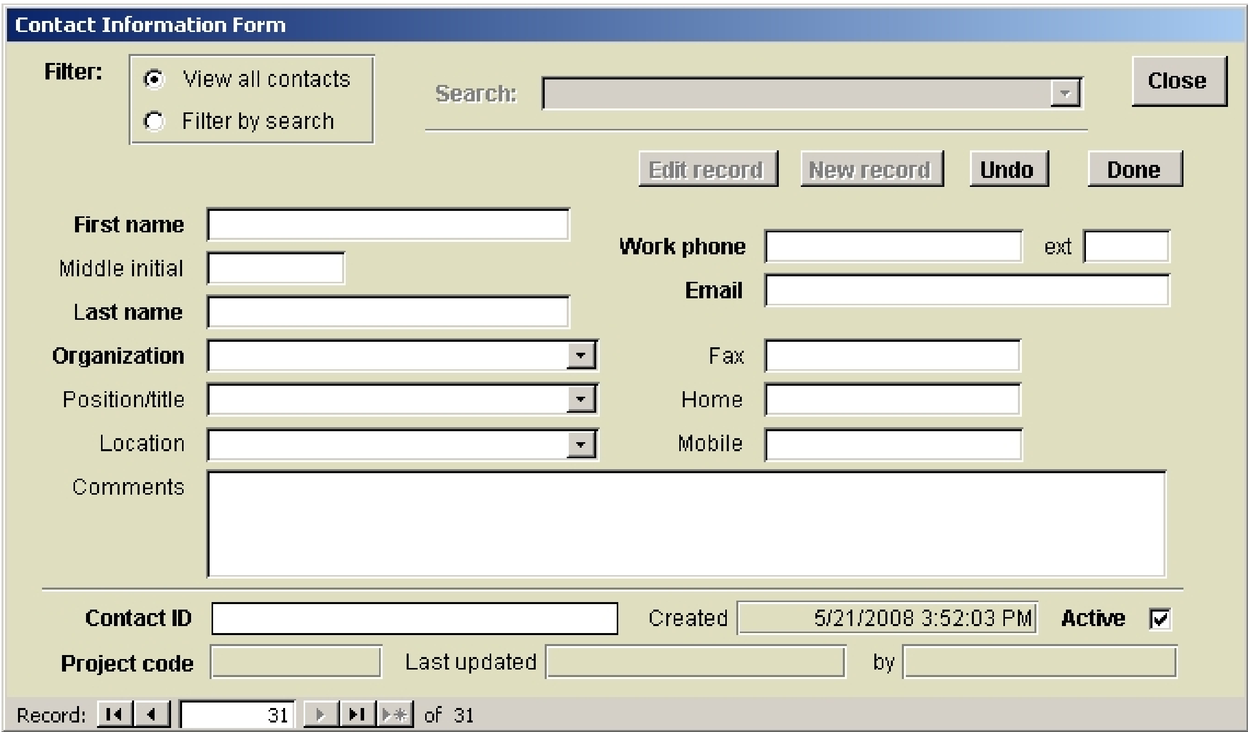
Manage Lookup Tables

From the main startup menu, click on ‘Lookup tables’ to open the Manage Lookup Tables Form. This form has three tabs – one for the project species list, another for the project crew list, and a third for viewing the contents of all other lookup tables. Minor edits may be made on the species list tab by putting the form into Edit mode. By selecting a record and clicking on “View details”, or by double-clicking on any record selector (the gray box to the left of each record), the Species Information Form will open. To add a new record click on ‘New record’.



The Species Information Form can be used for adding or editing species records. Required fields are shown in bold, and items with an asterisk (*) next to the name are not to be edited except by the Data Manager (these come from either ITIS or the NPSpecies application). The Integrated Taxonomic Information System (ITIS) website may be accessed by clicking on the button labeled ‘ITIS website’, or by clicking on either the Taxonomic Serial Number (TSN) or scientific name if either of these fields is already populated. All new records – except for unknown taxa or temporary names – should have TSN entered if it exists on the ITIS website.

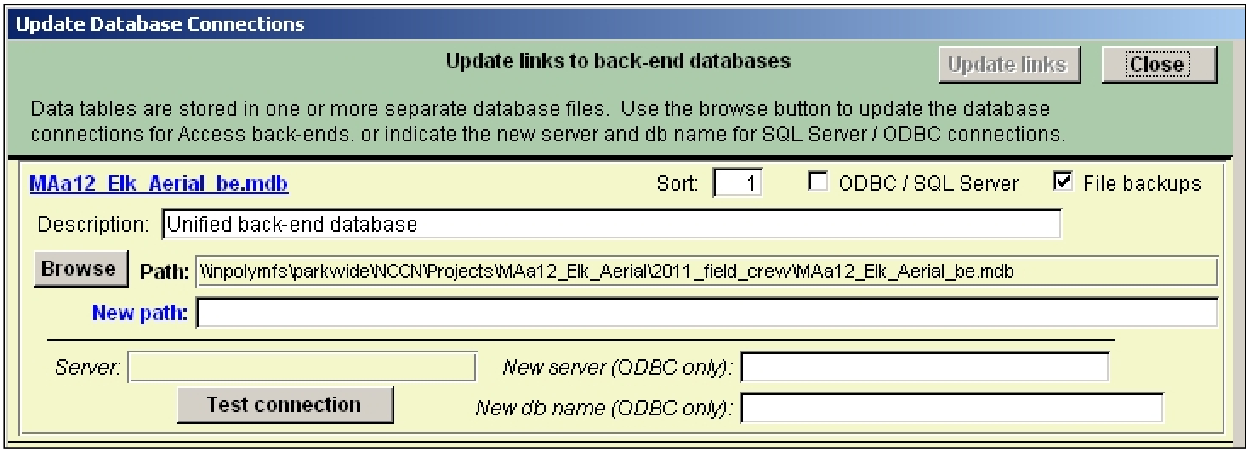
The second tab of the lookups module is a list of contacts for the project. By selecting a contact record and clicking on the “View / edit” button, or by double-clicking on a contact record, the Contact Information Form is opened in edit mode. Once edits are accepted with the “Done” button, the user may either page through the records using the record navigator at the bottom of the form, or may search for a particular name in the drop-down pick list.



The third tab in the Manage Lookups Form has a dropdown pick list for selecting other lookup tables in the database. This can be useful when a user needs to learn more about the domain values and definitions for the project. These lookups may be edited only by power users and administrators.

Update Database Connections

When first using the front-end application, the user may need to establish the connections to the back-end database(s). Database connections can be updated using the Update Database Connections form, available by clicking on the 'Db connections' button on the main switchboard menu. A separate record will be shown for each back-end database. For SQL Server databases, specify the server and database name. For Access back-ends, browse to the desired back-end file. To complete the connection updates, click on 'Update links'.



SOP 10: Processing Digital Photographs

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This document describes procedures that will be used to process, name, and store photographic images that are collected to document phenological or other environmental conditions during elk surveys, to document size and composition of elk groups, or for any other project-related activities. Images that are acquired by other means – e.g., downloaded from a website – are not project records and should be stored separately and named in such a way that they can be readily identified and not be mistaken for project records.

Photos of elk groups should be processed following this protocol before data are entered into the database. Data forms from surveys (Census Data Form and Flight Information Forms) should be on hand during image processing because the forms may need to be updated based on information from the photos.

To effectively manage potentially hundreds of images requires a consistent method for downloading, naming, editing and documenting. The general process for managing project images is as follows:

1. Prepare image workspace – Set up the folder directory structure prior to acquisition.
2. Acquire images.
3. Download and process images.
    a. Download the photo files from the camera
    b. Copy and store the original, unedited versions
    c. Determine which elk groups or phenology points are represented by photos
    d. Rename the files according to prescribed convention detailed below
    e. Review elk group photos for group size and composition
    f. Edit the photos as needed, and delete unneeded or poor quality photos
    g. Move the files into appropriate folders for storage
4. Deliver image files for final storage.

Data Photos Defined

Care should be taken to distinguish data photos from incidental or opportunistic photos taken by project staff. Data photos are those taken for one of two reasons:

- To document group size and / or composition of an observed elk group
- To document the phenological conditions at specified locations
- To document survey conditions (e.g., cloud cover)

Data photos are processed to link them to specific records within the database (elk group observations; survey flights), and are stored in a manner that permits the preservation of those database links. Other photos – e.g., of survey crew members at work, or photos showing habitat conditions in general – may also be retained but are not necessarily linked with database records.

Image Workspace Setup

Prior to each season's data collection, the Project Lead (or a designee) should create a new set of image folders, beginning with the new season year, under the Images section of the project workspace and seasonal workspaces (refer to **SOP 1: Project Workspace and Records Management**). The workspace subfolders are as follows:

[Year]	The appropriate year – 2011, 2012, etc.
[Park code_Season]	Name of park and season – MORA_Sum, OLYM_Sum, or OLYM_Spr
1_Originals	Renamed, but otherwise unedited image file copies
[Download date]	Arranged by download date to preserve file names
2_Processing	Processing workspace
[Flight number]	Arranged in folders by flight number
3_Data_Elk_Groups	Required data images taken of observed elk groups
[Flight number]	Arranged in folders by flight number
4_Data_Phenology	Required data images taken at phenology photo points
[Flight number]	Arranged in folders by flight number
5_Miscellaneous	Non-data images taken incidental to the survey
[Flight number]	Arranged in folders by flight number
6_Flight_Conditions	Non-data images taken at start and end of flight (optional)
[Flight number]	Arranged in folders by flight number
7_Other_Sources	Images acquired from other sources (i.e., non-record)

This folder structure permits data images to be stored and managed separately from non-record and miscellaneous images collected during the course of the project. This structure also provides separate space for image processing and storage of originals. Note: For additional information about the project workspace, refer to **SOP 1: Project Workspace and Records Management**.

In all cases, folder names should follow these guidelines:

- No spaces or special characters in the folder name.
- Use the underbar ("_") character to separate words in folder names.
- Try to limit folder names to 30 characters or fewer.
- Date names should be formatted as YYYYMMDD.
- Use full year (i.e., 2013).
- Use abbreviations for season name (i.e., Win or Sum).

Image Acquisition

For details on image acquisition, see **SOP 7: Conducting Helicopter Surveys**; Photography. When survey crews find groups of ~20 or more elk, those groups should be photographed, preferably so that all the elk in the group are visible within one photograph. Phenology photo points are designated locations in OLYM surveys that are photographed any time that the nearby survey unit is surveyed.

Capture images at a high enough resolution to classify elk into sex and age categories, but with consideration of computer memory space limitations. If space on the project worksite becomes limiting, it may be necessary to store images on an external device. Although photographs taken to facilitate future navigation to the site do not need to be taken at the same resolution as those that may be used to document environmental change at the site, it may be more efficient to capture all images at the same resolution. A recommended minimum raw resolution is 1600 x 1200 pixels (approximately 2 megapixels). Higher resolutions may be available but are undesirable from the perspective of data storage and information content.

Download and Processing Procedures

A. Under the appropriate "Originals" subfolder, create a subfolder for the download date (e.g., 20120715). Other suffixes may be used to distinguish downloads when cameras are downloaded on the same date (e.g., "a", "b", etc.).
B. Download the raw, unedited images from the camera into the appropriate "Originals" folder. NPS staff should download all images taken during NPS-funded aerial surveys into this folder. Also, the MORA project manager should copy elk group images that are sent by MIT, PTOI, and WDFW project participants into the appropriate "Originals" folder. Depending on the operating system used by the person downloading, it may be possible to greatly reduce the time and effort it takes to rename the images in subsequent steps.
    a. Plug in the camera to the USB port and turn the camera on.
    b. From the Start menu, select All Programs > Accessories > Scanner and Camera Wizard (or select this option if a dialog box appears upon plugging in the camera).
    c. Follow screen prompts until reaching the 'Picture Name and Destination' screen. You will be able to select name prefix/suffix, image format, and photo destination.
        i. For name prefix, use the naming conventions indicated later in this SOP.
        ii. For image file format, select the default (JPG).
        iii. For photo destination, browse to the appropriate "Originals" subfolder.
C. Copy the images to the “Processing” folder and set the contents under "Originals" as read-only by right clicking in Windows Explorer and checking the appropriate box. These originals serve as backups in case of unintended file alterations (e.g., incorrect names applied, file deletion, loss of resolution, or loss of image metadata upon rotation).
D. Determine which photos correspond to elk groups of ~20 or more, and which are phenology photo points.
    a. Find what time the photographs were taken, and compare this to the times recorded for each elk group (on the Census Data Form) or each phenology photo point (on the Flight Information Form).

b. Open the "Processing" folder that contains the photos and select View > Details from the uppermost menu (Figure 10.1); this creates a detailed list of the files. To see the time that each photo was created, right-click on the grey bar just above the file names; this shows a pick list of file attributes that can be displayed.
c. At the bottom of that list, select “More…” (Figure 10.2).
d. From the Details list, check “Date Picture Taken” (Figure 10.3). Note: the “Date Created” choice here only reflects the date when the file was copied to the folder – not the date or time when the photo was taken. Based on the Date Picture Taken field, determine which photos match a time for a large elk group observation, or for a phenology photo point.

E. Rename the images according to the ***Image File Naming Standards*** section.
  a. If image file names were noted on the field data forms, update the file name on the field form to reflect the new image file name prior to data entry. Field form annotations should be done in a different color ink from the original notation, after first drawing a line through the original entry (for more information, refer to **4D, Field Form Handling Procedures**).
  b. Renaming may be most efficiently done as a batch using image processing software such as Microsoft Office Picture Manager, which allows a standard prefix or suffix to be added to the camera file name. After batch renaming, a descriptive component may be added manually to each file name.

F. Review the photos for group size and composition before any data are entered into the database.
  a. To evaluate group size, use the photo of a given elk group that includes the greatest number of animals.
  b. Count them.
  c. If the total number of elk in the photo is *less* than that written on the Census Data Form, do not change the value for group size on the data form (this reflects an assumption that the number of elk counted in the air may have included elk that were not photographed). On the comments line of the Census Data Form, note the number of animals that are not visible in the picture (i.e., “Photo not of complete group; 2 bulls out of picture.”).
  d. If the number of elk in the photo is larger than that on the Census Data Form, then the value on the data form should be increased to match that from the photo. To evaluate composition, count the number of cows, calves, yearling bulls, subadult bulls, mature bulls, and unknown elk in the photo.
     Based on the best available photo of the group, update the composition values on the Census Data Form. This process may be somewhat subjective. Upon close examination, what appeared from the air to be cows may actually be calves or yearling bulls. The total number of elk in the group should generally be the greater of: the group size originally written on the Census Data Form; or the total

number visible in the best, most complete photo. The decision about whether or not to update the recorded composition values may depend on whether the photographer included all the animals in the group in the photo. Counts of each age and sex for classification may rely on the best counts for each age and sex class, which may sometimes be based on several photos.
Print a hard copy of any photo that is used to update the group size or composition of any group, label the hard copy with the flight and observations number, then attach it to the original data sheets, for archiving.

Note: In some cases, the MIT, PTOI, or WDFW biologist will already have counted group size and/ or composition before sending a photo to the MORA project manager. The MORA project manager should defer to those counts, or consult with the biologist that sent the image if he / she comes to different count values.

e. Edit or delete photos, as necessary.
    i. Delete any poor quality photos, repeats, or otherwise unnecessary photos. Low quality photos might be retained if the subject is unique, or the photo is irreplaceable.
    ii. Rotate the image to make the horizon level
    iii. Photos may be cropped to remove edge areas that grossly distract from the subject.

G. Move the image files that are to be retained and possibly linked in the database to the appropriate folder.
H. Photos of potential interest to a greater audience should be copied to the park Digital Image Library.
I. Delete files from the "Processing" folder between downloads to minimize the chance for accidental deletion or overwriting of needed files.

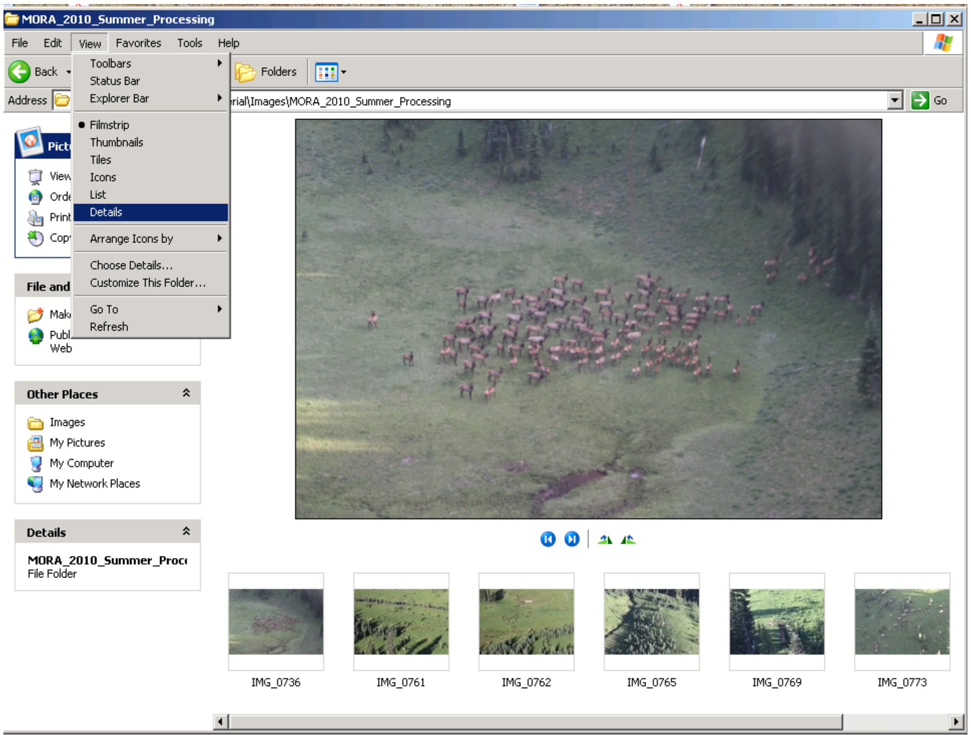


Figure 10.1. Select View→ Details to create a detailed list of the photos in the'2 _Processing' folder.

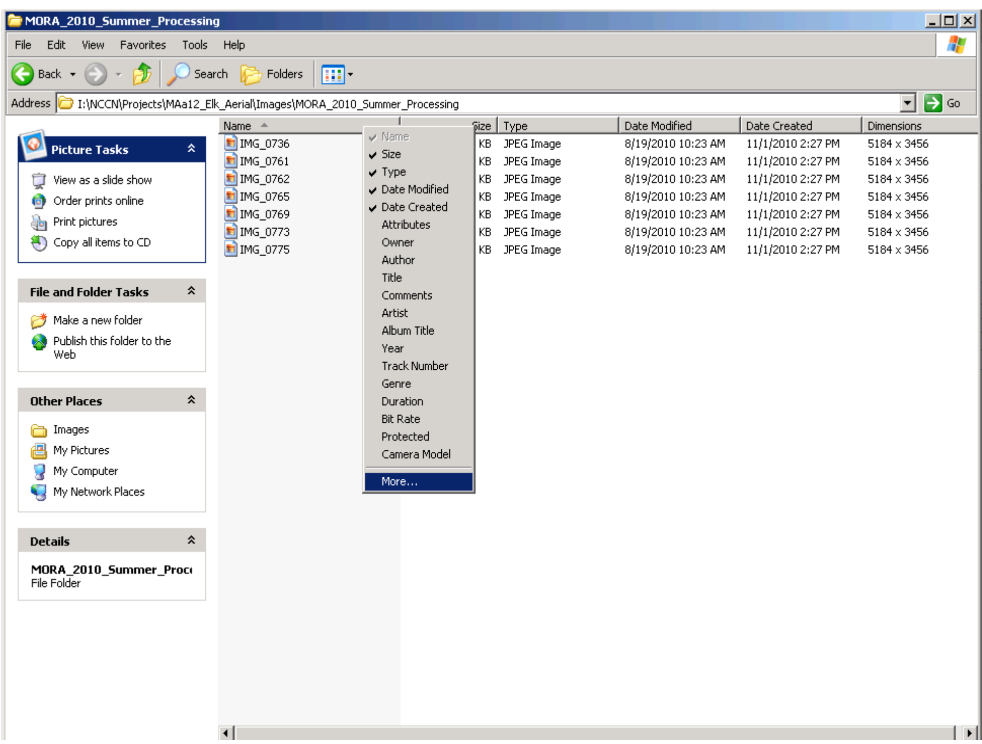


Figure 10.2. Right click and select "More…" to see more detail options about the photo files.

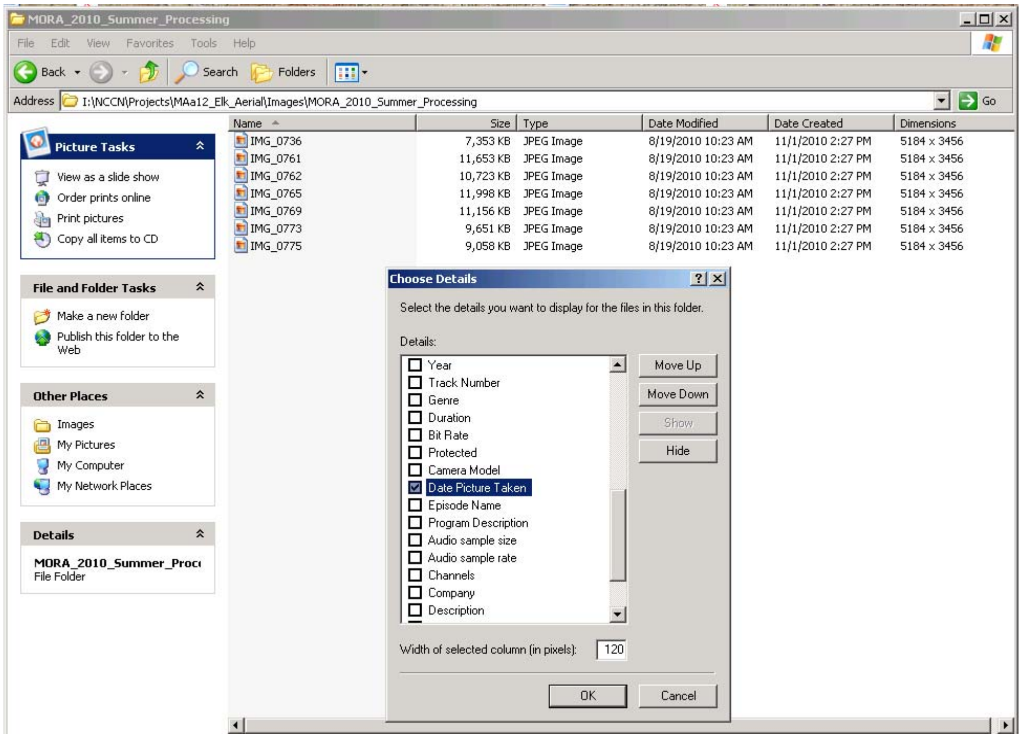


Figure 10.3. Scroll down in the More Details list and check the box next to "Date Picture Taken," so that the time and date when each photo was taken will be visible along with other file details.

Image File Naming Standards

In all cases, image names should follow these guidelines:

- No spaces or special characters in the file name.
- Use the underbar ("_") character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Park code, year, season, flight, and elk observation number or photo point number should be included in the file name.
- Dates should be formatted as YYYYMMDD (this leads to better sorting than other date naming conventions).

The image file name should consist of the following parts:

- Park (MORA or OLYM)
- Year (_2011, _2012, etc.)
- Season (_Spr or _Sum)
- Flight number (_f##)
- Elk group observation number (_o##) or phenology photo point number (_p##)
- Optional: a sequential letter if multiple images were captured (a, b, c, etc.)
- Optional: abbreviated original camera-given file name of the image (i.e., IMG_0756)
- For phenology photos: a one-letter or two-letter code denoting trend count area (in OLYM, codes are _C, _NW, _E, _Q, or _SE; in MORA, codes are _N or _S)

Examples:

• OLYM_2014_Spr_f4_o3b.jpg	The second of two photos (b) of elk group observation number 3, flight 4, in OLYM spring surveys of 2014
• MORA_2012_Sum_f10_o5.jpg	Photo of elk group observation number 5, from flight number 10, in MORA summer surveys.
• OLYM_2013_Sum_f3_p2_C.jpg	Photo of phenology point number 2 for the OLYM Core trend count area, taken on flight 3 summer surveys of 2013

Post-season Cleanup Procedures

After each season, the Project Lead (or a designee) should:

1. Review the seasonal workspace folders to make sure that all images are properly named, filed, and accounted for.
2. The "Processing" folder should be emptied and may then be deleted.
3. Files in the "Other_Sources" folder may be re-filed as appropriate.
4. The contents of the "Originals" folder may be deleted once all desired files are accounted for. Originals of data images may be retained as desired, depending on the size of the files and storage limitations.
5. Copy the entire contents of the "Images" subfolder from the seasonal workspace to the main project workspace, and delete the images subfolders from the seasonal workspace.
6. If it is necessary to conserve network server memory space, save photos from the 1_Originals folders off line after data certification is completed.
7. Set the images in the project workspace to read-only to prevent unintended changes.

SOP 11: Geospatial Data Management

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

Spatial data collection is central to this project. Spatial data include:

- Survey area boundaries
- Navigation aids (river miles, mountain peaks, refueling locations, helispots)
- Flight paths (ferry, survey, telemetry)
- Animal observation locations

Organized field data collection is essential because data are being generated by two national parks, the Muckleshoot Indian Tribe, the Puyallup Tribe of Indians, and the Washington Department of Fish and Wildlife. All of these data must be compatible in order to be merged together and meet project objectives.

Animal observation locations are stored in the project relational database, and most other spatial data are stored in a geodatabase (ESRI, Redlands, California). Spatial features in the geodatabase are linked with related data elements (e.g., flight number) via primary key relationships with records maintained in the relational database. The geodatabase contains survey boundaries and flight paths – spatial data that are difficult to enter, visualize, and manage in a tabular format.

Spatial data collected in the field are organized each day, and processed and attributed as soon as possible after a field tour. At the end of a field season, final coordinate data for group observations are derived from flight line data. These final coordinates are then stored in the relational database after linking on flight number and observation timestamp. The relational database is then used the long-term repository for observation coordinates, where additional processing and quality assurance procedures occurs. Animal group locations can then be displayed in GIS by using ODBC queries on data in the relational database.

Outline:

I. Spatial Data Collection in the Field

a. See SOP 4, SOP 7, and SOP 8 for more detailed spatial data collection methods.
b. Have a GPS receiver prepared that is capable of collecting flight path and waypoint data.
c. Have a GIS project file (.mxd) prepared for collecting flight data.

d. Implement a standard directory structure on a laptop that best fits quick field preparations (e.g. C:\Daily_Survey).
e. Use GPS and, if desired, GIS to collect flight line and observation data.
f. After a day's flights are completed, rename files collected during the field day with a standard naming structure
    i. GPS receiver files are named "GPSRec_Agency_Flt_xx" where Agency is NPS (MORA or OLYM in ParkCode field) , WDFW (state), PTOI or MIT (Tribal) and "xx" is the assigned flight number
    ii. GIS flight log files are named "GPSLog_Agency_Flt_xx.shp" where Agency is NPS (MORA or OLYM in ParkCode field) , WDFW (state), PTOI or MIT (Tribal), and "xx" is the assigned flight number
g. After a day's survey flights are completed, place daily files into proper project file folders (such as C:\MAa12_MORA\GPS_Data\ and C:\MAa12_MORA\Spatial_Info\GIS_Data)
h. Make a back-up of GPS and GIS file folders using a flash drive (if in the field) or an agency computer network (if returning to an office)
i. Obtain spatial data from all agencies willing to share their spatial data as soon as possible after survey flights are completed

II. Process GPS Data and Update Relational Database Records
a. GPS files from multiple agencies will likely be a mix of GPS file types, formats, projections, and datums
b. GPS data will likely be in either UTM zone 10 NAD 1983 or geographic coordinates WGS 1984
c. GPS data will likely be able to be exported into text files and/or ESRI shapefiles from specific GPS software programs
d. Export GPS flight line data as line shapefiles for storage in a geodatabase
    i. Attribute flight lines with
        a. Date
        b. Flight number
        c. Agency code (NPS, WDFW, MIT, PTOI)
        d. Flight line type (requires GIS editing)
            1. Ferry
            2. Survey
            3. Telemetry
    ii. Merge all attributed flight line shapefiles from the survey season into one shapefile
    iii. Name the merged shapefile as MAa12_Flights_YYYY.shp where YYYY is the four digit year
e. Export GPS flight line files as text files where
    i. Flight lines are comprised of interval time stamps

ii. Each time stamp has associated coordinates
iii. Flight line time stamps and associated coordinates are used to assign coordinates to observation records entered into the database
iv. Reformat text files
a. Each exported GPS text file will need some reformatting for upload into the project database because each GPS software program exports data in different formats
b. Reformatting includes separating time and date if they are in the same field, making sure coordinates are in a standard format (for example, UTM coordinates or decimal degrees, not degrees minutes and seconds), making sure time is local time (Pacific Daylight Savings time, not Universal Coordinated Time)
c. Reformatting can also be accomplished in Microsoft Excel

f. Update relational database records with final group coordinate data
i. Import reformatted GPS text or Excel files into the project database as temporary tables
ii. Append newly imported GPS data tables into tbl_GPS_Info
iii. Enter observation data from the field datasheets into the database
iv. Match entered species observation time stamps to flight line time stamps in tbl_GPS_Info

III. Quality Review of Spatial Data
a. Determine which observations are >= ten seconds from a flight line time stamp
i. Manually view in GIS to see if there was a gap in flight line coverage
ii. Manually determine which flight line time stamp was closest to the observed elk group or generate a UTM coordinate that represents the center of the estimated helicopter orbit flight path
b. Determine where flight line gaps occur (indicates satellite reception was lost for a period of time while flying) >= 30 seconds in flight line time stamps
i. Manually view in GIS to see if there is a straight connection line between satellite reception acquisitions
ii. Manually adjust observation locations if necessary and enter UTM coordinates more representative of an elk group location
c. Update tbl_Observations with UTM coordinates from tbl_GPS_Info
d. Archive original GPS files in a designated project archive folder
e. Export tbl_GPS_Info records into an Excel spreadsheet or an archival database table and save it to a designated project archive folder
f. Delete tbl_GPS_Info records

IV. Query and Update Spatial Attributes of Locations
a. Sample observation locations using GIS

i. Obtain elevation (meters) from 10m DEM (point in raster)
ii. Obtain survey unit number in which observation was made (intersect command)
iii. Obtain distance (meters) from nearest survey unit boundary if observation was outside of survey unit boundaries (near command for point to line)

b. Import GIS sampled data, as a temporary table, into the project database
c. Update proper database table records with elevation (meters), survey polygon number in which group was located, and distance beyond nearest survey polygon boundary a group was located

V. Import Data Representing Flight Lines and Observations into the Geodatabase
   a. Import the merged flight line shapefile into the Survey_Flights feature class
   b. Import animal observations into the Survey_Obs feature class or tie the observations table to the geodatabase via ODBC

SOP 12: Data Quality Review and Certification

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP describes the procedures for validation and certification of data in the project database. Refer also to protocol narrative **Section 4C (Overview of Database Design)**, **Section 4E (Quality Review)**, and **Section 4G (Data Certification and Delivery)** for related guidance.

A critical part of project quality assurance is the year-end data quality review and certification. After the season's field data have been entered and processed, they need to be reviewed and certified by the Project Lead before they can be used for analysis and reporting. Data validation is the process of rigorously testing data for completeness, structural integrity, and logical consistency. Although the front-end data entry forms have built-in quality assurance measures – such as domain lookup pick lists, defined range limits for numeric data, and checks for missing values – not all errors can be caught during the data entry step. The following are a few of the general sources of data problems that might be identified during the validation:

1. The response design is ambiguous or insufficiently documented to prevent data gaps and logical inconsistencies.
2. There were logistics problems or a change of plans that prevented a complete sample (e.g., weather conditions or staffing changes).
3. Field crew members did not collect or properly record one or more data elements in the field.
4. Data were entered incorrectly or incompletely.
5. Database records were edited incorrectly or deleted after entry.
6. There is a design flaw in the front-end application that causes data errors during or after data entry.

Given the varied sources of data problems, there is a need for a thorough check of data quality on a regular basis as a means of ensuring continued data quality throughout the span of the project. The front-end database application includes a Quality Review Tool to facilitate the review process by showing the results of pre-built queries that check for data integrity, data outliers, missing values, and illogical values. The user may then fix these problems and document the fixes. Not all errors and inconsistencies can be fixed (e.g., missing response variable values), in which case documentation of the resulting errors and why records were not fixed is included in the metadata and certification report.

Once the data have been through the validation process and metadata have been developed for them, the Project Lead should certify the data by completing the NCCN Project Data Certification Form, available on the NCCN website.

Data Quality Review

Validation Queries

Table 12.1 shows the set of validation checks that are performed on the data set. Each line represents a pre-built database query that checks for potential problems in the data set, including data outliers, missing values, and illogical values. The set of queries is customized to match project requirements and the structure of the underlying data model. Each query is classified in one of three categories:

1. Critical – These queries check for structural integrity problems or gaps in critical information. This category might include queries that check for missing primary key values, mismatches between data values and lookup domain values, duplicate records, or illogical data combinations. Records returned by these queries fail to meet basic project requirements or structural requirements of the data model, and must be fixed so that they do not return any records before the data can be certified.

2. Warning – These queries represent problems that range in importance, but in any case have the potential to compromise data usability or representativeness if they are not addressed or at least made known to the end user. This category might include queries that check for missing response variables (e.g., number of individuals observed) or values that are beyond a reasonable range; alternatively, it may include queries that require follow-up on data records that can only be done after the field season (e.g., changing status of a survey unit from "Proposed" to "Active"). The person performing the quality review should make efforts to fix as many of these records as possible by reviewing hard-copy data forms or otherwise following up. However, it may frequently be the case that records in this category cannot be fixed because the reviewer does not have the information needed to fix the record. In such cases the reviewer should provide documentation about which records were not fixed and why using the space provided in the quality review tool (see ***Using the Quality Review Tool***). If there are numerous records that cannot be fixed, a general description such as "80 records" or "all reconnaissance sites, 43 records", along with a statement of why these were not fixed, will suffice. Documentation will help future data users to know that reasonable efforts were made to address the problems.

3. Information – These queries provide information that can be used to evaluate the completeness and logical consistency of the data set – for example, the number of plots visited per park in a given season, the range of dates for sampling visits, or the number of trees recorded during a sampling event. This category may also include checks for missing values in less-vital or optional fields, where a large number of missing values may be anticipated on a regular basis (i.e., as an alternative to making these Warning queries that require follow-through and documentation).

The queries are named and numbered hierarchically so that high-order information – for example, from tables on the parent side of a parent-child relationship such as sample locations (e.g., survey units) – is addressed before low-order information (e.g., individual species observation records). The rationale for this is that one change in a high-order table affects many downstream records, and so proceeding in this fashion is the most efficient way to isolate and treat errors.

The set of queries may need to be augmented or changed as project requirements shift. The Data Manager is also available to revise queries or construct new database queries as needed. Throughout the quality review, the person performing the review should remain vigilant for problems that may not be caught by the validation queries. One task that cannot be automated is the process of making sure that all of the data for the current season are in fact entered into the database. This will often involve manual comparisons between field forms or other lists of the sites visited against the results of queries showing the sites for which data exist.

Using the Quality Review Tool

Open the front-end database application and hit the button labeled "QA checks" to open the quality review form. Upon opening, the quality review form automatically runs the validation queries and stores the results in a back-end database table (tbl_QA_Results). Each time the query results are refreshed, the number of records returned and the run times are updated so that the most recent result set is always available. Reviewer name and remedy descriptions are retained between query runs. Together, these results form the basis of documentation in the certification report output as shown below.

Across the very top of the form are indicators of the time frame (i.e., sample year) and scope of the data being validated. Data scope has three options:

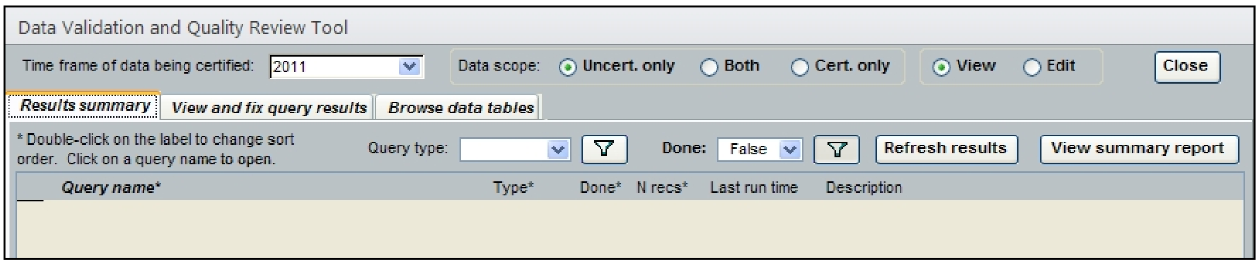
- Uncertified data only (default) – Only uncertified events (i.e., those from the current sampling year) will be considered in validation queries. Note that by design, certain queries will evaluate for problems in records are associated with certified data anyway – for example, all location records are evaluated for duplicate location codes, even those associated only with certified sampling events.
- Both uncertified and certified data – All database records will be included, including certified event data from previous years.
- Certified data only – Only certified events from previous seasons will be considered in the validation queries.

Changing the data scope will show only results for that scope – in other words, results and fixes associated with one scope will be retained even if the scope is changed and the results are refreshed.

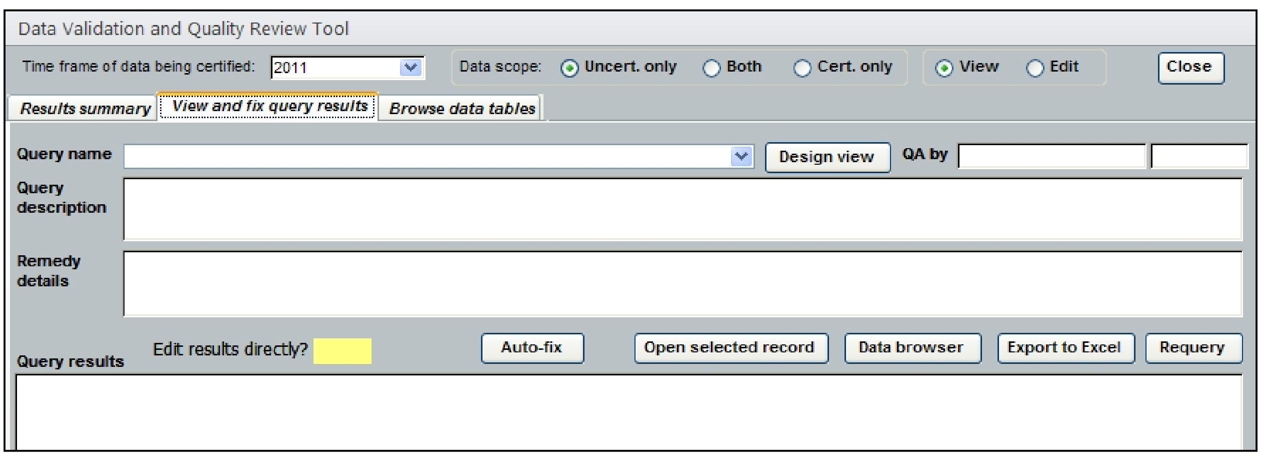
The first tab of the quality review form contains a results summary showing each validation query, the type of query (i.e., Critical, Warning or Information), the number of records returned by the query, the most recent query run time, and the description. At the top of the page, there is a button for refreshing the full set of results, which may need to be done periodically as changes in one part of the data structure may change the number of records returned by other queries.

Records default to sort by query name, but can be sorted by double-clicking on any of the column headings indicated with an asterisk.

There is also a "Done" checkbox that the reviewer can use as an indicator that they are finished looking at that particular query. Critical and Warning queries that return zero records from the start are automatically set to "Done". The results records may be filtered by query type and/or by whether or not the query has been marked as "Done". Note that updating records in one query may change the number of records returned by another query; if the number of records returned by a query changes, the "Done" indicator will be switched off automatically.



Upon double-clicking a particular query name, the second page will open up to show the results from that query. The "Query description" field will indicate the kind of records returned, and may also include a suggested remedy.



In the upper-right is a switch that allows the user to put the form in either view mode (default) or edit mode. Upon changing to edit mode, the form changes color to provide a visual reminder that edits are possible. At this point the query results may be modified and any documentation may be entered in the "Remedy details" section. If certain records in a query result set are not to be fixed for whatever reason, this is also the place to document that. Reviewer name is automatically filled in (if it was blank) once the user updates the documentation. If the reviewer does not have sufficient information to fix one or more records returned by a query, s/he should describe which records were not fixed and why. If there are numerous records that cannot be fixed, a general description such as "80 records" or "All elk group observations, 43 records", along with a statement of why these were not fixed, will suffice. Documentation will help future data users to know that reasonable efforts were made to address the problems.

Some of the other functions of this second page of the Quality Review Tool:

- Edit results directly? – A flag to indicate whether the results for the selected query can be edited directly inside the query results subform. Queries that contain complex joins, subqueries, or grouping functions cannot be edited directly, and instead must be edited in the original data entry form.
- Auto-fix – A button that runs an action query for bulk updates if such a solution is appropriate and available (e.g., replacing all missing values with a code for "Unknown"). Not all validation queries contain references to a bulk update query.
- Open selected record – Opens the selected record returned by the query in the appropriate form. This is useful for quickly moving to the place where the fix can be made most efficiently, and taking advantage of existing quality assurance functionality.
- Data browser – Opens the Data Browser form, which provides comprehensive access to data arranged by sampling location.
- Export to Excel – Exports the validation query results to Excel. This can be helpful when there is a need to follow up on complex problems or to verify that all data have been entered.
- Requery – Reruns the validation query and updates the results set.

On this page is also a button labeled “Design view”, which will open the currently selected query in the design interface in Access. In this manner, the user can verify that the query is in fact filtering records appropriately. Note: Please contact the Data Manager before making any changes to query structure or names.

Finally, the third page of the Quality Review Tool is for viewing and editing data tables directly if needed. This page is only available for those with power user or administrator privileges to the database. Important: As with all edits performed during the quality review, these types of direct edits in the data tables should be made with extreme care as many of the quality assurance measures built into the data entry forms are not present in the tables themselves. It is possible, therefore, to make edits to the tables that may result in a loss of data integrity and quality.

Completing Data Certification

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks outlined above; and 3) they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Lead is the primary person responsible for completing an NCCN Project Data Certification Form, available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm. This brief form should be submitted with the certified data according to the timeline in **Appendix A: Yearly Project Task List**. Refer to **SOP 14: Product Delivery, Posting and Distribution** for delivery instructions.

Generating Output for the Certification Report

The first page of the Quality Review Tool has a button labeled "View summary report". This button opens the formatted information for each query, the last run time, the number of records returned at last run time, a description and any remedy details that were typed in by the user. This report can be exported from the database and included as an attachment to the certification report.

SOP 13: Data Summary, Analysis, and Reporting

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP lists contents of flight reports, annual reports, and four-year reports, and describes data summaries and analyses necessary for report preparation. Flight reports briefly describe each NPS survey flight. Annual reports summarize observed data from one year of surveys, including surveys by NPS and all participating tribes and agencies. After the year's data are entered into the relational database and geodatabase, and are verified and certified, we will use database queries and the geodatabase to prepare tables and maps of survey results. In annual reports, estimates of abundance and composition will be presented if there is a statistical model that can be applied to each observed elk group to account for detection bias. At this time, there is a double-observer sightability model for application to MORA summer surveys. Four-year reports are prepared once per four years of survey, and present variance estimates for the annual elk abundance and composition values for each trend count area, and tests of trend in those measures. Within single trend count areas, four-year analyses assess temporal changes in the spatial distribution of elk density, estimated at the spatial scale of survey units. Queries of the database provide some tabular outputs that are used in four-year analyses; other four-year analyses are described in this SOP and in **Appendix C: Analyses of Detection Bias**.

Flight Reports

Within one week of the end of any spring (OLYM) and summer (MORA and OLYM) surveys, the project manager for each park should complete a brief flight report of NPS surveys, not to exceed three pages. The flight report is a written summary of events, meant to complement the observation data, and to record any lessons learned, for the improvement of future surveys. Flight reports are useful references for annual report and four-year report preparation. The MORA project manager should also include information about the flights made by other participating tribes and Washington Department of Fish and Wildlife (WDFW), based on post-survey conversations with the respective wildlife biologists. In addition to any general notes the Project Manager wishes to include, all flight reports should include the following information:

- Weather and flight conditions, including lessons learned;
- Trend count areas and survey units surveyed;
- Unusual observations;
- Observations of any gross changes in vegetation in the surveyed areas;

Flight reports are not published. They are archived with other project documents, in the project folder /Documents/Flight Reports (**SOP 1: Project Workspace and Records Management**). A template for flight reports is stored in that folder.

Annual Reports

For years when surveys take place, annual reports present data summaries of surveys made during a one-year period from October 1 through the following September 30 (**Appendix A: Yearly Project Task List**). For the purposes of this SOP, we refer to that time frame as “the year.” One year may include a spring survey season at OLYM if supplemental funding permits it, and the year includes the summer survey season at MORA and OLYM. Annual reports are prepared as a Natural Resource Data Series (**SOP 14: Product Delivery, Posting and Distribution**). An interim report based on certified data from OLYM spring surveys may be prepared as a memo, but such a memo would be for internal NPS use only. If a year includes OLYM spring surveys, results from those surveys are included in annual reports.

The Muckleshoot Indian Tribe (MIT), Puyallup Tribe of Indians (PTOI), and WDFW rely on timely results of summer surveys for their management decisions, so draft manuscripts of the annual report should be shared with each of the MORA participating tribes and agencies as soon as possible. Before sharing data, however: the project manager for each park must ensure that written data and geospatial data are entered into the database and verified (**SOP 9: Data Entry and Verification**); and the project managers, along with the GIS Specialist and the Data Manager, contribute to data quality review and certification (**SOP 12: Data Quality Review and Certification**). After the observation data and geospatial data are certified, the Data Analyst and GIS Specialist can proceed with data summaries and mapping.

For each park and survey of a trend count area, the contents of the annual report should include:

- Summarized flight information;
- Number of observed elk groups and number of observed elk;
- Estimated abundance, when there is an applicable double-observer sightability model;
- Observed composition, which is the numbers of calves observed per 100 cows observed, and total bulls per 100 cows observed. Bulls per 100 cows should be further divided into each of the three bull age categories;
- Estimated composition, when there is an applicable double-observer sightability model;
- Maps of survey flight paths and the locations of observed elk groups;
- Records of changes in vegetation that may warrant consideration of changing a survey unit boundary;
- Number and results of double-observer sightability trials, if any.

Steps of summary and / or analysis that lead to these results are described below.

Flight Information

The database query (qs_Flight_info) results in a table with information about each survey flight, including the following information.

- Date and flight number
- Sponsoring tribe or agency

- Pilot name
- Helicopter model (Bell Jet Ranger or Hughes 500)
- Crew members and seat positions (left front, right front, left back, right back)
- Trend count area and / or survey units completed
- Total survey time (i.e., time spent within survey units)
- Total survey intensity (i.e., total survey time per square kilometer [min / km^2])

When two numbered flights are separated only by a brief refueling break, the results of qs_Flight_info should be combined for those two flights. The MORA project manager will also note in the annual report which of the flights formed complementary parts of complete surveys of the north or south trend count areas. Flights are considered complementary parts of a complete survey if all the survey units of a given trend count area were surveyed as a result of those flights. For annual reports, the total survey time and total survey intensity outputs from qs_Flight_info query should be combined from any two or more survey flights that comprised a complete survey of a trend count area.

Observed Elk Count

For each survey, annual reports present the number of elk groups seen, the mean group size, and the total number of elk seen in each survey unit and throughout each trend count area surveyed. One query of the database (qs_Obs_trend_count_area) yields these values. If two or more survey flights achieved full survey coverage of a single trend count area, then the results from those two or more flights are presented as complementary parts of a single complete survey of the trend count area. When there are two complete surveys of a given MORA trend count area in one year, observed elk counts are tabulated separately for each complete survey. At OLYM there is at most one survey per year of a given trend count area.

Observed Composition

Composition is reported for each survey of a trend count area, in terms of the relative number of calves per 100 cows, and bulls per 100 cows. The bulls per 100 cows ratio is described further in terms of each of the three bull age categories: yearlings, subadults, and mature bulls. The database query (qs_Comp_trend_ count_area) yields those observed composition values for each survey replicate of a trend count area. The query draws on the numbers of cows, calves, and bulls in each elk group recorded in survey units or within 300 m of a survey unit, and the flight numbers of survey flights that formed complementary parts of a complete survey replicate for a trend count area. The slightly larger margin (300 m) around the survey units that is included in groups that contribute to the composition values will include some elk groups that were seen slightly outside survey units. In determining whether a group is close enough to a survey unit to be included in the calculation of observed composition, the query refers to values for the fields In_unit and Unit_dist_m in the database table tbl_Observations. Those values for In_unit and Unit_dist_m are attributed by the geodatabse and updated within the relational database (**SOP 11: Geospatial Data Management,** IV. Query and Update Spatial Attributes of Locations).

Estimated Abundance and Composition

Estimated Abundance

The observed number of elk underestimates the true abundance of elk in a trend count area because of detection bias – the failure to detect elk groups that were present but not seen. We will use a double-observer sightability model to estimate abundance within trend count areas and individual survey units from the raw counts for the MORA summer surveys, and OLYM summer surveys after the model has been more fully developed and tested for application in OLYM (**Appendix C: Analyses of Detection Bias**). Applying a group-specific weighting factor to the number and composition of elk observed for each group leads to estimates of abundance and composition that account for detection bias. For a given elk group, j, with observed covariates, a double-observer sightability model estimates the unconditional probability of detection for each j observed elk group ($\hat{p}_j$) and the related, group-specific, estimated correction factor ($\overline{\hat{\theta}_j}$).

For trend count area i, estimated abundance for one complete survey in year t is $\widehat{N}_{i,t}$; this is calculated as the sum of observed group sizes, n_j, each weighted by a group-specific correction factor, $\overline{\hat{\theta}_j}$ (Equation 12.1). For MORA, point estimates of $\widehat{N}_{i,t}$ will be presented in annual reports, based on the double-observer sightability model that was estimated from MORA 2008-2010 data.

$$\widehat{N}_{i,t} = \sum \overline{\hat{\theta}_j} * n_j \qquad \text{Equation 12.1}$$

In OLYM, trend count areas are surveyed at most once per year. At MORA, however, there can be up to two complete surveys per year for each trend count area, so in each year there can be up to two reported values for $\widehat{N}_{North,t}$ and for $\widehat{N}_{South,t}$.

Before abundance or composition can be estimated, the correction factor for each group, $\overline{\hat{\theta}_j}$, must be determined and stored in the project database, in the Theta_hat field of tbl_Observations. The database query qs_Covariates is used to generate one row of covariate data for each elk group observation, containing one formatted value for each of the following fields: Obs_ID, Telemetry, Left_front, Right_front, Left_back, Right_back, Pilot_experienced, Seen_missed, Side_of_ship, Pilot_Side, Center, Activity, Cover_Type, Midpoint, Light, and Group_size. These values are exported to Excel, and then pasted into the appropriate blank cells into the Mt_Rainier_data worksheet of the Excel file “Theta_hat_calculator.xlsm,” (Figure 13.1) which is stored in the project’s Analysis folder. After this calculation, the estimated values for Theta_hat that are associated with each Obs_ID are imported into the project database, where they are stored in the database table tbl_Observations.

The database query, qs_Est_abundance, yields the estimated abundance for each complete survey replicate of a trend count area. This query is similar to the query that finds the observed total number of elk per survey unit and trend count area, except that the estimated abundance query also includes a step that multiplies each group’s observed group size by its group-specific correction factor, referring in the database to each group’s value of Theta_hat, and sums these products (following Equation 12.1) to obtain the total estimated abundance for each trend count area. The estimated abundance is found separately for each survey unit, and also summed across all survey units in a trend count area. Variance estimation for these abundance estimates is computationally more intensive, and only takes place during four-year analyses (see below). Testing for the significance of any apparent trend should only take place when variance estimates are available, during four-year analyses.

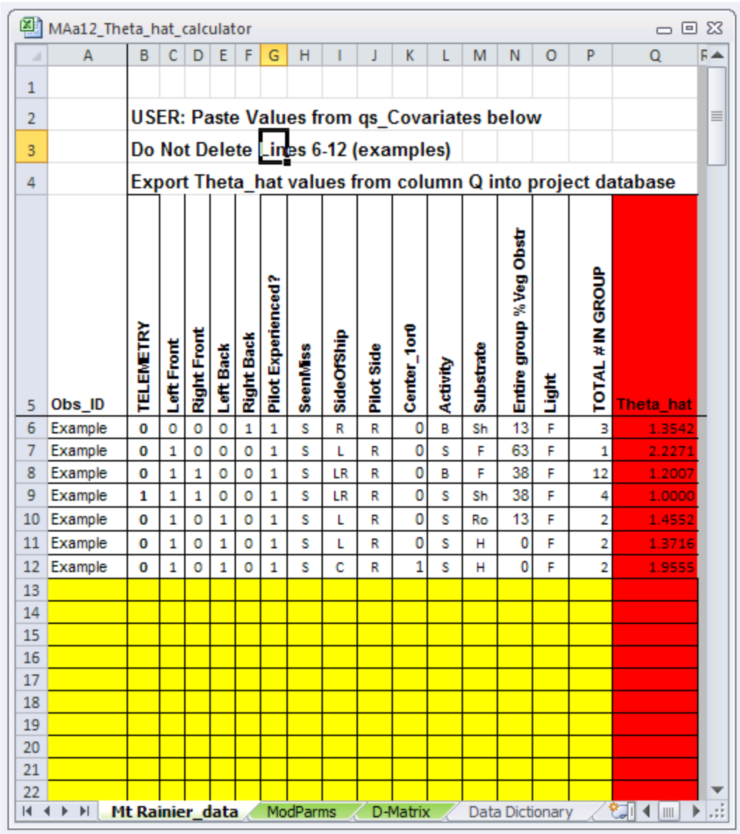


Figure 13.1. View of the Excel file “Theta_hat_calculator.xlsm.” Exported data rows from the query qs_Covariates are pasted into the yellow-colored cells. Pasting covariates into the 16 yellow columns yields the estimated model averaged correction factor for each group in the red Theta_hat column. Calculations take place in cells to the right, with reference to parameter estimates saved on the ModParms worksheet, and design matrix structures saved on the D-matrix worksheet.

Double-observer sightability models have not yet been developed for OLYM spring surveys or for OLYM summer surveys. Field data collection, implemented as part of this protocol, will be used for the development of sightability models for those surveys. Until models are developed for OLYM spring and summer surveys, we will continue to report only the observed (uncorrected) counts and composition values in annual reports.

Estimated Composition

The database query qs_Est_composition yields the estimated composition ratios for each complete survey replicate of a trend count area. This query generally follows the analytical methods of the query used to estimate abundance (qs_Est_abundance), but it uses observations of elk groups inside, or within 300 m of, a trend count area to estimate composition for that trend count area, in terms of calves per 100 cows and bulls per 100 cows.

As noted in the preceding section (*Estimated Abundance*), the database uses each group's recorded covariates to find that group's estimated correction factor ($\overline{\hat{\theta}_j}$), a value that is associated with each Obs_ID in the database field Theta_hat. For each observed group, j, the observed number of cows ($n_{j,cow}$), calves ($n_{j,calf}$), and bulls ($n_{j,bull}$) are multiplied by Theta_hat to estimate the group's contribution to the total number of cows, calves, and bulls used in the composition estimate for the trend count area. The query also returns a more detailed estimate of the number of bulls in each age class (yearling bull, subadult bull, and mature bull) per 100 cows.

Maps of Flight Paths and Observed Elk Locations

The GIS Specialist should prepare maps that illustrate the helicopter flight paths for each replicate survey of a trend count area. As noted in the **Flight Information** section, a single replicate survey may include two or more numbered flights. Lines should indicate flight paths, with line color signifying the agency or tribe that sponsored the flight. Circular markers should indicate the locations where elk groups were observed. Map templates for flight paths and elk group locations are stored in the geodatabase (**SOP 11: Geospatial Data Management**). Figure 13.2 is an example map from the August 18, 2009 survey flights over the MORA South herd trend count area.

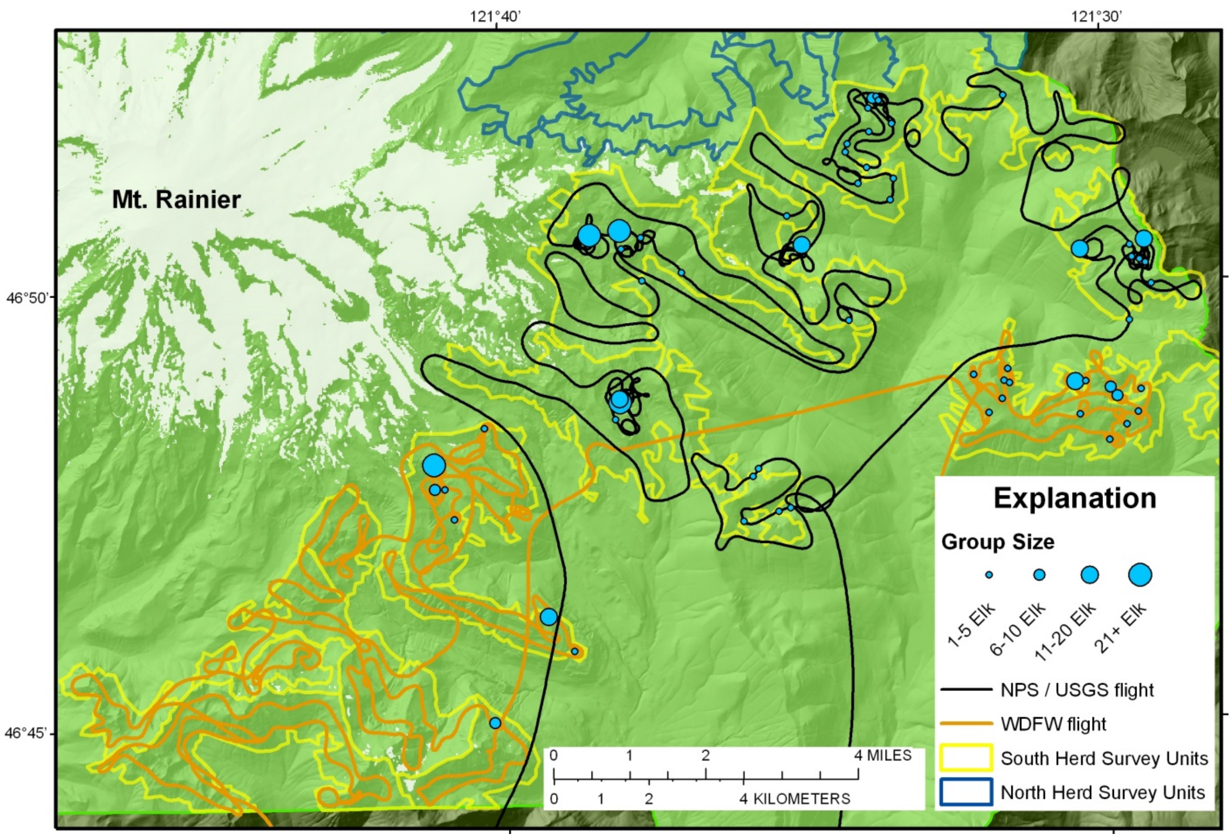


Figure 13.2. Survey flight paths and elk group locations observed on August 18, 2009, in the MORA South herd trend count area. The WDFW flight path is shown as an orange line and the NPS / USGS flight path is shown as a black line. Blue circles indicate the locations of observed elk groups, with circle size corresponding to group size. One South herd survey unit was not visited: S20, at the eastern park boundary.

Number and Results of Double-Observer Sightability Trials

Double-observer sightability trials are attempts by aerial survey crews to detect elk groups containing at least one radio-collared elk. Annual reports should present the number of double-observer sightability trials conducted during summer surveys, and the number of trials resulting in 'seen' versus 'missed' groups. If spring surveys took place, the annual report should present any results from double-observer sightability trials from those surveys. Telemetry procedures used to determine the results (elk group 'seen' versus 'missed') of individual sightability trials are described in **SOP 7: Conducting Helicopter Surveys**. As described previously (**Section 2.0 A. General Survey Strategy**), we will continue to record double-observer sightability trials in OLYM summer surveys until there are sufficient data to generalize the model for application in both parks (**Appendix C: Analyses of Detection Bias**). Further, double-observer trial data may be collected in MORA to facilitate future comparisons of detection models in the future (see **3.0 E. Details of Taking Measurements**).

Four-year Reports

Four-year reports present analyses of trends. These trend estimates incorporate estimates from the preceding four years of survey, along with earlier data. Four-year reports are prepared as Natural Resource Technical Reports (**SOP 14: Product Delivery, Posting and Distribution**). Estimates of trend made during four-year analyses are stored in a database table (tbl_Trend_Results).

Four-year report contents should include:

- Variance estimates for abundance estimates in the preceding four years of survey
- Trends in estimated abundance in each summer trend count area
- Trends in estimated composition in each summer trend count area
- Trends in spatial distribution of relative elk abundance, within each trend count area
- Trends in raw counts of elk in trend count areas for which a double-observer sightability model has not been developed or tested
- Assessment of adequacy of statistical models that account for detection bias

Trends in Estimated Abundance

Four-year analyses use the estimates of abundance and associated variance estimates from annual reports to test for positive or negative trends in abundance, separately for each summer trend count area. The regression line to fit to the $\widehat{N}_{i,t}$ values should be weighted according to the inverse of the variance for each year's point estimate, $Var\left(\widehat{N}_{i,t}\right)$ (Gerrodette 1991). In any publication, any reporting of trends should be accompanied by the explicit caveat that inferences about trends in abundance are limited to elk that use the selected trend count areas at the time of surveys.

Variance estimates for each point estimate of abundance are calculated by simulating observation data sets ('bootstrapping'), based on the observed data and refitting the double-observer sightability model for each simulation. Estimated $\overline{\hat{\theta}_j}$ values are applied to the original data set to generate simulated observation data sets. Each simulated data set contains elk groups with covariates corresponding to those in the actual data set. Based on evaluating random numbers against the model-averaged estimates for each j elk group's unconditional $\hat{p}_{front,j}$ and $\hat{p}_{back,j}$, each simulated elk group is recorded as either detected or not detected by front and back observers. Contributing model weights, parameter estimates, and the resulting model-averaged abundance estimates for each simulated survey are estimated and tabulated for each simulated data set. The coefficient of variation for the point estimate of abundance, CV($\widehat{N}$), and confidence limits, are calculated based on the range of simulated abundance estimates. Estimated values for variance in abundance are stored in the database table tbl_Trend_Area_Results. Details of the simulation are presented in **Appendix C: Analyses of Detection Bias**.

At MORA, there may be more than one estimate of abundance for each trend count area, because two complete replicate surveys of all survey units may have been completed. In that case, both estimated values of $\widehat{N}_{North,t}$ or $\widehat{N}_{South,t}$, and their associated variance estimates, should be included in the analysis of trend. Including both values should lead to better estimates of both process and sampling variance over time.

2008 is the first year with data that can be used in estimating trends in summer survey abundance. Historic MORA summer surveys did not consistently cover the same trend count areas, and did not record the covariates needed to convert observed counts to estimated abundance. There are no historic data points for summer OLYM trend count areas. Peripheral OLYM summer trend count areas are only surveyed once per four years; it will not be possible to test for a trend in a given peripheral trend count area until it has been surveyed twice.

Trends in Estimated Composition

As with abundance trend estimation, four-year analyses use the composition estimates and associated variance estimates from annual reports to test for positive or negative trends in composition, separately for each summer trend count area. For each summer trend count area, this entails estimating trend for both the calves per 100 cows measure, and the bulls per 100 cows measure. Variance estimates for the point estimates of composition for each survey are estimated in four-year analyses, with bootstrapping procedures similar to those used to compute variance in abundance estimates. As with abundance, the regression line to fit to the annual estimates of composition should be weighted according to the inverse of the variance for each year's point estimate (Gerrodette 1991). Because of the rotating survey design, it will not be possible to test for a trend in composition in a given peripheral trend count area until it has been surveyed twice.

Trends in Spatial Distribution of Relative Elk Abundance

Trends in the spatial distribution of elk observations can be presented in tables or maps. Annual abundance estimates for each survey unit and trend count area are stored in database tables (tbl_Unit_Results and tbl_Trend_Area_Results). We will first convert abundance estimates to indices of relative abundance in each survey unit by dividing the estimate for each survey unit by the total abundance estimated for the trend count area. Within each trend count area, relative abundances for individual survey units sum to one. For each survey unit, the data analyst should estimate a trend in relative abundance over time; results of these calculations for unit-specific intercepts, slopes, and standard errors of slopes are stored in tbl_Unit_Trends. Any temporal trends in relative abundance should be presented graphically, by color coding each survey unit to depict positive, neutral, or negative change in relative abundance over time.

Trends in Abundance, Composition and Spatial Distribution of Raw Counts

The first four-year report of elk population trends on summer ranges and spring ranges in OLYM (to be completed in 2012) will require the assessment of apparent trends in raw data, because double-observer sightability models have not been developed and tested for OLYM. As a result, any initially reported apparent trends in OLYM will rely on uncorrected counts of observed elk from within summer and spring trend count areas. In the second four-year report, we will have a double-observer model ready for application to OLYM summer range surveys, and we will be able to retroactively test for trends in abundance, based on estimated values of elk abundance, beginning with surveys from 2008. We will continue to assess apparent trends of elk on spring trend count areas based on raw counts from any years in which spring surveys take place.

For long-term monitoring, estimates of abundance that account for detection bias are superior to raw elk counts. The raw counts can be used, however, as an index of elk density. For trend count areas that have no applicable double-observer sightability model, we will assess the apparent trends in raw elk counts by fitting simple linear regressions through the observed values of the log-transformed number of observed elk over time, and through the observed composition ratios over time (for OLYM summer surveys). Assessing apparent trends in this way requires the untested assumption that the relationship between the number of elk counted and the number of elk actually present is stable over time (Thompson et al. 1998). Once there is a double-observer sightability model that can be applied to present and past data for OLYM summer surveys, trend assessments from that point forward will only use estimates of abundance or estimates of composition. Even after development of an applicable sightability model for OLYM summer surveys, in four-year reports we will continue to plot the raw numbers of observed elk and the raw composition ratios over time, although we will highlight the assumption that the uncorrected values do not account for detection bias. Similarly, for MORA data we will present raw numbers of observed elk, and raw composition values over time. Despite the necessary caveats, in our experience readers often appreciate the presentation of such uncorrected values.

Assessing the Adequacy of Double-observer Sightability Models

The methods detailed in **SOP 7: Conducting Helicopter Surveys** will allow for continued collection of data that can be used to parameterize a double-observer sightability model for OLYM summer surveys in the near future. Over the long term, if supplemental funding allows for many years of OLYM spring surveys, then it may be possible to develop a separate double-observer sightability model for OLYM spring surveys. Four year reports should detail the progress toward collection of data sets, enumerating the sample sizes of double-observer data points and double-observer sightability trail data points (**Appendix C: Analyses of Detection Bias**) separately for OLYM summer surveys and OLYM spring surveys.

The MORA double-observer sightability model was developed based on data collected from 2008-2010. Those data were collected by many observers under a wide variety of survey conditions. Nonetheless, it is possible that future changes in survey conditions, elk behaviors, or crew acuity could affect sightability, thus introducing bias. Our continued collection of data using double-observer methods (**SOP 7: Conducting Helicopter Surveys**) will allow us to test for changes over time in detection probabilities, as a function of observed covariates. **Appendix C: Analyses of Detection Bias** outlines analytical steps that would identify such changes. The same type of analysis will be applied to assess the adequacy of the MORA double-observer sightability model for use with OLYM summer survey data.

If we find that future detection probabilities differ from those that led to the current MORA double-observer sightability model, prescribed actions may include selectively removing observers with demonstrably low acuity, requiring higher training levels for observers, rotating observer positions, incorporating recent double-observer data and double-observer sightability trial data to revise the double-observer sightability model, or relying only on updated double-observer data and double-observer sightability trial data to create a new double-observer sightability model. Four-year reports will provide recommendations for any necessary analytical work to review or revise sightability models.

Literature Cited

Gerrodette, T. 1991. Models for power of detecting trends – a reply to Link and Hatfield. Ecology 72:1889-1892.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California.

SOP 14: Product Delivery, Posting and Distribution

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides a schedule, product specifications, and instructions for delivering completed data sets, reports and other project deliverables for long-term storage (Table 14.1). Details are also provided on posting products to websites and clearinghouses, and on responding to data requests.

Product Delivery Schedule and Specifications

Table 14.1. Schedule and instructions for project deliverables.

Deliverable Product	Primary Responsibility	Target Date	Delivery Instructions
Flight reports	Park Leads	April 15 (spring surveys) and September 30 (Summer surveys)	Save files to the project workspace in: Documents/Flight_reports. Upload digital file in Microsoft Word format to the NCCN Digital Library.
Raw GPS data files	GIS Specialist, Technicians	Sep 30 of the same year	Store in appropriate sections of the project workspace
Processed GPS data files	GIS Specialist		
Digital photographs	Project Lead	Sep 30 of the same year	Organize, name and maintain photographic images in the project workspace according to **SOP 10: Processing Digital Photographs**.
Certified back-end database	Project Lead	November 30 of the same year; data are not posted to public sites until April of the second year	Refer to the section in this SOP on delivering certified data and related materials.
Certified geospatial data	Park Leads, with GIS Specialist		
Data certification report	Project Lead		
Metadata interview form	Project Lead	December 31 of the same year	
Full metadata (parsed XML)	Data Manager and GIS Specialist	May 31 of the following year	Upload the parsed XML record to the NPS Data Store [1].
Annual I&M report	Park Leads	February 28 of the following year	Refer to the section in this SOP on reports and publications.

Table 14.1. Schedule and instructions for project deliverables (continued).

Deliverable Product	Primary Responsibility	Target Date	Delivery Instructions
Four-year analysis report	Park Leads, Data Analyst	Every 4th survey year by April 30	
Other publications	Park Leads, Data Analyst	As completed	
Field data forms	Park Leads, GIS Specialist, or Technicians	February 28 of following year	Scan original, marked-up field forms as PDF files and store in the project workspace. Hard copy originals go to the Park Curator for archiving four years after data collection.
Other records	Project Lead	Review for retention every May	Retain or dispose of records following NPS Director's Order 19 [2]. Organize and send analog files to Park Curator for archiving. Digital files that are slated for permanent retention should be uploaded to the NCCN Digital Library.

[1] The NPS Data Store is an internet clearinghouse for documents, data and metadata on natural and cultural resources in parks. It is a primary component of the NPS Integrated Resource Management Applications (IRMA) portal (http://irma.nps.gov).

[2] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm

NCCN Digital Library

The NCCN Digital Library is a document management system maintained in a Microsoft SharePoint environment at: http://imnetsharepoint/nccn/default.aspx. The primary purpose of this system is to maintain important digital files – such as reports, protocol documents, and selected project images – within a content management system, and to make them available to NCCN and NPS users. NCCN users may view, post and edit documents within this system; other NPS users have read-only access to these files, except where information sensitivity may preclude general access.

To enable discovery and long-term usability of key documents, certain information about each file needs to be filled in as files are uploaded, for example:

- Document title
- Project code (e.g., "MAa12" for Elk Aerial Surveys at MORA and OLYM)
- Park(s) to which the file(s) apply; multiple parks may be selected for each upload
- Document type (e.g., formal report, database, protocol, etc.)
- Date of publication or last revision
- Author name(s)
- Sensitivity: Sensitive, NPS Only, or Public. Sensitive files will not be viewable without permission. For a definition of sensitive information, see **Section 4I, Identifying and Handling Sensitive Information**.
- Description - Document abstract, additional authors and credits, special use instructions, etc.

For project staff without access to the NPS intranet, files may be sent by email or CD/DVD to the Project Lead or Data Manager for upload, along with the information from the above list, in a text file or accompanying email.

Park Collections

Hardcopy field forms will be filed in the archives of the park where the data were collected (i.e., MORA or OLYM). Printouts of annual reports, technical reports, and other publications will also be filed at each park. In addition, other hard copy project records should be reviewed and organized on an annual basis (or at the conclusion of a project), and sent to park collections for long-term storage.

Delivering Certified Data and Related Materials

Data certification is a benchmark in the project information management process that indicates that the data: 1) are complete for the period of record; 2) have undergone and passed the quality assurance checks; and 3) are appropriately documented and in a condition for archiving, posting and distribution as appropriate. To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. For more information refer to **SOP 12: Data Quality Review and Certification**.

The following deliverables should be delivered as a package:

- *Certified back-end database* – Database containing data for the current season that has been through the quality assurance checks documented in **SOP 12: Data Quality Review and Certification**. Delivery of this item is only applicable in cases where the back-end database is implemented in Microsoft Access and/or is deployed outside the NPS firewall during the quality review. In all other cases, the Data Manager will already have access to the certified data.
- *Certified geospatial data* – GIS themes in ESRI coverage or shapefile format. Refer to NCCN GIS Development Guidelines (NCCN 2009) and NCCN GIS Product Specifications (NCCN 2007a) for more information.
- *Data certification report* – A brief questionnaire in Microsoft Word that describes the certified data product(s) being delivered. A template form is available on the NCCN website at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm.
- *Metadata interview form* – The metadata interview form is a Microsoft Word questionnaire that greatly facilitates metadata creation. It is available on the NCCN website at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm. For more information, refer to **Section 4F, Metadata Procedures**.

After the quality review is completed, the Project Lead (or a designee) should package the certification materials for delivery as follows:

1. Create a compression file (using WinZip® or similar software, or by right-clicking in Windows Explorer). This file should be named in accordance with general file naming standards, and the name should include the project code ("MAa12") and the year or span of years for the data being certified. For example: MAa12_2011_certification_pkg.zip.
2. In cases where the back-end database is implemented in Microsoft Access and/or is deployed outside the NPS firewall during the quality review:

   a. Open the certified back-end database file and compact it (in Microsoft Access version 2003 and earlier, Tools > Database Utilities > Compact and Repair Database). This will make the file size much smaller. Back-end files are typically indicated with the letters "_be" in the name (e.g., MAa12_Elk_Aerial_be.mdb).
   b. Add the back-end database file to the compression file.
   c. Note: The front-end application does not contain project data and as such should not be included in the delivery file.
3. Add the completed metadata interview and data certification forms to the compressed file. Both files should be named in a manner consistent with the file naming standards described in **SOP 1: Project Workspace and Records Management**.
4. Add any geospatial data files that are not already in the possession of the GIS Specialist. Geospatial data files should be developed and named according to NCCN GIS Naming Conventions (NCCN 2007b).
5. Deliver the compressed file containing all certification materials to the Data Manager by placing it in the Data folder of the project workspace and notifying the Data Manager by email. If the Project Lead does not have network access, then certification materials should be delivered as follows:
   a. If the compressed file is under 9.5 mb in size, it may be delivered directly to the Data Manager by email.
   b. If the compressed file is larger than 9.5 mb, it should be copied to a CD or DVD and delivered in this manner. Under no circumstances should products containing sensitive information be posted to an FTP site or other unsecured web portal (refer to **Section 4I, Identifying and Handling Sensitive Information**).

Upon receiving the certification materials, the Data Manager will:

1. Review them for completeness and work with the Project Lead if there are any questions.
2. Check in the delivered products using the NCCN project tracking application.
3. Notify the GIS Specialist if any geospatial data are delivered. The GIS Specialist will then review the data, and update any project GIS data sets and metadata accordingly, and file those products in the project workspace.
4. Work with the GIS Specialist to finalize coordinate data in the database, generate public coordinates (as applicable – see **Section 4I, Identifying and Handling Sensitive Information**), and update any GIS-derived data fields therein (e.g., elevation, slope, aspect).
5. Archive the certified products in the project workspace.
6. Notify the Project Lead that the year's data have been successfully reviewed and processed. The Project Lead may then proceed with data summarization, analysis and reporting.
7. Export MORA survey data and provide this to the MORA Lead, who will share these results with wildlife biologists from participating tribes and agencies (MIT, PTOI, and WDFW).
8. Develop, parse and post the XML metadata record to the NPS Data Store.
9. After a holding period of two years, the Data Manager will upload the certified data to the NPS Data Store. This holding period is to protect professional authorship priority and to provide sufficient time to catch any undetected data quality problems.

No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to the NPS Data Store or any other publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Only products that are intended for public/general-use may be posted to public websites and clearinghouses – these may not contain sensitive information.

Instructions for Reports and Publications

Annual reports and four-year analysis reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Technical Report (NRTR) template, and four-year analysis and other peer-reviewed technical reports will use the Natural Resource Report (NRR) template. These templates and documentation of the NPS publication standards are available at: http://www.nature.nps.gov/publications/NRPM/index.cfm.

The procedures for annual reports, technical reports, and publications are as follows. (Note: This is optional for flight reports, which are intended to be internal communications only). It is the intent of this protocol that the contributing wildlife biologists from MIT, PTOI, and WDFW be invited to be authors on all annual and four-year reports, so they will be involved with reviewing reports before they are sent to peer review.

1. The Project Lead or Data Analyst formats the document according to the NPS Natural Resource Publications standards.
   a. Formatting according to NPS standards is easiest when using the report template from the very beginning, as opposed to reformatting an existing document.
   b. When creating the file, use appropriate naming standards (described in this document). If creating the document in SharePoint (e.g., the NCCN Digital Library), attribute the file as a draft; otherwise add "DRAFT" to the file name.
   c. Open the document and add "DRAFT" to the header or document watermark as appropriate.
2. The document is reviewed internally by participating wildlife biologists from MIT, PTOI, and WDFW.
3. The document should be peer reviewed at the appropriate level. For example, I&M Annual Reports should be reviewed by other members of the project work group. The Network Program Manager will also review all annual reports for completeness and compliance with I&M standards and expectations. Before sending the document for review, rename the document by adding a date stamp to the end of the file name using the YYYYMMDD format.
4. Upon completing the peer review, the Project Lead should acquire a publication series number from the appropriate regional or national key official. Instructions for acquiring a series number are available at: http://www.nature.nps.gov/publications/NRPM/index.cfm.
5. The Project Lead should finalize the document:
   a. Ensure that the publication/version date (last saved date field code in the document header, if used) and file name (field code in the document footer, if used) are updated properly throughout the document.
   b. Remove the word "DRAFT" from watermarks, document headers, and file name.
   c. Remove any previous date stamp from the file name.

   d. If the document has been developed and maintained in SharePoint (e.g., the NCCN Digital Library), update the document attribute to “Final”.
   e. To avoid unplanned edits to the document, reset the document to read-only by right-clicking on the document in Windows Explorer and checking the appropriate box in the Properties popup.
   f. Create a PDF version of the document and upload the final file and PDF copy to the NCCN Digital Library for long-term storage.
   g. Store both the Word document and PDF copy in the appropriate section of the project workspace (see **SOP 1: Project Workspace and Records Management**).
6. Notify the Park Curator and Data Manager that the report is available, and send a printout to the Park Curator to add to the host park collections.
7. The Data Manager (or a designee) will create a bibliographic record and upload the PDF copy to the NPS Data Store according to document sensitivity.
8. The MORA Lead will send copies of any reports referring to MORA elk surveys to the wildlife biologists from all participating tribes and agencies (i.e., MIT, PTOI, WDFW).

File Naming Standards

Prior to delivering or uploading digital products, files should be named according to the naming conventions appropriate to each product type.

Reports and Publications

- No spaces or special characters in the file name.
- Use the underbar (“_”) character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Dates should be formatted as YYYYMMDD.
- As appropriate, include the project code (e.g., “MAa12”), network code (“NCCN”) or park code ("MORA,” “OLYM,” or “MORA_OLYM”), and year in the file name.

Examples:

- MAa12_NCCN_2011_Annual_report.pdf
- MAa12_OLYM_Spring_2011_Flight_report.doc
- MAa12_NCCN_2011_Certification_report.doc

Other Files

General naming standards as described in **SOP 1: Project Workspace and Records Management** apply to all deliverables. When delivering files to the NCCN Digital Library, file names should be modified as needed to include the project code (e.g., “MAa12”), network code (“NCCN”) or park code, and year as appropriate (e.g., NCCN_MAa12_2012_cert_package.zip). Specific standards for images are described in **SOP 10: Processing Digital Photographs** and in **SOP 15: Revising the Protocol** for protocol documents.

Product Posting

Once digital products have been delivered and processed, the Data Manager or a designee will post them to or otherwise update the following applications to make them generally available:

1. The NPS Data Store is an internet clearinghouse for documents, data and metadata on natural and cultural resources in parks. It is a primary component of the NPS Integrated Resource Management Applications (IRMA) portal (http://irma.nps.gov). Refer to the section on sensitive information in **Section 4I, Identifying and Handling Sensitive Information** for information on options for flagging products containing sensitive information within the system, or for modifying products prior to posting so that they no longer contain sensitive information and can therefore be shared broadly. Full metadata records will be posted to the NPS Data Store as they are created; data sets will be posted after a two-year hold to protect professional authorship priority and to provide sufficient time to catch any undetected quality assurance problems. For reports and other publications, an online record is created after first verifying that one does not already exist. The digital report file in PDF format is then uploaded.
2. NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data, and is also a component of the IRMA portal (http://irma.nps.gov). Species observations will be extracted from project data sets and uploaded into NPSpecies.
3. NCCN Web Site is maintained by NCCN staff as part of the NPS Inventory and Monitoring web site (http://science.nature.nps.gov/im/units/nccn) to describe our program, the vital signs selected for monitoring, and to highlight certain products and information derived from inventory and monitoring work at NCCN. The site has both internet and intranet components. Select products such as annual reports and technical reports will be posted to the web site.

These applications serve as the primary mechanisms for sharing reports, data, and other project deliverables with other agencies, organizations, and the general public.

Holding Period for Project Data

To protect professional authorship priority and to provide sufficient time to complete quality assurance measures, there is a two-year holding period before posting or otherwise distributing certified project data. This means that certified data sets are first posted to publicly-accessible websites (i.e., the NPS Data Store) approximately 24 months after they are certified (e.g., data collected in September 2011 and certified in March 2012 becomes generally available through the NPS Data Store in March 2012). In certain circumstances, and at the discretion of the Project Lead, MORA project manager, and OLYM project manager, data may be shared before a full two years have elapsed.

Note: This hold only applies to raw data, and not to metadata, reports or other products which are posted to NPS clearinghouses immediately after being received and processed.

Responding to Data Requests

Occasionally, a park or project staff member may be contacted directly regarding a specific data request from another agency, organization, scientist, or from a member of the general public. The following points should be considered when responding to data requests:

- For all Inventory and Monitoring projects in NCCN, NPS is the originator and steward of the data that are collected by NPS staff. The NPS Inventory and Monitoring Program should be acknowledged in any professional publication using these data.
- NPS retains distribution rights; copies of the data collected by NPS staff should not be redistributed by anyone but NPS.
- The data that project staff members and cooperators collect using public funds are public records and as such cannot be considered personal or professional intellectual property.
- No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to the NPS Data Store or any other publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Refer to **Section 4I, Identifying and Handling Sensitive Information**.
- For quality assurance, only certified, finalized versions of data sets should be shared with others. In exceptional cases where a provisional data set needs to be shared with others prior to certification:
    - Any accompanying communications should clearly indicate that the data set is provisional and subject to change according to our quality review process.
    - File names and the media it is sent on should be clearly labeled as containing provisional data not for distribution.

The Project Lead will handle all data requests as follows:

1. Discuss the request with other Park Biologists as necessary to make those with a need to know aware of the request and, if necessary, to work together on a response.
2. Notify the Data Manager if s/he is needed to facilitate fulfilling the request in some manner.
3. Respond to the request in an official email or memo.
4. In the response, refer the requestor to the NPS Data Store and the IRMA portal (http://irma.nps.gov), so they may download the necessary data and/or metadata. If the request cannot be fulfilled in that manner – either because the data products have not been posted yet, or because the requested data include sensitive information – work with the Data Manager to discuss options for fulfilling the request directly (e.g., writing data to CD or DVD). Ordinarily, only certified data sets should be shared outside NPS.
5. It is recommended that documents and presentation files be converted to PDF format prior to distribution. This is to maximize portability and to reduce the ability for others to alter and redistribute files.
6. If the request is for data that may reveal the location of protected resources, refer to the next section in this document about sensitive information and also to **Section 4I, Identifying and Handling Sensitive Information**.
7. After responding, provide the following information to the Data Manager, who will maintain a log of all requests in the NCCN project tracking database:
    a. Name and affiliation of requestor
    b. Request date
    c. Nature of request
    d. Responder
    e. Response date

f. Nature of response
g. List of specific data sets and products sent (if any)

Freedom of Information (FOIA) Requests

All official FOIA requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

Special Procedures for Sensitive Information

Products that have been identified upon delivery by the Project Lead as containing sensitive information (i.e., locations of threatened or endangered species, archaeological or other sensitive resources) will normally be revised into a form that does not disclose the locations of protected resources – most often by removing specific coordinates and only providing coordinates that include a random offset to indicate the general locality of the occurrence. If this kind of measure is not a sufficient safeguard given the nature of the product or the protected resource in question, the product(s) will be withheld from posting and distribution.

If requests for distribution of products containing sensitive information are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (i.e., the full data set that includes sensitive information) may be shared only after a confidentiality agreement has been established between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Refer to **Section 4I, Identifying and Handling Sensitive Information** for more information.

Literature Cited

North Coast and Cascades Network. 2009. GIS Development Guidelines. USDI National Park Service. Available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

North Coast and Cascades Network. 2007a. GIS Product Specifications. USDI National Park Service. Available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

North Coast and Cascades Network. 2007b. GIS Naming Conventions. USDI National Park Service. Available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

SOP 15: Revising the Protocol

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP describes how to make and track changes to the NCCN Elk Aerial Survey Monitoring Protocol, including its accompanying SOPs. Project staff should refer to this SOP whenever edits are necessary, and should be familiar with the protocol versioning conventions in order to identify and use the most current versions of the protocol documents. Required revisions should be made in a timely manner to minimize disruptions to project operations.

Peer Review

This protocol attempts to incorporate the best and most cost-effective methods for monitoring and information management. As new technologies, methods, and equipment become available, this protocol will be updated as appropriate, by balancing current best practices against the continuity of protocol information.

All edits require review for clarity and technical soundness. Small changes to existing documents – e.g., formatting, simple clarification of existing content, minor changes to the task schedule or project budget, or general updates to information management SOPs – may be reviewed in-house by project and NCCN staff. However, changes to data collection or analysis techniques, sampling design, or response design are usually more significant in scope and impact and will typically trigger an outside review to be coordinated by the Pacific West Regional Office of the National Park Service.

Document Life Cycle

Protocol documents may be maintained as separate files for each component (e.g., narrative, SOPs, appendices in separate document files) or unified into a single document file. During its life cycle, each document file can be classified in one of six life cycle stages:

- Draft documents – Documents that have been drafted or revised but have not been reviewed and approved yet.
- Review documents – Draft documents that have been sent out for peer review or administrative review.
- Active documents – The current, reviewed and accepted version of each protocol component in Microsoft Word format. These documents have been reviewed and approved at the appropriate level, and are currently implemented for active monitoring projects.

- Inactive documents – Older versions of approved protocol components that are no longer in active implementation.
- Archived documents – Comprehensive set of active protocol components plus older, inactive versions of approved protocol components in Microsoft Word format. These are stored as read-only and have a date stamp to identify their approval date. The history of the protocol versions through time should be entirely traceable from within the document archive.
- Distribution copies – PDF versions of approved, date-stamped protocol components, used to post to websites or otherwise share outside NPS.

Protocol documents are stored in the project workspace in separate subfolders named for each life cycle stage, except for inactive documents which are filed together with date-stamped copies of active documents in the archive folder. See **SOP 1: Project Workspace and Records Management** for additional details about the project workspace.

Document Versioning Conventions

Rather than using a sequential numeric versioning convention, we use date stamps to distinguish document versions because they are more intuitive and informative than version numbers. Date stamps are embedded within the document header, and also included in the document name.

Document Header

Within each document, the upper right section of the document header should show the date that the document was last saved. By using save date instead of current date, printouts and document previews will show the correct version number. The following is the field code to be used within the header to indicate the version number:

```
SAVEDATE } \@ "MMMM d, yyyy"
```

File Naming Conventions

All documents *except for active documents and draft documents* should include the last edit date as a suffix, using the YYYYMMDD format so that documents will sort by date rather than month or day (e.g., NCCN_Elk_Aerial_Protocol_DRAFT_20110430.doc for the review draft on 4/30/2011).

Active documents and draft documents that have not been shared with others (as review documents) should not include the date because – unlike documents in other life cycle stages – they are not "point in time" document snapshots. By omitting the date stamp from these documents, they can more easily be distinguished from review drafts and archive or distribution copies. Draft documents should clearly contain the word "DRAFT" in the file name.

Note: General file and folder naming conventions are described in **SOP 1: Project Workspace and Records Management**; these should be followed when naming protocol document files.

Revision Procedures

Proposed changes to protocol components should be discussed among project staff and vital cooperators (especially partnering agencies/tribes for MORA surveys) prior to making modifications. It is also important to consult with the Data Manager prior to making changes because certain types of changes may jeopardize data set integrity unless they are planned and executed with the continuity of the data set in mind. Because certain changes may require altering the database structure or functionality, advance notice of changes is important to minimize disruptions to project operations. Consensus should be reached on who will be making the agreed-upon changes and in what timeframe.

Note: A change in one document also may necessitate other changes elsewhere in the protocol. For example, a change in the narrative may require changes to several SOPs. Similarly, renumbering an SOP may mean changing document references in several other sections of the protocol. The project task list and other appendices also may need to be updated to reflect changes in timing or responsibilities for the various project tasks.

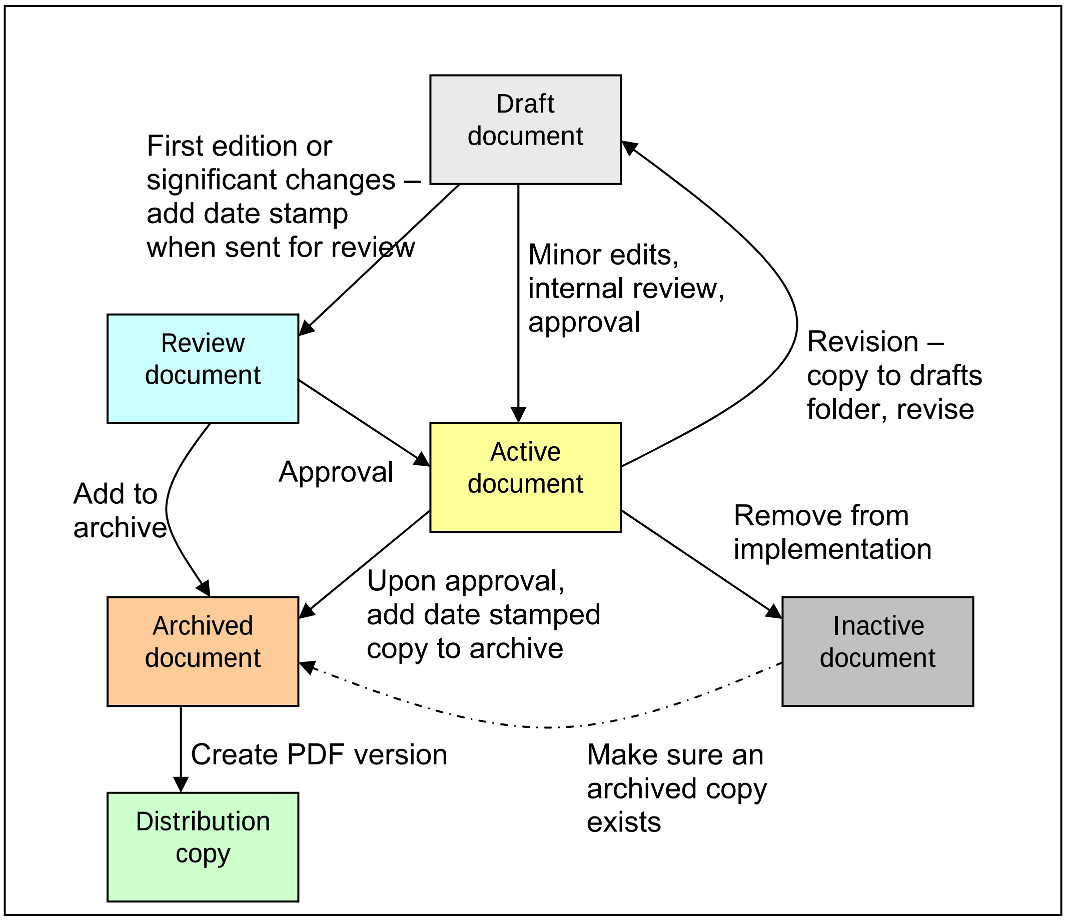


Figure 15.1. Process for creating and revising protocol documents. Boxes represent document life cycle stages, and connecting arrows indicate procedures.

The Project Lead is the primarily responsible for making edits and ensuring document review at the appropriate level. The process for creating and revising protocol documents is shown in Figure 15.1, and outlined below:

1. Create the draft document in Microsoft Word format. If modifying an existing document (usually an active document), copy the document to the draft document folder, remove

any date stamp from the name. Add "DRAFT" to the file name. Open the document and add "DRAFT" to the header or document watermark as appropriate.

2. Track revision history. If modifying an existing document, document all edits in the Revision History Log embedded in the protocol narrative and each SOP. Log changes only for the section of the document being edited (i.e., if there is a change to an SOP, log those changes only in the revision history log for that SOP). Record the date of the changes (i.e., the date on which all changes were finalized), author of the revision, describe the change and cite the paragraph(s) and page(s) where changes are made, and briefly indicate the reason for making the changes.
3. Document review. Circulate the changed document for internal review among project staff and cooperators. If the changes are significant enough to trigger peer review (as defined in the **Peer Review** section of this SOP), create a review document by adding a date stamp to the end of the file name using the YYYYMMDD format, copy the file to the archive folder, and submit the document for peer review according to current instructions.
4. Finalize and archive. Upon approval and final changes:
   a. Ensure that the version date (last saved date field code in the document header) and file name (field code in the document footer, if used) are updated properly throughout the document.
   b. Move the approved document to the active folder. Remove the word "DRAFT" from watermarks, document headers, and file name. Remove any previous date stamp. This is now an active, implemented document.
   c. To avoid unplanned edits to the document, reset the document to read-only by right-clicking on the document in Windows Explorer and checking the appropriate box in the Properties popup.
   d. Create a copy of the file and add the revision date to the end of the file name using the YYYYMMDD format. Move this copy to the archive folder.
   e. Inform the Data Manager so the new version number can be incorporated into the project metadata.
5. Create distribution copies. As needed, create a PDF version of the archived document to post to the internet and share with others. These PDF versions should have the same date-stamped name as the archived Microsoft Word file. Post the distribution copy to the NCCN Digital Library and forward copies to all individuals who had been using a previous version of the affected document.
6. Remove from implementation. If it is decided that a document needs to be removed from implementation – either because it is no longer necessary (e.g., an unneeded SOP), or because it has been superseded by a more recent version – this can be easily done by removing the document from the active document folder, after first checking that a copy of that version already exists in the archive folder.

Appendix A. Yearly Project Task List

Table A.1. For years in which surveys take place, this table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution. Protocol sections and SOPs are referenced as appropriate. The timing of project activities reflects the assumption that one annual cycle of the project begins on October 1, and runs through September 30. Summer survey flights occur in August and September, so many events in this annual cycle occur during the following fiscal year; these events are indicated with an asterisk.

Project Stage	**Task Description**	**Responsibility**	**Timing, OLYM spring surveys**	**Timing, MORA summer surveys**	**Timing, OLYM summer survey**
Preparation (*Section 3A, 3B, 4B, and 6C; SOPs 1, 2, 3, 4, 7, and 11*)	Communicate with tribal and WDFW project participants to schedule a pre-survey meeting that will take place in May-June	MORA Project Manager	n/a	March - April	n/a
	Meet (or conference call) to recap past field season, discuss the upcoming field season, document any needed changes to field sampling protocols or the database, and identify training needed for non-federal personnel participation on federal flights	Project Lead, Park Project Managers, Data Manager, and GIS Specialist	February	April - June	July
	Ensure all project compliance needs are completed for the coming season	Park Project Managers	Jan-Feb	June-Aug	
	Prepare and secure approval for flight safety plans for federal flights; inform state and tribal participants about flight rules over park airspace	Park Project Managers, Helicopter Manager, Aviation Manager	Jan - Feb	June-Aug	
	Confirm that all crew members for federal flights have met aviation training requirements (SOP 3)	Park Project Managers	June of the preceding year		
	Ensure that all flights are included in the park's annual flight planning request. Review helicopter contracting details with a helicopter manager	Park Project Managers	January		
	Plan field season budget, logistics and staffing, including training schedule	Project Lead, Park Project Managers	December		

Table A.1. For years in which surveys take place, this table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution (continued). Protocol sections and SOPs are referenced as appropriate. The timing of project activities reflects the assumption that one annual cycle of the project begins on October 1, and runs through September 30. Summer survey flights occur in August and September, so many events in this annual cycle occur during the following fiscal year; these events are indicated with an asterisk.

Project Stage	Task Description	Responsibility	Timing, OLYM spring surveys	Timing, MORA summer surveys	Timing, OLYM summer surveys
Preparation (*Section 3A, 3B, 4B, and 6C; SOPs 1, 2, 3, 4, 7, and 11*)	Check status of equipment and supplies (SOP 7; Equipment Checklist), and order any needed equipment and supplies	Park Project Managers	January	June-July	
	Reserve helicopter use for survey	Helicopter Manager	Jan - Feb	May - June	
	Inform GIS Specialist and Data Manager of specific needs for upcoming field season	Park Project Managers	by Jan 30	by July 1	
	Generate list of coordinates from the database, prepare and print field maps (SOP 2)	GIS Specialist	by Feb 30	by July 15	by Aug 1
	Distribute electronic copies of maps (SOP 11) and field forms (SOP 7) to other project participants	MORA Project Manager	n/a	by Aug 1	n/a
	Distribute hard copies of maps to park dispatch	Park Project Managers or Helicopter Managers	by Feb 30	by Aug 15	
	Train crew members in double-observer methods (SOP 3) and data entry	Park Project Managers, State and Tribal Biologists	by Feb 30	By Aug 15	
	Ensure that project workspace is ready for use (SOP 1)	Project Lead	by Feb 30	by Aug 15	
	Deliver GPS units with updated data dictionary, background maps, and target coordinates (SOP 4)	GIS Specialist	by Feb 30	by Aug 15	
	Update and deploy database application for data entry	Data Manager	by Feb 30, as needed	by Aug 15, as needed	
	Provide database and GPS training as needed	Data Manager and GIS Specialist	April	Sept – Oct*	

Table A.1. For years in which surveys take place, this table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution (continued). Protocol sections and SOPs are referenced as appropriate. The timing of project activities reflects the assumption that one annual cycle of the project begins on October 1, and runs through September 30. Summer survey flights occur in August and September, so many events in this annual cycle occur during the following fiscal year; these events are indicated with an asterisk.

Project Stage	**Task Description**	**Responsibility**	**Timing, OLYM spring surveys**	**Timing, MORA and OLYM summer surveys**
Data Acquisition (*Sections 3C, 3D; SOPs 5,6, 7 and 8*)	Make weather calls to arrange helicopter flights (SOP 5, SOP 6)	Park Project Managers and Helicopter Managers	Dates of survey, March	Dates of survey, Aug 15 - Sept 15
	Collect observation data (SOP 7, SOP 8)	Park Project Managers, State and Tribal Biologists, GIS Specialist, Technicians, USGS Liaison	Dates of survey, March	Dates of survey, Aug 15 - Sept 15
	Review data forms for completeness and accuracy immediately after landing, before the crew disperses.	Park Project Managers, State and Tribal Biologists, GIS Specialist, Technicians, USGS Liaison	Dates of survey, March	Dates of survey, Aug 15 - Sept 15
	Review AMD-23 form; ensure that project is within budget	Helicopter Managers and Park Project Managers	Dates of survey, March	Dates of survey, Aug 15 - Sept 15
Data Entry & Processing (*Section 4C and 4D; SOPs 4, 8, 9, and 10*)	Download GPS data; send GPS data files to GIS Specialist (SOP 4)	GIS Specialist, Park Project Managers, State & Tribal Biologists	March	Aug - Sept
	Download and process digital images (SOP 10)	Park Project Managers, State and Tribal Biologists,	March	Aug - Sept
	Transcribe 'Other species' data from in-flight audio recordings (SOP 8)	Technicians	n/a	Aug – Sept
	Enter data into the database (SOP 9)	Park Project Managers, Technicians	Mar - April	Aug – Sept
	Verify accurate transcription from field forms to database (SOP 9); scan all field forms to PDF format and store in the project workspace	Park Project Managers, Technicians	April	October*
	Review database entries for completeness and accuracy	Park Project Managers	April	October*
	Confirm that data entry for all flights is complete, and notify the Data Manager and the GIS Specialist	Project Lead	April	October*
	Merge, correct, and export GPS data. Upload processed and verified coordinates to database	GIS Specialist	April	Oct* - Nov*

Table A.1. For years in which surveys take place, this table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution (continued). Protocol sections and SOPs are referenced as appropriate. The timing of project activities reflects the assumption that one annual cycle of the project begins on October 1, and runs through September 30. Summer survey flights occur in August and September, so many events in this annual cycle occur during the following fiscal year; these events are indicated with an asterisk.

Project Stage	Task Description	Responsibility	Timing, OLYM spring surveys	Timing, MORA summer surveys	Timing, OLYM summer surveys
Product Development (Section 4H; SOP 13)	Complete flight reports (SOP 13)	Park Project Managers	by Apr 15	by Sept 30	
Quality Review (Section 4E; SOP 12)	Quality review and data validation using database tools (SOP 12)	Park Project Managers	May	November*	
Metadata (*Section 4F*)	Update project metadata interview form	Park Project Managers	December*		
Data Certification & Delivery (*Section 4G; SOPs 11, 12 and 14*)	Certify the season's data and complete the certification report (SOP 12)	Park Project Managers	by Nov 30*		
	Send preliminary summaries of raw counts from MORA surveys to project participants	MORA Project Managers	n/a	by Nov 30*	n/a
	Deliver certification report, certified data, and updated metadata to Data Manager and GIS Specialist (SOP 14)	Project Lead	by Nov 30*		
	Store certified data files in the project workspace (SOP 14)	Data Manager	December*		
	Review and update project GIS data and associated metadata (SOP 11)	GIS Specialist	December*		
	Finalize and parse metadata, store in the project workspace (SOP 14)	Data Manager and GIS Specialist	May*		
Data Analysis (*Section 4H, 5B, and 5C; SOP 13*)	Export automated summary queries and reports from database	Data Analyst	May	January*	
	Once per four years, assess suitability of models that account for detection bias, based on recent data	Data Analyst	April*		

Table A.1. For years in which surveys take place, this table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution (continued). Protocol sections and SOPs are referenced as appropriate. The timing of project activities reflects the assumption that one annual cycle of the project begins on October 1, and runs through September 30. Summer survey flights occur in August and September, so many events in this annual cycle occur during the following fiscal year; these events are indicated with an asterisk.

Project Stage	**Task Description**	**Responsibility**	**Timing, OLYM spring surveys**	**Timing, MORA and OLYM summer surveys**
Reporting & Product Development (*Section 4H, 5A*)	Acquire the proper report template from the NPS website (http://www.nature.nps.gov/publications/NRPM/index.cfm), and create annual report	Data Analyst, Park Project Managers, Project Lead	January*	
	Prepare Interim Report of Spring OLYM survey results, for internal records	OLYM Project Manager	June	n/a
	Prepare Annual Report	Park Project Managers, Project Lead	January* - February*	
	Submit draft I&M annual report to Network Program Manager and Park Biologists for review	Project Lead	by February 28*	
	Review report for formatting and completeness, notify Project Lead of approval or need for changes	Network Program Manager	March*	
Product Delivery (*Section 4J; SOP 14*)	Upload completed report to NCCN Digital Library [1], notify Data Manager (SOP 14)	Project Lead	upon approval	
	Deliver other products according to the delivery schedule and instructions (SOP 14)	Project Lead	upon completion	
	Product check-in	Data Manager	upon receipt	
	Submit metadata to the NPS Data Store [2]	Data Manager	By May 15*	
	Create and online reference record and post reports to the NPS Data Store [2]	Data Manager	upon receipt	

Table A.1. For years in which surveys take place, this table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution (continued). Protocol sections and SOPs are referenced as appropriate. The timing of project activities reflects the assumption that one annual cycle of the project begins on October 1, and runs through September 30. Summer survey flights occur in August and September, so many events in this annual cycle occur during the following fiscal year; these events are indicated with an asterisk.

Project Stage	Task Description	Responsibility	Timing, OLYM spring surveys	Timing, MORA and OLYM summer surveys
Posting & Distribution (*Section 4J; SOP 14*)	Update NPSpecies [3] records according to data observations	Data Manager	April* - May*	
	Submit certified data and GIS data sets to the NPS Data Store [2]	Data Manager	April* (after 2-year hold)	
	Store finished products slated for permanent retention in NCCN Digital Library [1]	Data Manager	upon receipt	
	Review, clean up and store and/or dispose of project files according to NPS Director's Order 19 [4]	Project Lead	May*	
Archival & Records Management (*Section 4K; SOPs 1, 14*)	Inventory equipment and supplies	Park Project Managers	April	October*
	Send original field forms to Park Archives (SOP 14)	Park Project Managers	February*	
	Conference call (MORA) or meeting (OLYM) to discuss recent field season (close out); discuss who needs to do what to get data ready for analysis	Project Lead, Park Project Managers, Data Manager, and GIS Specialist	April	October*
Season Close-out (*Section 4L*)	Discuss and document needed changes to analysis and reporting procedures	Project Lead, Park Project Managers, and Data Manager; Tribal and State Wildlife Biologists as needed	May*	

* Dates indicated with this asterisk are in the fiscal year following summer survey flights.

[1] The NCCN Digital Library is a document management system implemented in Microsoft SharePoint for maintaining important digital files (reports, protocol documents, and selected project images) within a content management system, and to make them available to NCCN and NPS users.

[2] The NPS Data Store is an internet clearinghouse for documents, data and metadata on natural and cultural resources in parks. It is a primary component of the NPS Integrated Resource Management Applications (IRMA) portal (http://irma.nps.gov).

[3] NPSpecies is the NPS database and applications for maintaining park-specific species lists and observation data, and is also a component of the IRMA portal (http://irma.nps.gov).

[4] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm.

Appendix B. Elk Aerial Survey Database Documentation

The database for this project consists of three types of tables: core tables describing the “who, where and when” of data collection, project-specific tables, and lookup tables that contain domain constraints for other tables. Although core tables are based on NCCN standards, they may contain fields, domains or descriptions that have been added or altered to meet project objectives.

The database includes the following standard tables:

tbl_Locations	Sample locations - survey units within which aerial counts are conducted
tbl_Events	Data collection events (flights)
tbl_GPS_Info	GPS information associated with flight paths and group observations
tbl_Observers	Observers for each sampling event
tbl_QA_Results	Quality assurance query results for the working data set
tbl_Edit_Log	Edit log for changes made to data after certification
tbl_Images	Images associated with flights or individual observations

The following are project-specific data tables:

tbl_Audio_Files	Flight recordings, used for data review and incidental species observations
tbl_Incidental_Obs	Incidental species observations made during flights
tbl_Observations	Elk group observations
tbl_Phenology_Points	Phenology observation photo points
tbl_Pilot_Experience	Information about pilot experience by year
tbl_Survey_Conditions	Observed conditions at survey start and stop times
tbl_Survey_Times	Unit survey start and stop times
tbl_Telemetry_Times	Telemetry interval start and stop times
tbl_Trend_Area_Results	Variance estimates associated with annual abundance estimates by trend count area (i.e., grouped survey units) and replicate
tbl_Trend_Area_Trends	Trend estimates for relative use by trend count area (i.e., grouped survey units), derived from data analysis
tbl_Unit_Results	Survey unit results - raw and corrected abundance and composition results
tbl_Unit_Surveys	Survey information specific to individual units
tbl_Unit_Trends	Survey unit trend estimates for relative use, derived from data analysis

The following are a few of the more prominent, standard lookup tables:

tlu_Project_Crew	List of personnel associated with a project
tlu_Project_Taxa	List of species associated with project observations
tlu_Park_Taxa	Park-specific attributes for taxa

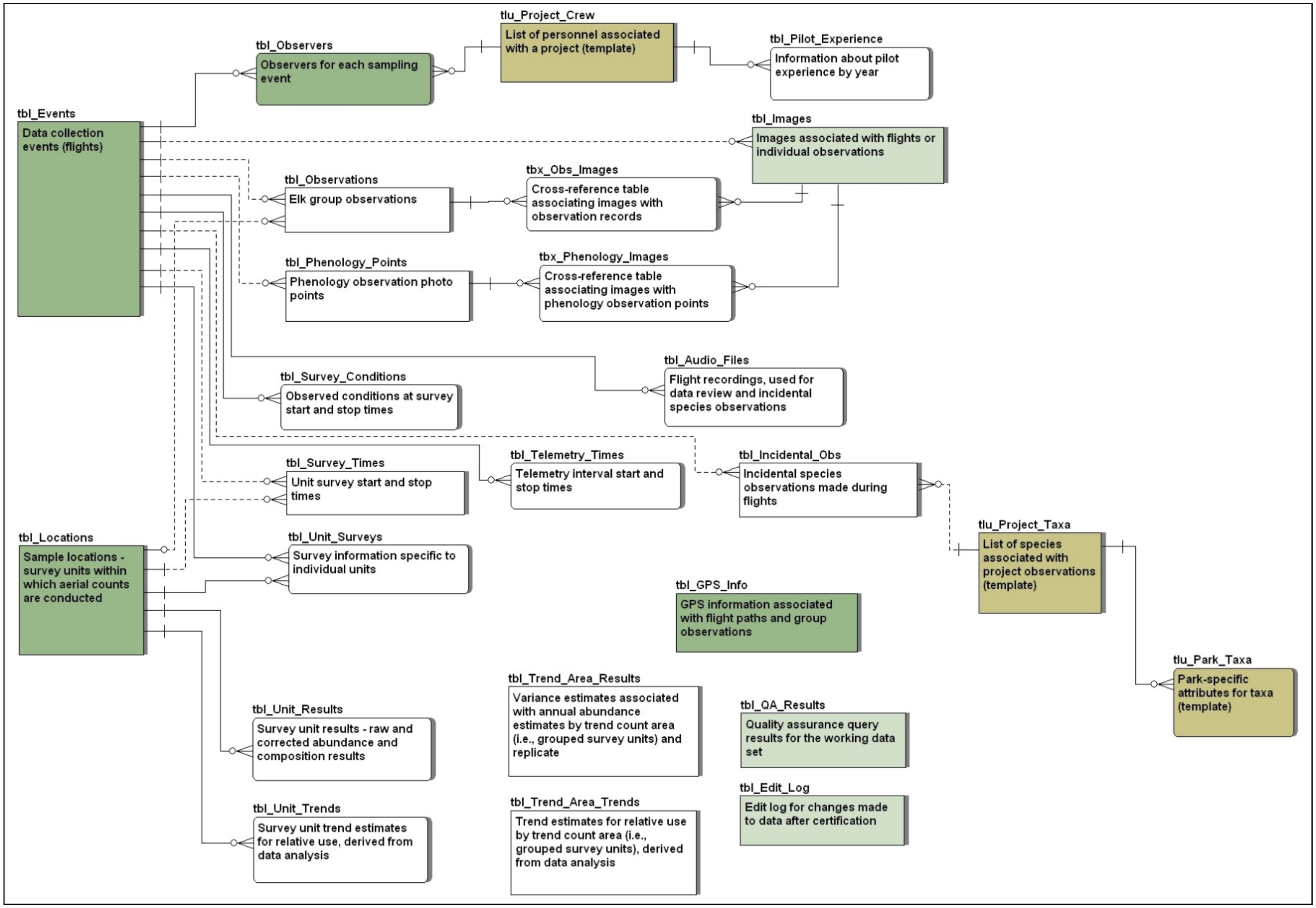


Figure B.1. Entity relationship diagram for the project database. Relationships between tables are represented by lines. Dark green tables represent core standard tables; light green represents extended standard tables; light brown are standard lookup tables. Project-specific tables are unshaded.

Data Dictionary

Required fields are denoted with an asterisk (*).

tbl_Audio_Files - Flight recordings, used for data review and incidental species observations

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Audio_file	unique *	text (100)	Name of the audio file including extension, but without the path
Transcribed_by		text (50)	Person who listened to and transcribed data from the audio file
Start_time		datetime	Start time for the audio recording
End_time		datetime	End time for the audio recording
Total_length		datetime	Total length of the audio recording file
Audio_comments		text (50)	Comments about the audio file or its contents

tbl_Edit_Log - Edit log for changes made to data after certification

Index	*Index columns*
Edit_date	Edit_date
Edit_type	Edit_type
pk_tbl_Edit_Log (primary)	Data_edit_ID
Project_code	Project_code
Table_affected	Table_affected
User_name	User_name

Field name	*Index/key*	*Data type*	*Description*
Data_edit_ID	primary *	text (50)	Unique identifier for each data edit record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Project_code	indexed *	text (10)	Project code, for linking information with other data sets and applications
	Default: "MAa12"		
Edit_date	indexed *	datetime	Date on which the edits took place
	Default: Now()		
Edit_type	indexed *	text (12)	Type of edits made: deletion, update, append, reformat, tbl design
Edit_reason	*	text (100)	Brief description of the reason for edits
User_name	indexed *	text (50)	Name of the person making data edits
Table_affected	indexed	text (50)	Table affected by edits
Fields_affected		text (200)	Description of the fields affected
Records_affected		text (200)	Description of the records affected
Data_edit_notes		memo	Comments about the data edits

tbl_Events - Data collection events (flights)
Constraints: : [End_time] Is Null Or [Start_time] Is Null Or [End_time]>=[Start_time]

Index	*Index columns*
Arrival_loc	Arrival_loc
Certified_date	Certified_date
Departure_loc	Departure_loc
Entered_date	Entered_date
Flight_num	Flight_num
Park_code	Park_code
pk_tbl_Events (primary)	Event_ID
Survey_date	Survey_date
udx_tbl_Events (unique)	Park_code, Survey_date, Flight_num
Updated_date	Updated_date
Verified_date	Verified_date

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary *	text (50)	Unique identifier for each sampling event
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Park_code	unique *	text (4)	Park in which the flight occurred
Survey_date	unique *	datetime	Date of the survey flight
Flight_num	unique *	tinyint	Sequential flight number
Project_code	*	text (10)	Project code, for linking information with other data sets and applications
	Default: "MAa12"		
Start_time		datetime	Start time of the sampling event
End_time		datetime	End time of the sampling event (optional)
Departure_loc	indexed	text (50)	Departure location
Arrival_loc	indexed	text (50)	Arrival location
Overall_conditions		text (10)	Overall count conditions observed during the flight
Aircraft_model		text (50)	Make and model of aircraft used
Aircraft_ID		text (25)	Aircraft tail number or similar identifier
Company		text (50)	Aviation company that owns the aircraft used
Helicopter_mgr		text (50)	Helicopter manager for the flight
GPS_file_name		text (50)	GPS rover file used for data downloads
GPS_model		text (25)	Make and model of GPS unit used to collect field coordinates
Units_surveyed		text (200)	List of units surveyed during the flight
Survey_completed		bit	Indicates whether or not the intended unit surveys were completed as planned
Flight_comments		memo	Comments about the flight as recorded on the field form
Survey_comments		memo	Survey comments made during the course of unit surveys

Event_notes		memo	Comments about the sampling event
Entered_by		text (50)	Person who entered the data for this event
Entered_date	indexed	datetime	Date on which data entry occurred
	Default: Now()		
Updated_by		text (50)	Person who made the most recent updates
Updated_date	indexed	datetime	Date of the most recent edits
Verified_by		text (50)	Person who verified accurate data transcription
Verified_date	indexed	datetime	Date on which data were verified
Certified_by		text (50)	Person who certified data for accuracy and completeness
Certified_date	indexed	datetime	Date on which data were certified
Is_excluded		bit	Flag to exclude the sampling event from data summary output
	Default: False		
QA_notes		memo	Quality assurance comments for the selected sampling event
Other_comments		memo	Comments recorded regarding other species observations made during unit surveys

tbl_GPS_Info - GPS information associated with flight paths and group observations

Index	*Index columns*
Corr_type	Corr_type
Datum	GPS_datum
Feat_name	Feat_name
Feat_type	Feat_type
GPS_date	GPS_date
GPS_file	GPS_file
Event_ID	Event_ID
pk_tbl_GPS_Info (primary)	GPS_ID
Obs_ID	Obs_ID

Field name	*Index/key*	*Data type*	*Description*
GPS_ID	primary *	text (50)	Unique identifier for the GPS record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	indexed	text (50)	Sample event, used for temporary links
Feat_name	indexed	text (50)	Feature name in data dictionary
Flag *	bit	Internal flag	used to identify records while matching with tbl_Coordinates during post-season processing
	Default: False		
GPS_file	indexed	text (50)	GPS file name
GPS_date	indexed	datetime	Date GPS file was collected
GPS_time		datetime	Time GPS file was collected
Corr_type	indexed	text (50)	GPS file correction type
GPS_UTME		double	UTM easting in GPS unit
GPS_UTMN		double	UTM northing in GPS unit

UTM_zone		text (5)	UTM projection system zone
	Default: "10N"		
GPS_datum	indexed	text (5)	Datum of GPS coordinates
Feat_type	indexed	text (20)	Feature type (point, line, or polygon) collected with GPS
Data_dict_name		text (50)	Data dictionary name used to collect feature
Elev_m		double	Elevation (meters) in GPS unit
Num_sat		smallint	Number of satellites tracked by GPS unit during data collection
GPS_duration		text (25)	Length of time GPS file was open
Filt_pos		smallint	Number of GPS positions exported from GPS file
PDOP		double	Position dilution of precision scale
HDOP		double	Horizontal dilution of precision scale
H_err_m		double	Horizontal error (meters)
V_err_m		double	Vertical error (meters)
Std_dev_m		double	Standard deviation (meters)
GPS_process_notes		text (255)	GPS file processing notes
Is_better	*	bit	Indicates that the field crew thought this coordinate record to be an improvement over the current Is_best coordinate
	Default: False		
Obs_ID	indexed *	int	Observation ID

tbl_Images - Images associated with flights or individual observations

Index	*Index columns*
Event_ID	Event_ID
Image_label	Image_label
Image_quality	Image_quality
Image_type	Image_type
pk_tbl_Images (primary)	Image_ID
Sort_order	Sort_order

Field name	*Index/key*	*Data type*	*Description*
Image_ID	primary *	text (50)	Unique identifier for each image record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	indexed (FK)*	text (50)	Sampling event
Image_type	indexed	text (20)	Type of image
	Default: "Ground photo"		
Image_label	indexed	text (25)	Image caption or label
Image_desc		text (255)	Brief description of the image bearing, perspective, etc.
Frame_number		text (10)	Frame number for photographic images
Image_date		datetime	Date on which the image was created, if different from the sampling event date

Image_source		text (50)	Name of the person or organization that created the image
Image_quality	indexed	tinyint	Quality of the image
Is_edited_version		bit	Indicates whether this version of the image is the edited (originals = False)
Object_format		text (20)	Format of the image
Orig_format		text (20)	Format of the original image
Image_edit_notes		text (200)	Comments about the editing or processing performed on the image
Image_is_active		bit	Indicates whether the image is still being used for navigation or interpretation
	Default: True		
Image_root_path		text (100)	Drive space location of the main project folder or image library
Image_project_path		text (100)	Location of the image from the main project folder or image library
	Default: "Images\"		
Image_filename		text (100)	Name of the image including extension (.jpg) but without the image path
Image_notes		memo	Comments about the image
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Incidental_Obs - Incidental species observations made during flights

Index	*Index columns*
Datum	Datum
Event_ID	Event_ID
Obs_num	Obs_num
Obs_time	Obs_time
pk_tbl_Incidental_Obs (primary)	Incidental_ID
Sort_order	Sort_order
Taxon_ID	Taxon_ID
udx_tbl_Incidental_Obs (unique)	Event_ID, Obs_num

Field name	*Index/key*	*Data type*	*Description*
Incidental_ID	primary *	text (50)	Unique identifier for each incidental species observation
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	unique (FK)*	text (50)	Sampling event
Obs_num	unique *	tinyint	Sequential observation number for each species observation made during the flight
Taxon_ID	indexed *	text (50)	Species observed
N_observed	*	smallint	Total number of individuals observed
	Constraint: >=0 And <=1000		

Running_time		datetime	Audio file running time corresponding to the observation
Obs_time	indexed	datetime	Time at which the observation was made; used to derive coordinates from GPS flight data
UTM_east		int	UTM easting (zone 10N, meters), derived from GPS flight data
UTM_north		int	UTM northing (zone 10N, meters), derived from GPS flight data
Datum		indexed	text (5) Datum of UTM_east and UTM_north
	Default: "NAD83"		
Coord_source		text (12)	Source of coordinate data
Obs_flight_notes		text (255)	Comments about the observation recorded during the flight
Obs_comments		text (255)	Other comments about this observation record
Activity		text (2)	Activity of the individual or majority of the group upon initial sighting
Cover_type		text (5)	Cover type observed in association with the species observation
Veg_cover		text (5)	Estimate of concealing vegetation observed around the individual or group
Photos_taken	*	bit	Indicates whether photos were taken
	Default: False		
Elevation_m		single	Ground elevation of the observation in meters, as determined with GIS
	Constraint: Is Null Or (>=0 And <=5000)		
Sort_order	indexed *	int	Used to show records in the order in which they were entered

tbl_Locations - Sample locations - survey units within which aerial counts are conducted

Index	*Index columns*
Loc_updated	Loc_updated
Location_code	Location_code
Location_status	Location_status
Location_type	Location_type
Park_code	Park_code
pk_tbl_Locations (primary)	Location_ID
Public_offset	Public_offset
Trend_count_area	Trend_count_area
udx_tbl_Locations	Location_code

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary *	text (50)	Unique identifier for each sample location
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Park_code	indexed *	text (4)	Park code

Location_code	indexed *	text (10)	Alphanumeric code for the sample location
Trend_count_area	indexed *	text (50)	Larger trend count area used to group survey units for summary and analysis
Location_type	indexed *	text (20)	Indicates the type of sample location
Location_status	indexed *	text (10)	Status of the sample location
	Default: "Active"		
Location_name		text (50)	Brief colloquial name of the sample location (optional)
UTME_public		double	UTM easting (zone 10N, meters) of the unit polygon centroid
UTMN_public		double	UTM northing (zone 10N, meters) of the unit polygon centroid
Public_offset	indexed	text (50)	Type of processing performed to make coordinates publishable
Unit_area_km2		single	Unit area in square kilometers, derived from GIS
Location_desc		memo	Environmental description of the sampling location
Location_notes		memo	Other notes about the sample location
Loc_established		datetime	Date the sample location was established
Loc_discontinued		datetime	Date the sample location was discontinued
Loc_created_date		datetime	Time stamp for record creation
	Default: Now()		
Loc_updated	indexed	datetime	Date of the last update to this record
Loc_updated_by		text (50)	Person who made the most recent edits

tbl_Observations - Elk group observations

Index	*Index columns*
Datum	Datum
Event_ID	Event_ID
Location_ID	Location_ID
Obs_num	Obs_num
Obs_time	Obs_time
pk_tbl_Observations (primary)	Obs_ID
udx_tbl_Observations (unique)	Event_ID, Obs_num
In_unit	In_unit
Index_num	Index_num

Field name	*Index/key*	*Data type*	*Description*
Obs_ID	primary *	int	Unique identifier for each elk group observation
Event_ID	unique (FK)*	text (50)	Sampling event
Obs_num	unique *	tinyint	Sequential observation number for each elk group number observed during the flight
Obs_time	indexed	datetime	Time at which the observation was made, used to derive coordinates from GPS flight data
UTM_east		int	UTM easting (zone 10N, meters), derived from GPS flight data

UTM_north		int	UTM northing (zone 10N, meters), derived from GPS flight data
Datum		indexed	text (5) Datum of UTM_east and UTM_north
	Default: "NAD83"		
Coord_source		text (12)	Source of coordinate data
Obs_flight_notes		text (255)	Comments about the observation recorded during the flight
Obs_comments		text (255)	Other comments about this observation record
Activity		text (2)	Activity of the majority of the group upon initial sighting
Cover_type		text (5)	Cover type observed for the group
Veg_initial		text (5)	Estimate of concealing vegetation observed around the elk that were first observed
Veg_final		text (5)	Final estimate that best describes the amount of concealing vegetation for the group as a whole
Light_level		text (1)	Observed light conditions
Snow_present		text (1)	Indicates whether snow was present
Complete_count	*	bit	Indicates whether the crew was confident that a complete count was accomplished
	Default: True		
Total_elk	*	smallint	Total number of elk individuals observed in the group
	Constraint: >=0 And <=1000		
Cows		tinyint	Number of cows observed in the group
	Constraint: Is Null Or (>0 And <=250)		
Calves			tinyint Number of calves observed in the group
	Constraint: Is Null Or (>0 And <=250)		
Yearling_bulls		tinyint	Number of yearling bulls observed in the group
	Constraint: Is Null Or (>0 And <=250)		
Subadult_bulls		tinyint	Number of subadult bulls observed in the group
	Constraint: Is Null Or (>0 And <=250)		
Mature_bulls		tinyint	Number of mature bulls observed in the group
	Constraint: Is Null Or (>0 And <=250)		
Other_bulls		tinyint	Number of other bulls observed, especially during OLYM spring surveys
	Constraint: Is Null Or (>0 And <=250)		
Unclassified		tinyint	Number of elk counted in the group but not clearly classified
	Constraint: Is Null Or (>0 And <=250)		
Left_front		bit	Indicates whether the left front observer saw the group
Right_front		bit	Indicates whether the right front observer saw the group

Left_back		bit	Indicates whether the left rear observer saw the group
Right_back		bit	Indicates whether the right rear observer saw the group
Side_of_ship		text (1)	Side of the aircraft from which the elk group was observed
Back_front_ind	*	bit	Indicates whether back- and front-seat observers had an independent chance to detect the group
	Default: True		
Front_front_ind	*	bit	Indicates whether both front-seat observers had an independent chance to detect the group
	Default: True		
Photos_taken	*	bit	Indicates whether photos of the group were taken
	Default: False		
Missed	*	bit	Indicates whether the group was missed during surveys but was later found because one or more of the elk had a radio collar
	Default: False		
Missed_code		text (10)	In-flight determination about whether the missed group was in fact seen
Elk_code		text (25)	Elk collar code, name or similar identifier; blank if no radio collar was detected
Field_call		text (10)	For missed groups, in-flight determination of whether the group was in or out of the unit
GPS_call	indexed	text (1)	Whether the observation position was inside the survey unit, as determined with GIS
Final_call		text (10)	Final determination of whether the group was in or out of the unit, using GIS position and flight information
Duplicate	*	bit	Indicates whether the observation represented a duplicate count already represented; duplicates are not included in summaries
Location_ID	indexed (FK)	text (50)	Nearest sampling unit for the group, as determined with GIS
Unit_dist_m		single	Distance from the observation position to the nearest unit boundary, as determined with GIS
	Constraint: Is Null Or (>=0 And <=25000)		
Elevation_m		single	Ground elevation of the observation position in meters, as determined with GIS
	Constraint: Is Null Or (>=0 And <=5000)		
Theta_hat		double	Group detection correction factor
Index_num	indexed	smallint	Sightability model record identifier
	Constraint: Is Null Or (>=0)		

tbl_Observers - Observers for each sampling event

Index	*Index columns*
Contact_ID	Contact_ID
Event_ID	Event_ID
Observer_role	Observer_role
pk_tbl_Observers (primary)	Event_ID, Contact_ID, Observer_role
Position_code	Position_code

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event identifier
Contact_ID	primary (FK)*	text (50)	Observer identifier
Observer_role	primary *	text (25)	Role of the observer during data collection (optional)
Position_code	indexed	text (10)	Observer position in the aircraft
Observer_notes		text (200)	Comments about the observer specific to this sampling event

tbl_Phenology_Points - Phenology observation photo points

Index	*Index columns*
Datum	Datum
Event_ID	Event_ID
pk_tbl_Phenology_Points (primary)	Phenology_ID
Phenology_loc	Phenology_loc

Field name	*Index/key*	*Data type*	*Description*
Phenology_ID	primary *	text (50)	Unique identifier for each phenology observation point
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	indexed (FK)*	text (50)	Sampling event
GPS_time		datetime	Time at which the phenology observation photo(s) were taken, used to derive coordinates from GPS flight data
Photo_numbers		text (50)	List of photo numbers taken at the observation point
Phenology_notes		text (200)	Comments about observed phenology or the photos taken
UTM_east		int	UTM easting (zone 10N, meters), derived from GPS flight data
UTM_north		int	UTM northing (zone 10N, meters), derived from GPS flight data
Datum	indexed	text (5)	Datum of UTM_east and UTM_north
	Default: "NAD83"		
Coord_source		text (12)	Source of coordinate data
Coordinate_notes		text (50)	Notes about this set of coordinates

Phenology_loc	indexed	text (50)	Phenology photo point location (optional)

tbl_Pilot_Experience - Information about pilot experience by year

Index	*Index columns*
Contact_ID	Contact_ID
pk_tbl_Pilot_Experience (primary)	Contact_ID, Survey_year
Survey_year	Survey_year

Field name	*Index/key*	*Data type*	*Description*
Contact_ID	primary (FK)*	text (50)	Pilot identifier
Survey_year	primary *	smallint	Survey year
	Constraint: >=1900 And <=2100		
Experienced		bit	Did the pilot have at least 10 flights of large mammal survey experience prior to flying on these surveys?
Pilot_notes		memo	Comments about the pilot performance or experience level for the year specified

tbl_QA_Results - Quality assurance query results for the working data set

Index	*Index columns*
Data_scope	Data_scope
pk_tbl_QA_Results (primary)	Query_name, Time_frame, Data_scope
Query_name	Query_name
Query_result	Query_result
Query_type	Query_type
Time_frame	Time_frame

Field name	*Index/key*	*Data type*	*Description*
Query_name	primary *	text (100)	Name of the quality assurance query
Data_scope	primary *	tinyint	Scope of the data included in queries: 0=Uncertified events only, 1=Both certified and uncertified, 2=Certified events only
Time_frame	primary *	text (30)	Field season year or range of dates for the data being passed through quality assurance checks
Query_type	indexed	text (20)	Severity of data errors being trapped: 1=Critical, 2=Warning, 3=Information
Query_result	indexed	text (50)	Query result as the number of records returned the last time the query was run
Query_run_time		datetime	Run time of the query results
Query_description		memo	Description of the query
Query_expression		memo	Evaluation expression built into the query
Remedy_desc		memo	Details about actions taken and/or not taken to resolve errors
Remedy_date		datetime	When the remedy description was last edited
QA_user		text (50)	Name of the person doing quality assurance

Is_done	*	bit	Temporary flag to indicate that the user is done reviewing this query even if some records remain

tbl_Survey_Conditions - Observed conditions at survey start and stop times

Index	*Index columns*
Cond_rec_time	Cond_rec_time
Event_ID	Event_ID
pk_tbl_Survey_Conditions (primary)	Event_ID, Cond_rec_time

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Cond_rec_time	primary *	text (5)	Indicates the part of the flight during which the conditions were recorded
Recorded_time		datetime	Time at which the conditions were recorded; coincides with times for entering first survey unit of the flight, or leaving the last unit of the flight
Cloud_cover		tinyint	Percentage of overhead cloud cover observed
	Constraint: Is Null Or (>=0 And <=100)		
Mist		tinyint	Percentage of the ground that is obscured by mist or fog
	Constraint: Is Null Or (>=0 And <=100)		
Wind_code		text (12)	Observed wind conditions
Precip_code		text (12)	Observed precipitation conditions
Temp_obs		smallint	Outside air temperature
	Constraint: Is Null Or (>-50 And <120)		
Temp_units		text (1)	Units for observed air temperature
	Constraint: Is Null Or "C" Or "F"		
Elevation_ft		smallint	Elevation at which the temperature observation was made, in feet
	Constraint: Is Null Or (>=0 And <=10000)		
Light_level		text (1)	Observed light conditions
Conditions_notes		text (100)	Comments about observed conditions

tbl_Survey_Times - Unit survey start and stop times

Constraints: : [End_time] Is Null Or [Start_time] Is Null Or [End_time]>=[Start_time]

Index	*Index columns*
Event_ID	Event_ID
Location_ID	Location_ID
pk_tbl_Survey_Times (primary)	Record_ID

Field name	*Index/key*	*Data type*	*Description*
Record_ID	primary *	int	Unique record identifier, also indicates the data entry sort order
Event_ID	indexed (FK)*	text (50)	Sampling event
Location_ID	indexed (FK)*	text (50)	Unit surveyed

Start_time	datetime	Start time reported for the unit survey
End_time	datetime	End time reported for the unit survey
Unit_notes	text (50)	Comments about the unit visit

tbl_Telemetry_Times - Telemetry interval start and stop times

Constraints: : [End_time] Is Null Or [Start_time] Is Null Or [End_time]>=[Start_time]

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Telemetry_Times (primary)	Event_ID, Rec_num
Rec_num	Rec_num

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Rec_num	primary *	tinyint	Sequential telemetry interval record number for each flight
Start_time	*	datetime	Start time of the telemetry interval
End_time		datetime	End time of the telemetry interval
Telemetry_notes		text (255)	Comments about the telemetry interval

tbl_Trend_Area_Results - Variance estimates associated with annual abundance estimates by trend count area (i.e., grouped survey units) and replicate

Index	*Index columns*
Location_ID	Trend_area
pk_tbl_Trend_Area_Results (primary)	Survey_year, Trend_area, Replicate_num
Replicate_num	Replicate_num
Survey_year	Survey_year

Field name	*Index/key*	*Data type*	*Description*
Survey_year	primary *	smallint	Survey year
	Constraint: >=1900 And <=2100		
Trend_area	primary *	text (50)	Trend count area
Replicate_num	primary *	tinyint	Survey replicate number
Calculation_date	*	datetime	Date the results were calculated
Var_total_elk		double	Variance in the total estimated number of elk in the trend count area
Var_bull_cow		double	Variance in the ratio of adjusted number of bulls to adjusted number of cows in the trend count area
Var_calf_cow		double	Variance in the ratio of adjusted number of calves to adjusted number of cows in the trend count area
Trend_area_notes		memo	Comments about results for this trend count area and replicate
Updated_by		text (50)	Person who last edited the record
Updated_date		datetime	Date on which the record was last edited

tbl_Trend_Area_Trends - Trend estimates for relative use by trend count area (i.e., grouped survey units), derived from data analysis

Index	*Index columns*
End_year	End_year
Location_ID	Trend_area
pk_tbl_Trend_Area_Trends (primary)	Start_year, End_year, Trend_area, Trend_type
Start_year	Start_year
Trend_type	Trend_type

Field name	*Index/key*	*Data type*	*Description*
Start_year	primary *	smallint	Start year of the data set from which trends were estimated
	Constraint: >=1900 And <=2100		
End_year	primary *	smallint	End year of the data set from which trends were estimated
	Constraint: >=1900 And <=2100		
Trend_area	primary *	text (50)	Trend count area
Trend_type	primary *	text (25)	Type of trend calculated
Calculation_date	*	datetime	Date the trend was estimated
Slope		double	Estimated slope, change in relative use per year for the trend count area
Intercept		double	Estimated y-axis intercept
Slope_std_error		double	Standard error of the estimated slope
Trend_area_notes		memo	Comments about period trend values for this trend count area
Calculated_by		text (50)	Analyst who performed the trend analysis

tbl_Unit_Results - Survey unit results - raw and corrected abundance and composition results

Index	*Index columns*
Location_ID	Location_ID
pk_tbl_Unit_Results (primary)	Survey_year, Location_ID, Replicate_num
Replicate_num	Replicate_num
Survey_year	Survey_year

Field name	*Index/key*	*Data type*	*Description*
Survey_year	primary *	smallint	Survey year
	Constraint: >=1900 And <=2100		
Location_ID	primary (FK)*	text (50)	Sampling unit
Replicate_num	primary *	tinyint	Survey replicate number
Calculation_date	*	datetime	Date the results were calculated
Groups_raw		smallint	Raw number of elk groups observed
Elk_raw		smallint	Raw number of elk individuals observed
Elk_est		single	Adjusted number of elk individuals, corrected for detection bias
Bulls_raw		smallint	Raw number of bull elk individuals observed

Bulls_est	single	Adjusted number of bull elk individuals, corrected for detection bias
Cows_raw	smallint	Raw number of elk cows observed
Cows_est	single	Adjusted number of elk cows, corrected for detection bias
Calves_raw	smallint	Raw number of elk calves observed
Calves_est	single	Adjusted number of elk calves, corrected for detection bias
Unit_results_notes	memo	Comments about results for this unit and replicate
Updated_by	text (50)	Person who last edited the record
Updated_date	datetime	Date on which the record was last edited

tbl_Unit_Surveys - Survey information specific to individual units

Index	*Index columns*
Event_ID	Event_ID
Location_ID	Location_ID
pk_tbl_Unit_Surveys (primary)	Event_ID, Location_ID, Rep_num

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Location_ID	primary (FK)*	text (50)	Unit surveyed
Rep_num	primary *	tinyint	Replicate number for the season
	Default: 1		
Survey_completed		bit	Indicates whether or not the intended unit surveys were completed as planned
	Default: True		
Is_excluded		bit	Flag to exclude the unit from data summary output
	Default: False		
Unit_survey_notes		text (255)	Comments about the unit survey

tbl_Unit_Trends - Survey unit trend estimates for relative use, derived from data analysis

Index	*Index columns*
End_year	End_year
Location_ID	Location_ID
pk_tbl_Unit_Trends (primary)	Start_year, End_year, Location_ID
Start_year	Start_year

Field name	*Index/key*	*Data type*	*Description*
Start_year	primary *	smallint	Start year of the data set from which trends were estimated
	Constraint: >=1900 And <=2100		
End_year	primary *	smallint	End year of the data set from which trends were estimated
	Constraint: >=1900 And <=2100		
Location_ID	primary (FK)*	text (50)	Sampling unit

Calculation_date	*	datetime	Date the trend was estimated
Slope		double	Estimated slope, change in relative use per year for the survey unit
Intercept		double	Estimated y-axis intercept for the survey unit
Slope_std_error		double	Standard error of the estimated slope
Unit_trend_notes		memo	Comments about period trend values for this unit
Calculated_by		text (50)	Analyst who performed the trend analysis

tbx_Obs_Images - Cross-reference table associating images with observation records

Index	*Index columns*
Image_ID	Image_ID
Obs_ID	Obs_ID
pk_tbx_Obs_Images (primary)	Obs_ID, Image_ID

Field name	*Index/key*	*Data type*	*Description*
Obs_ID	primary (FK)*	int	Observation ID
Image_ID	primary (FK)*	text (50)	Image record ID

tbx_Phenology_Images - Cross-reference table associating images with phenology observation points

Index	*Index columns*
Image_ID	Image_ID
Phenology_ID	Phenology_ID
pk_tbx_Phenology_Images (primary)	Phenology_ID, Image_ID

Field name	*Index/key*	*Data type*	*Description*
Phenology_ID	primary (FK)*	text (50)	Phenology photopoint ID
Image_ID	primary (FK)*	text (50)	Image record ID

tlu_Activity_Code - List of animal activity codes

Field name	*Index/key*	*Data type*	*Description*
Activity_code	primary *	text (2)	
Activity_desc		text (100)	
Sort_order		tinyint	

tlu_Aircraft_Model - List of aircraft models

Field name	*Index/key*	*Data type*	*Description*
Aircraft_model	primary *	text (50)	
Model_notes		memo	
Is_active		bit	
	Default: True		

tlu_Aircraft_Provider - List of aircraft provider companies

Field name	*Index/key*	*Data type*	*Description*
Company	primary *	text (50)	
Location		text (200)	

Company_notes		memo	
Is_active		bit	
	Default: True		

tlu_Condition_Code - List of flight condition codes

Field name	*Index/key*	*Data type*	*Description*
Condition_code	primary *	text (10)	
Condition_desc		text (100)	
Sort_order		tinyint	

tlu_Coord_Source - List of coordinate data sources

Field name	*Index/key*	*Data type*	*Description*
Coord_source	primary *	text (12)	
Coord_source_desc			text (100)
Sort_order		tinyint	

tlu_Cover_Type - List of cover type codes

Field name	*Index/key*	*Data type*	*Description*
Cover_type	primary *	text (5)	
Cover_desc		text (100)	
Spring_surveys		bit	Flag to indicate whether the cover type category use is limited to spring surveys
Sort_order		tinyint	

tlu_Datum - List of coordinate datum codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Datum		primary *	text (5)
Datum_desc		text (50)	
Sort_order		tinyint	

tlu_Edit_Type - List of the types of post-certification edits made to data (standard)

Field name	*Index/key*	*Data type*	*Description*
Edit_type	primary *	text (12)	
Edit_type_desc		text (100)	
Sort_order		tinyint	

tlu_GPS_Model - List of GPS devices used to collect coordinate data (template)

Field name	*Index/key*	*Data type*	*Description*
GPS_model	primary *	text (25)	
Sort_order		tinyint	

tlu_Image_Format - List of image, map, and photographic formats (template)

Field name	*Index/key*	*Data type*	*Description*
Image_format	primary *	text (12)	
Image_format_desc			text (100)
Sort_order		tinyint	

tlu_Image_Quality - List of quality ranks for images (template)

Field name	*Index/key*	*Data type*	*Description*
Quality_code	primary *	tinyint	
Image_quality	*	text (20)	
Image_quality_desc			text (100)

tlu_Image_Type - List of image types (template)

Field name	*Index/key*	*Data type*	*Description*
Image_type	primary *	text (12)	
Image_type_desc		text (100)	
Sort_order		tinyint	

tlu_Light_Level - List of observed light level codes

Index	*Index columns*
Light_level (unique)	Light_level
pk_tlu_Light_Level (primary)	Light_code

Field name	*Index/key*	*Data type*	*Description*
Light_code	primary *	text (1)	
Light_level	unique *	text (20)	
Light_desc		text (50)	
Sort_order		tinyint	

tlu_Location_Type - List of location type codes (template)

Field name	*Index/key*	*Data type*	*Description*
Location_type	primary *	text (20)	
Loc_type_desc		text (200)	
Sort_order		tinyint	

tlu_Missed_Code - List of codes for in-flight determinations about missed groups

Field name	*Index/key*	*Data type*	*Description*
Missed_code	primary *	text (10)	
Missed_desc		text (100)	
Sort_order		tinyint	

tlu_Observer_Role - List of observer role assignments (template)

Field name	*Index/key*	*Data type*	*Description*
Observer_role	primary *	text (25)	
Role_desc		text (100)	
Sort_order		tinyint	

tlu_Origin_Code - List of origin codes for park taxa (standard)

Field name	*Index/key*	*Data type*	*Description*
Origin_code	primary *	text (16)	
Origin_desc		text (100)	
NPSpp_ID		smallint	

Sort_order		tinyint	

tlu_Parks - List of NCCN parks and park codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Park_code	primary *	text (4)	
Park_name		text (50)	

tlu_Park_Taxa - Park-specific attributes for taxa (template)

Index	*Index columns*
Park_origin	Park_origin
Park_status	Park_status
pk_tlu_Park_Taxa (primary)	Taxon_ID, Park_code
Record_status	Record_status

Field name	*Index/key*	*Data type*	*Description*
Taxon_ID	primary (FK)*	text (50)	Taxon identifier
Park_code	primary *	text (4)	Park code
Park_status	indexed	text (16)	Status of the taxon in this park (from NPSpecies)
	Default: "Unknown"		
Park_origin	indexed	text (16)	Origin of the taxon in this park (from NPSpecies)
	Default: "Unspecified"		
Local_list		bit	Indicates that the taxon is the preferred one for use at the park (from NPSpecies)
Local_accepted_TSN		int	Taxonomic serial number of the local preferred taxon (from NPSpecies)
Preferred_sci_name		text (255)	Preferred scientific name of the taxon at the park (from NPSpecies)
Park_taxon_notes		memo	Comments about the taxon specific to this park
Record_status	indexed	text (16)	Indicates the status of the record in terms of synchrony with master databases
	Default: "New record"		
Created_date		datetime	Time stamp for record creation
	Default: Now()		
Updated_date		datetime	Date of the last update to this record
Updated_by		text (50)	Person who made the most recent edits

tlu_Park_Taxon_Status - List of codes for park species occurrence (standard)

Field name	*Index/key*	*Data type*	*Description*
Taxon_status_code	primary *	text (16)	
Taxon_status_desc		text (250)	
NPSpp_ID		smallint	
Sort_order		tinyint	

tlu_Position_Code - List of codes denoting the positions of observers in the aircraft

Field name	*Index/key*	*Data type*	*Description*
Position_code	primary *	text (5)	
Position_desc		text (100)	
Sort_order		tinyint	

tlu_Precip_Code - List of observed precipitation condition codes

Field name	*Index/key*	*Data type*	*Description*
Precip_code	primary *	text (12)	
Precip_desc		text (50)	
Sort_order		tinyint	

tlu_Project_Crew - List of personnel associated with a project (template)

Index	*Index columns*
Contact_location	Contact_location
Contact_updated	Contact_updated
First_name	First_name
Last_name	Last_name
Organization	Organization
pk_tlu_Project_Crew (primary)	Contact_ID
Project_code	Project_code

Field name	*Index/key*	*Data type*	*Description*
Contact_ID	primary *	text (50)	Unique identifier for the individual (Lastname_Firstname_MI)
Project_code	indexed *	text (10)	Project code, for linking information with other data sets and applications
Last_name	indexed *	text (24)	Last name
First_name	indexed	text (20)	First name
Middle_init		text (4)	Middle initials
Organization	indexed	text (50)	Employer (e.g., NPS-MORA)
Position_title		text (50)	Position title held by the individual
Email			text (50) Email address
Work_voice		text (25)	Work phone number
Work_ext		text (5)	Work extension number
Mobile_voice		text (25)	Mobile phone number
Home_voice		text (25)	Home phone number
Fax		text (25)	Fax number
Contact_location	indexed	text (255)	Where the individual is located
Contact_notes		memo	Notes about the contact
Contact_created		datetime	Time stamp for record creation
	Default: Now()		
Contact_updated	indexed	datetime	Date of the last update to this record
Contact_updated_by			text (50) Person who made the most recent edits

Contact_is_active		bit	Indicates that the contact record is currently available for data entry pick lists
	Default: True		

tlu_Project_Taxa - List of species associated with project observations (template)
Constraints: : ([Taxon_is_active] And [Refers_to] Is Null) Or ([Taxon_is_active]=False And [Refers_to] Is Not Null)

Index	*Index columns*
Accepted_TSN	Accepted_TSN
Category	Category
pk_tlu_Project_Taxa (primary)	Taxon_ID
Project_code	Project_code
Record_status	Record_status
Scientific_name (unique)	Scientific_name
Species_code (unique)	Species_code
Subcategory	Subcategory
Taxon_type	Taxon_type
TSN	TSN

Field name	*Index/key*	*Data type*	*Description*
Taxon_ID	primary *	text (50)	Unique identifier for each taxon
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Project_code	indexed *	text (10)	Project code, for linking information with other data sets and applications
	Default: "MAa12"		
Species_code	unique *	text (20)	Unique field code for each project taxon
Scientific_name	unique *	text (100)	Scientific name of the taxon (from ITIS/NPSpecies)
Common_name		text (100)	Common name for the taxon (from ITIS/NPSpecies)
Pref_com_name		text (100)	Preferred common name for this project
TSN	indexed	int	ITIS taxonomic serial number or a provisional number (from NPSpecies)
Accepted_TSN	indexed	int	ITIS taxonomic serial number of the accepted name for this taxon (from NPSpecies)
Category	indexed *	text (20)	General category of the taxon (from NPSpecies)
	Default: "Unspecified"		
Subcategory	indexed	text (20)	Subcategory specific to the needs of each taxonomic discipline (from NPSpecies)
Authority		text (60)	Taxonomic authority (from ITIS)
Authority_subsp		text (60)	Taxonomic authority for subspecific taxa (from ITIS)
Family		text (60)	Taxonomic family (from ITIS)

Taxon_type	indexed *	text (12)	Indicates the taxonomic resolution and certainty represented by this record
	Default: "Specific"		
Taxon_notes		memo	General notes about the taxon
Created_date		datetime	Time stamp for record creation
	Default: Now()		
Updated_date		datetime	Date of the last update to this record
Updated_by		text (50)	Person who made the most recent edits
Taxon_is_active		bit	Indicates that the record is currently available for data entry pick lists
	Default: True		
Record_status	indexed	text (16)	Indicates the status of the record in terms of synchrony with master databases
	Default: "New record"		
Refers_to		text (50)	Valid taxon the record should refer to for analysis and summaries
Rec_status_notes		text (255)	Notes about the disposition of the record
Project_taxon_notes			memo Project-specific comments about the taxon

tlu_Ship_Side - List of codes denoting sides of the aircraft from which observations were made

Field name	*Index/key*	*Data type*	*Description*
Ship_side_code	primary *	text (1)	
Ship_side_desc		text (100)	
Sort_order		tinyint	

tlu_Site_Status - List of status codes for sampling stations (standard)

Field name	*Index/key*	*Data type*	*Description*
Site_status	primary *	text (10)	
Site_status_desc		text (200)	
Sort_order		tinyint	

tlu_Taxon_Category - List of taxonomic categories (standard)

Field name	*Index/key*	*Data type*	*Description*
Category	primary *	text (20)	
Category_desc		text (100)	
NPSpp_ID		smallint	
Sort_order		tinyint	

tlu_Taxon_Rec_Status - List of status codes for taxon records (standard)

Field name	*Index/key*	*Data type*	*Description*
Record_status_code		primary *	text (16)
Record_status_desc			text (200)
Sort_order		tinyint	

tlu_Taxon_Type - List of taxon resolution codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Taxon_type	primary *	text (12)	
Taxon_type_desc		text (200)	
Sort_order		tinyint	

tlu_Trend_Type - List of trend types

Field name	*Index/key*	*Data type*	*Description*
Trend_type	primary *	text (25)	
Sort_order		tinyint	

tlu_Veg_Cover - List of obscuring vegetation cover codes

Field name	*Index/key*	*Data type*	*Description*
Veg_cover	primary *	text (5)	
Cover_desc		text (100)	
Midpoint		tinyint	Midpoint value for the cover class
Sort_order		tinyint	

tlu_Wind_Code - List of observed wind condition codes

Field name	*Index/key*	*Data type*	*Description*
Wind_code	primary *	text (12)	
Wind_desc		text (50)	
Sort_order		tinyint	

tsys_App_Releases - Application table - Application release history

Index	*Index columns*
pk_tsys_App_Releases (primary)	Release_ID
udx_tsys_App_Releases (unique)	Release_date, Database_title, Version_number

Field name	*Index/key*	*Data type*	*Description*
Release_ID	primary *	text (50)	Unique identifier for the release
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Release_date	unique *	datetime	Date of the release
Database_title	unique *	text (100)	Title of the database
Version_number	unique *	text (20)	Version control number
File_name		text (50)	Filename, used to identify older versions of the database
Release_by		text (50)	Person who issued the release
Release_notes		memo	Release notes, which may include a summary of revisions
Is_supported	*	tinyint	Indicates the support level of this release: 0=user must use a newer version; 1=supported but newer available; 2=full suport, current version
	Default: 2		

tsys_Bug_Reports - Application table - Application bugs and development history

Index	*Index columns*
Fix_date	Fix_date
pk_tsys_Bug_Reports (primary)	Bug_ID
Release_ID	Release_ID
Report_date	Report_date

Field name	*Index/key*	*Data type*	*Description*
Bug_ID	primary *	text (50)	Unique identifier for each bug record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Release_ID	indexed (FK)*	text (50)	Database release version of the report
Report_date	indexed *	datetime	Date the bug was reported
	Default: =Date()		
Found_by		text (50)	Person who found the bug
Reported_by		text (50)	Person who filled out this bug report
Report_details		memo	Nature of the bug report
Fix_date	indexed	datetime	Date the bug was fixed
Fixed_by		text (50)	Person who fixed the bug
Fix_details		memo	Notes on fix

tsys_Logins - Application table - Log of user access to the database through the front-end

Field name	*Index/key*	*Data type*	*Description*
Time_stamp	primary *	datetime	Time stamp of activity record
	Default: Now()		
User_name	primary *	text (50)	Login name of the user
Action_taken		text (50)	Action taken by the user

tsys_User_Roles - Application table - Determines user access privileges through the front-end

Field name	*Index/key*	*Data type*	*Description*
User_name	primary *	text (50)	Network login
User_role	*	text (50)	Database application role, used to determine the access level

Appendix C. Analyses of Detection Bias

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Overview of this Appendix

This appendix describes modeling methods used to estimate detection bias in aerial elk surveys, and the use of those models to adjust raw counts of elk to account for detection biases and obtain a less biased estimate of actual abundance. First, we describe the theoretical underpinning and concrete analytical steps that led to the development of the MORA double-observer sightability model. We demonstrate applications of that model for estimating abundance and composition within trend count areas. Next, we describe how iterative simulations (also known as "bootstraps") are used to evaluate variance estimates for those point estimates of abundance. Finally, we describe the analytical framework that will be used in the future, to assess the applicability of the MORA model to OLYM summer data, and to test for changes in detection probabilities.

The general approach used to convert observed elk counts to estimates of abundance and composition is outlined in Figure C.1. We recorded covariates and patterns of detection by different observers for elk groups with at least one animal with a working radio collar (double-observer sightability trial data), and for elk groups without any radio collared animals (double-observer data), following **SOP 7: Conducting Helicopter Surveys**. Both types of data from MORA surveys from 2008-2010 were combined into a single data set (first blue box in Figure C.1) and used to estimate the double-observer sightability model (second blue box in Figure C.1). That model can be applied to observation data (third blue box) to estimate expected detection probabilities ($\hat{p}^*_j$) for each j group of elk observed during a survey, and related group-specific correction factors (θ_j). Group-specific correction factors are multiplied by group size (n) for each observed group of elk, thus accounting for similar groups of elk not seen during the survey. The adjusted estimates are summed to estimate abundance (upper purple box in Figure C.1) and composition for a given survey. Variance in abundance for a given survey is estimated by simulating multiple observation data sets, determining a double-observer sightability model and associated abundance estimates from each simulated data set, and assessing the range of possible abundance estimates that result (red boxes in Figure C.1).

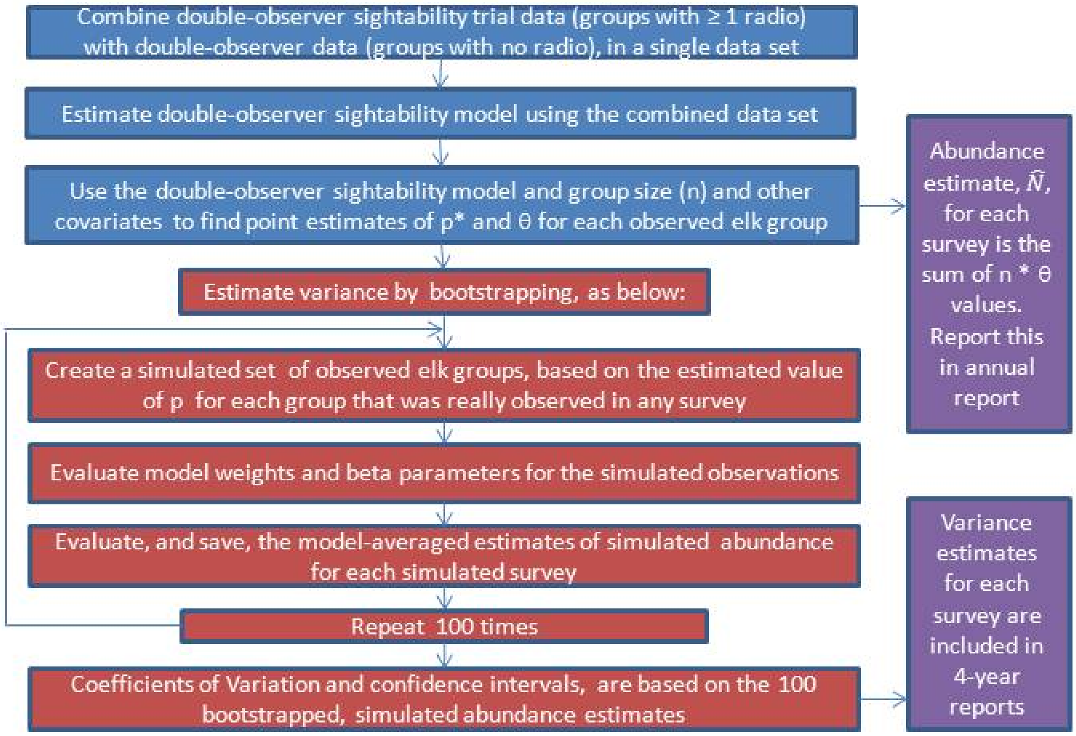


Figure C.1. Conceptual outline of analyses used to estimate abundance and variance for each trend count areas. The model averaged double-observer sightability model is used to estimate detection probability, p^*, and the correction factor, θ, for each observed group. Variance is estimated by simulating a set of elk group observations 100 times, each time fitting detection models to those simulations and estimating the abundance estimates that would arise from such simulated observations.

Theoretical Background

The observed number of elk underestimates the true abundance of elk in a trend count area because of detection bias – the failure to detect elk groups that were present but not seen. The inverse of each group's detection probability ($1 / \hat{p}^*_j$) is an expected correction factor ($\hat{\theta}_j$) that represents the number of elk present in the surveyed area per elk seen in that group. Applying the group-specific correction factor to the group sizes and composition of elk groups observed leads to point estimates of abundance and composition that account for detection bias.

Double observer sightability trial data and double observer data were collected following **SOP 7: Conducting Helicopter Surveys**, and combined into a single data set. Groups of elk, rather than individuals, are the independent units of observation used in the analysis of detection biases. Because observer teams work independently within the helicopter, there are three independent observers or observer teams with the potential to observe any group of elk in the survey area: a radio-telemetry observer, the front seat observers, and the back seat observers. The radio-telemetry observer is an observer aboard the helicopter who uses a radio-telemetry receiver to determine if there is a radio-collared elk present in any group of elk detected during the survey (independent of, and after any sighted elk group is recorded). The radio-telemetry observer also uses a radio-telemetry receiver to scan each survey unit immediately after it has been surveyed to identify groups containing radio-collared elk that were not detected during the survey. Only elk groups containing at least one radio collared elk could be detected by the radio-telemetry observer. The front seat observer is the pilot and front-seat passenger team whose observations are pooled prior to analysis. The back seat observer is the team occupying the right and left back seats in the helicopter, whose observations are also pooled. All elk groups that are present in the surveyed areas are potentially available for detection by the front observer and the back seat observer.

The observations from each survey comprise a data set in which each elk group was observed by one, two, or all three observers. We used the Huggins closed capture estimator for mark-resight data with individual covariates in program MARK (White and Burnham 1999) to fit a set of competing candidate models to the data set. There were three capture occasions – one occasion for each of the possible observers (radio-telemetry, front, and back). Elk groups in the data set were divided into two categories, although they were combined in the single data set:

1. Those available to be detected by all three observers (radio-telemetry, front, and back); i.e., groups containing one or more radio-collared elk. These contribute to double-observer sightability trial data.
2. Those available for detection by only the front and back observers; i.e., groups with no radio-collared elk. These contribute to double-observer data.

Conceptually, there is a third category of elk groups that are in the survey area, but which are not part of the data set. These are elk groups without any radio collared elk, and which were not detected…it is the number of elk in these groups that is estimated through modeling.

Because there are two categories of elk groups and three observers represented in the data, there are six sighting probabilities in each candidate model: two are known and four are estimated (Table C.1). The radio-telemetry observer has perfect detection of groups with radio-collared elk ($p_{1,radio}$ = 1), and no chance of detecting groups without radio-telemetry collars ($p_{2,radio}$ = 0); the remaining probabilities are estimated.

Table C.1. Probabilities of seeing elk groups for each observer (columns), according to elk group category (rows) in helicopter surveys of elk in MORA.

	Observer		
Elk group category	Radio-Telemetry	Front	Back
1. Available to all	$p_{1,radio}$ = 1.0	$p_{1,f}$	$p_{1,b}$
2. Available to front and back seats	$p_{2,radio}$ = 0.0	$p_{2,f}$	$p_{2,b}$

In all candidate models, the sighting probability for an elk group in category g, by observer h was defined by the logistic function (Equation C.1). Equation C.1 specifies that detection probabilities are a logit function of the summed products of covariates times beta (β) coefficient parameters. Each of the six probabilities can be thought of as having an intercept beta parameter, and potentially including a number of other additive effects, represented by the product of other covariates and beta parameters.

$$p_{g,h} = \frac{e^{(\boldsymbol{\beta x'}_{g,h})}}{1+ e^{(\boldsymbol{\beta x'}_{g,h})}} \qquad \text{(Equation C.1)}$$

Where:

$\boldsymbol{\beta}$ = a vector of fitted coefficients for the logistic model (beta parameters)
$\boldsymbol{x}'_{g,h}$ = a transpose of the vector of observed covariates for an elk group in category g, observer h

The unconditional probability of detection should be the same for all elk groups, regardless of whether they have a radio-collared animal in the group, or not. The candidate models are structured to reflect the assumption that for groups containing radio-collared elk the detection probabilities for front ($p_{1,f}$) or back ($p_{1,b}$) observers are unconditional probabilities of detection. This assumption is warranted, because elk groups in this first category are all available to be detected, and their inclusion in the data set is not contingent on any circumstance other than that the group was present in the surveyed area. For the second category of elk groups, those not containing radio-collared elk, the detection probabilities for front ($p_{2,f}$) and back ($p_{2,b}$) observers are conditional on the group being in the data set, i.e., that it was seen by either the front or back observer. This is because a category 2 elk group is only included in the data set if it was seen by either the front or back observer, or both. Therefore, there is an inherent difference between $p_{1,f}$ and $p_{2,f}$, just as there is an inherent difference between $p_{1,b}$ and $p_{2,b}$. The difference reflects a heterogeneity effect in the pattern of double-observer data for the category 2 elk that is not adequately explained by model covariates. In other words, for reasons that are not measured, some groups that are inherently harder to see than others with identical values for the recorded covariates are less likely to be in the double-observer portion of the data set.

Those groups that are in the double-observer portion of the data set may be, therefore, inherently more visible. This bias due to group visibility heterogeneity is not present in the radio collared groups. The bias can be estimated with an additional parameter to explain the difference between sighting probability of radio-collared groups and non-radio collared groups (i.e., $p_{1,f}$ as compared with $p_{2,f}$). The difference is quantified by a heterogeneity parameter that is included in every candidate model (or, in some models, two heterogeneity parameters, corresponding to front and back observers).

The candidate models are all constrained so that the effects of sighting covariates on detection probability influence the functions describing front observer probability ($p_{1,f}$ and $p_{2,f}$) and back observer ($p_{1,b}$ and $p_{2,b}$) identically, regardless of elk group category. While the double-observer data for both categories of elk groups contribute to estimates of the effects of sighting covariates on detection probabilities, only data from the elk groups in category 1 can be used to fit estimates of the heterogeneity parameter (or the two heterogeneity parameters, in some models). Put another way, the heterogeneity parameter is included in calculating estimates of $p_{1,f}$ and $p_{1,b}$, but not of $p_{2,f}$ or $p_{2,b}$.

The unconditional overall detection probability (p^*_j) for elk group j is one minus the probability that it was missed by all observers (Equation C.2).

p^*_j = 1- (1- $p_{radio,j}$)*(1- $p_{1,f}$)*(1- $p_{1,b}$) (Equation C.2)

Note that elk groups with at least one radio-collared animal have p_{radio} = 1, so their p^*_j = 1. For elk groups with no radio collared animals, p_{radio} = 0, so p^*_j for those elk groups is only a function of $p_{1,f}$ and $p_{1,b}$. The group-specific correction factor ($\hat{\theta}_j$) is the inverse of the group's unconditional overall detection probability (Equation C.3).

$$\theta_j = \frac{1}{p^*_j}$$ (Equation C.3)

Correction factors can be thought of as the per-observed-elk contribution to the overall estimate of abundance; it is one, plus a corresponding number of unseen elk that occur in groups with the same covariates as that observed. The contribution to an abundance estimate coming from group j is the product of its group size (n_j) times its group-specific correction factor, θ_j. For a given survey, the total estimated abundance (N) is the sum of the products of group size weighted by group-specific correction factors (Equation C.4). Point estimates of abundance for each trend count area survey are presented in annual reports.

$$N = \sum \theta_j * n_j$$ (Equation C.4)

Correction factors for each group can also be applied to find the estimated composition ratios. For each observed group, j, the observed numbers of cows ($n_{j,cow}$), calves ($n_{j,calf}$), and bulls ($n_{j,bull}$) are multiplied by θ_j to estimate the group's contribution to the totals that are used in the composition estimates; totals are presented as calves per 100 cows (Equation C.5) and bulls per 100 cows (Equation C.6).

Calves : 100 Cows = $100 * \left(\sum \theta_j * n_{j,calf} \right) \div \left(\sum \theta_j * n_{j,cow} \right)$ (Equation C.5)

Bulls : 100 Cows = $100 * \left(\sum \theta_j * n_{j,bull} \right) \div \left(\sum \theta_j * n_{j,cow} \right)$ (Equation C.6)

Model Development

We developed double-observer sightability models based on 97 double-observer sightability trials associated with groups of elk containing radio-collared elk and 510 additional double observer trials based on groups without radiocollared elk. We recorded field data following procedures described in **SOP 7: Conducting Helicopter Surveys**. We structured candidate models to reflect the potential sighting covariates that we had identified a priori as possibly affecting sightability. These 'sighting covariates' included in models potentially included group size, the midpoint of percent concealing vegetation class, cover type, light level, and pilot experience level. Percent concealing vegetation was modeled as a continuous variable, where the value for each elk group was the database field Midpoint, which is the midpoint of the recorded range (Rice et al. 2009).

Prior to analysis, it was necessary, on occasion, to impute missing covariate values for groups of elk with radiocollars that we missed during aerial surveys and subsequently located using radio-telemetry. Generally this was because we could not determine group sizes or activities of groups that were beneath dense tree cover, and could not be seen when located using aerial radio-telemetry. For any double-observer sightability trial with missing data for group size, we substituted the median group size computed from all groups detected in the same category of percent concealing vegetation with at least one cow in the group. For double-observer sightability trials with no activity recorded, we used the modal activity out of all groups with at least one cow. For the one sightability trial with no percent concealing vegetation value recorded, we use the median group size out of all groups with at least one cow, and imputed the median percent concealing vegetation based on all groups with at least one cow. On rare occasions we also imputed which side of the helicopter an elk group was observed when that datum was not recorded. For the three double-observer sightability trials for which we could not deduce side-of-helicopter from the recorded flight line, we assumed that the elk group was available to be seen by crew on both the right and left sides of the helicopter. Because the number of double-observer data points was much larger than the number of double-observer sightability trial data points, we omitted from model creation 14 double-observer data points for which a sighting covariate was missing, and 22 double-observer data points for which the side of the helicopter value was not recorded. We omitted from model creation two double-observer observations because back seat observers did not have an independent opportunity to detect the group, i.e., because someone in the front seat pointed out the group prematurely. After these omissions, 510 double-observer data points remained for model development.

We developed a set of 28 candidate models including various combinations of the recorded covariates as well as different constraints on detection probabilities. These were all Huggins (1991) closed capture models with individual covariates, structured in MARK (White and Burnham 1999) with three capture occasions corresponding, respectively, to radio-telemetry, front, and back observers. The models were structured to solve for the four estimated detection probabilities listed in Table C.1. The differences between models reflected *a priori* hypotheses about observer acuity and the potential effects of sighting covariates. A number of specific model components (Table C.2) were either included or not included in candidate models; the inclusion of given components was reflected in the parameterizations of the logit link formulae (Equation C.1) used to express the six probabilities listed in Table C.1. We prepared the combined data set for input in program MARK (White and Burnham 1999); each line of the input file represented one elk group observation. The three 0 or 1 columns for each elk group's capture history correspond to detection (1) or nondetection (0) by the radio, front, and back observers.

In structuring the candidate model set, however, we wanted to avoid overfitting the model. We particularly wanted to minimize the number of model parameters, given the relatively small number of double-observer sightability trial data points ($n = 97$). We, therefore, limited model structures to those that potentially included effects of two sighting covariates almost universally shown to be important (group size, and percent concealing vegetation), effects of two conditions that are practically required by logical reasoning (an effect of pilot experience, and an effect of the elk group being less visible to back seat observers), and only up to one more effect of a sighting covariate. Because many observers (>15) contributed to double-observer data and double-observer sightability trial data, we chose not to include any covariates to represent individual observer acuity. One benefit of this approach is that because the models were fit to data from several observers, they should not be overly sensitive to future changes in personnel.

Table C.2. Model components used to model detection probabilities of aerial elk surveys in Mount Rainier National Park 2008-2010.

Model Component	Description of Model Component
F=B	A constraint forcing front (F) and back (B) observers to have a single parameter for the intercept of detection probability.
F/B	A constraint forcing the estimation of separate intercept parameters for front (F) and back (B) observer detection probabilities.
+Hetero	A constraint forcing front and back observers to have the same single parameter for the heterogeneity effect.
*Hetero	A constraint forcing the estimation of two separate parameters for the front (F) and back (B) observer heterogeneity effect.
No Hetero	A model specification with no heterogeneity effect, such that $p_{1,f} = p_{2,f}$ and $p_{1,b} = p_{2,b}$.
+ln(N)	An effect of the continuous variable, natural logarithm of elk group size, on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$.
+F:IXP	An effect of inexperienced pilots on detection probabilities for front observer, $p_{1,f}$, and $p_{2,f}$, when the elk group was on the same side of the helicopter as the pilot. Pilot was considered inexperienced if he had flown less than 10 times with radio-telemetry, or in surveying ungulates in mountainous topography.
+B:C	An effect of the elk group being visible primarily to the front observer, because the helicopter passed directly over the group, under the helicopter flight path's Centerline. This effect only influences back observer probabilities, $p_{1,b}$, and $p_{2,b}$.
+V	An effect of the continuous variable[1], percent concealing vegetation, on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$.
+L	An effect of flat Light level, on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$.
+M	An effect of animal activity, on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ – specifically, the effect of those animals being 'Moving' at the time of detection.
+H	An effect of the elk group being in the Herbaceous cover type on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$.
+F	An effect of the elk group being in the Forest cover type on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$.
+S	An effect of the elk group being in the Shrub cover type on detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$.

[1] Percent concealing vegetation is modeled as a continuous covariate, using the midpoint of the recorded range.

Because we had the *a priori* expectation that group size, the effect of any inexperienced pilot, and the inability of back seat observers to see elk groups along the center line of the flight path would all be important covariates, almost all models included the +ln(N), F:IXP, and B:C covariates. For the sake of testing those expectations, though, we also included several models without parameters for these covariates, and two without the heterogeneity parameter. We used Akaike's information criterion for small sample size, AIC_c, to rank model parsimony among the 28 candidate models (Burnham and Anderson 2002). For model averaging, we limited the contributing models to those models that were within AIC_c <4.0 of the top ranked model. These are the first 15 numbered models in Table C.3. What we refer to in the main text of the protocol as the MORA double-observer sightability model actually reflects model-averaged (Burnham and Anderson 2002) estimates from the 15 most plausible contributing models.

All of the 15 highest ranked models included effects of: at least one heterogeneity parameter, group size, the degree of concealing vegetation, an effect of the elk group being along the centerline of the helicopter flight path, and pilot experience level. There were also several other models that included these effects and one other (light level, cover type, or elk activity), and which were within AIC_c scores of 4.0 or less, so we used model averaging (Burnham and Anderson 2002) to properly include the effects of those covariates on overall estimated detection probability (see below, Using the MORA Double-Observer Sightability Model in Reporting). Among those 15 models, there were 16 beta parameters to estimate (Table C.4) – not all 16 of the beta parameters were included in any single model, but considering them as a set is useful for systematic analyses and record-keeping within the relational database and Excel analytical files.

Relative to the 15 contributing models, some other model structures had a much poorer fit to the data set, including those that did not have the heterogeneity parameter (i.e., models 25 and 26 in Table C.3); or that did not include the well-supported effects of group size (model 28), percent concealing vegetation (models 16 - 27), or elk group position along the center of the flight path on back seat observer detection (model 24). The effect of the shrub cover type was not well supported (model 23).

Estimated Detection Probability Functions for Each Model

Models were structured so that the detection probabilities $p_{1,radio}$, $p_{2,radio}$, $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ were estimated by including specific sets of products of covariates and coefficients ($\boldsymbol{\beta}$ parameters) in the logit link function (Equation C.1) for that probability. According to a given model, any single detection probability for a particular elk group and a particular observer depends on the covariates that are included in that model for that observer, and the coefficients that get multiplied by those covariates. There were eight covariates for coding model structure components included in each line of data. There were eight sighting covariates that were coded as dummy variables (1 or 0), or as continuous real numbers.

The β parameters in each model are coefficients that are multiplied by the corresponding covariates within the logit link functions used to estimate detection probabilities. Table C.4 lists descriptions of the covariate*β products, guidelines for coding covariate values, and comments about which detection probabilities may be influenced by the covariate*β product. The inclusion or omission of any of these covariate*β products as part of the logit link functions for a given detection probability is determined by a model's design matrix (see below, Design Matrices).

Table C.3. Model rank and AIC_c score for 28 candidate models. Only the 15 models with ΔAICc values <4.0, in bold, were included in model averaging. For those 15 models, model averaging was based on AIC_c weights recalculated from only on those 15 models. All model components are defined in Table C.2.

Model Number and Description	AIC_c	Delta AIC_c	AIC_c Weights	Num. Par
1. {F=B + Hetero + ln(N) + F:IXP + B:C + V + L}	**1303**	**0**	**0.15**	**7**
2. {F=B + Hetero + ln(N) + F:IXP + B:C + V}	**1304**	**0.538**	**0.115**	**6**
3. {F=B + Hetero + ln(N) + F:IXP + B:C + V + M}	**1304**	**0.725**	**0.104**	**7**
4. {F/B*Hetero + ln(N) + F:IXP + B:C + V + L}	**1305**	**1.249**	**0.08**	**9**
5. {F/B + Hetero + ln(N) + F:IXP + B:C + V + L}	**1305**	**1.331**	**0.077**	**8**
6. {F/B*Hetero + ln(N) + F:IXP + B:C + V}	**1305**	**1.645**	**0.066**	**8**
7. {F=B + Hetero + ln(N) + F:IXP + B:C + V + H}	**1305**	**1.778**	**0.062**	**7**
8. {F/B*Hetero + ln(N) + F:IXP + B:C + V + M}	**1305**	**1.849**	**0.06**	**9**
9. {F/B + Hetero + ln(N) + F:IXP + B:C + V}	**1305**	**1.976**	**0.056**	**7**
10. {F/B + Hetero + ln(N) + F:IXP + B:C + V + M}	**1305**	**2.019**	**0.055**	**8**
11. {F/B*Hetero + ln(N) + F:IXP + B:C + V + H}	**1306**	**2.548**	**0.042**	**9**
12. {F=B + Hetero + ln(N) + F:IXP + B:C + V + F}	**1306**	**2.894**	**0.035**	**7**
13. {F/B + Hetero + ln(N) + F:IXP + B:C + V + H}	**1306**	**2.954**	**0.034**	**8**
14. {F/B*Hetero + ln(N) + F:IXP + B:C + V + F}	**1307**	**3.79**	**0.023**	**9**
15. {F/B + Hetero + ln(N) + F:IXP + B:C + V + F}	**1307**	**3.864**	**0.022**	**8**
16. {F=B + Hetero + ln(N) + F:IXP + B:C + H}	1308	5.048	0.012	6
17 { F=B + Hetero + ln(N) + F:IXP + B:C + F}	1311	8.151	0.003	6
18. {F=B + Hetero + ln(N) + F:IXP + B:C + L}	1312	9.049	0.002	6
19. {F=B + Hetero + ln(N) + F:IXP + B:C}	1313	9.832	0.001	5
20. { O:F=R + Hetero + ln(N) + F:IXP + B:C + M}	1314	10.57	0.0008	6
21. {F/B + Hetero + ln(N) + F:IXP + B:C}	1314	11.1	0.0006	6
22. {F/B*Hetero + ln(N) + F:IXP + B:C}	1314	11.16	0.0006	7
23. {O:F=R + Hetero + ln(N) + F:IXP + B:C + S}	1315	11.48	0.0004	6
24. {F/B*Hetero + ln(N) + F:IXP}	1324	21.14	0	6
25. {F=B + NoHetero + ln(N) + F:IXP + B:C}	1326	22.8	0	4
26. {F/B, No Hetero + ln(N) + F:IXP + B:C}	1327	24.16	0	5
27. {F/B*Hetero + ln(N) + B:C}	1330	26.28	0	6
28. {F/B*Hetero + F:IXP + B:C}	1359	55.92	0	6

Table C.4. Description of 16 covariates recorded for each observed elk group in the data set used for the double-observer sightability model. The same covariates are used for applying the double-observer sightability model to estimate abundance and composition from future aerial surveys. Covariate Numbers and Names are at left. The Beta parameter numbers (β #) are in the next column. The column at right interprets the covariate*β product (bold font), indicates how covariate values were coded for each group (after the bullet point), and comments on which models and which detection probabilities were potentially influenced by the inclusion of that covariate*β product in logit link functions.

Covariate Number and Name	β #	**Description of the covariate*β product** • Guidelines for coding covariate values Comments about detection probabilities that may be influenced by the covariate*β product
1. G:Radio, O:Radio	β1	**Intercept for elk group category 1 (with a radio), for the Radio-telemetry observer**. • All elk groups in the data set have this covariate value coded as 1. (G:Radio,O:Radio)*β1 is only used in finding the radio-telemetry observer's detection of elk groups with a radio collar, $p_{1,radio}$. That probability is fixed as 1, so β1is fixed as 99.
2. G:NoRadio, O:Radio	β2	**Intercept for elk group category 2 (no radio), for the Radio-telemetry observer**. • All elk groups in the data set have this covariate value coded as 1. (G:NoRadio,O:Radio)*β2 is only used in finding the radio-telemetry observer's detection probability for elk groups with no radio collar, $p_{2,radio}$. That probability is fixed at 0, so β2 is fixed at -99.
3. O:F=B	β3	**Intercept for front and back observers, in models where those are equal.** • All elk groups in the data set have this covariate value coded as 1. (O:F=B)*β3 is included in detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models where front and back observers are modeled to have the same detection probability.
4. O:Front	β4	**Intercept for front observer, in models where it is not equal to back observer intercept.** • All elk groups in the data set have this covariate value coded as 1. O:Front*β4, is included in detection probabilities $p_{1,f}$, and $p_{2,f}$in models where front and back observers are modeled to have different intercepts.
5. O:Back	β5	**Intercept for back observer, in models where it is not equal to front observer intercept** • All elk groups in the data set have this covariate value coded as 1. O:Back*β5, is included in detection probabilities $p_{1,b}$, and $p_{2,b}$in models where front and back observers are modeled to have different intercepts.
6. G:Radio	β6	**Heterogeneity effect, in models where that is equal for front and back observers** • All elk groups in the data set have this covariate value coded as 1. G:Radio*β6, is included in unconditional probability estimates for front and back observers, $p_{1,f}$ and $p_{1,b}$, in models where front and back observers are modeled to have the same heterogeneity effect.
7. G:Radio,O:Front	β7	**Heterogeneity effect for front observer, in models where that is not equal for front and back observers** • All elk groups in the data set have this covariate value coded as 1. (G:Radio,O:Front)*β7 is only used in unconditional probability estimates for front observers, $p_{1,f}$, in models where front and back observers are modeled to have different heterogeneity effects.

Covariate Number and Name	β #	**Description of the covariate*β product** • Guidelines for coding covariate values Comments about detection probabilities that may be influenced by the covariate*β product
8. G:Radio, O:Back	β8	**Heterogeneity effect for back observer, in models where that is not equal for front and back observers** • All elk groups in the data set have this covariate value coded as 1. (G:Radio,O:Back)*β8 is only used in unconditional probability estimates for back seat observers, $p_{1,b}$, in models where front and back observers are modeled to have different heterogeneity parameters.
9. ln(N)	β9	**Effect of the natural logarithm of group size** • Each elk group's ln(N) covariate value is the natural logarithm of the observed group size. ln(N)*β9 is included in both front and back detection probabilities, $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models that include the effect of group size.
10. F:IXP	β10	**Effect of an Inexperienced pilot on front observer detection probability** • Each elk group's F:IXP covariate value depends on the pilot's experience. F:IXP = 0 if the pilot was experienced (10 or more telemetry / ungulate surveys in mountainous topography) ***or***, if the pilot was inexperienced, the elk group was not on the pilot's side of the helicopter. F:IXP = 1 if the pilot was inexperienced (less than 10 telemetry / ungulate surveys in mountainous topography) *and* the elk group was on the pilot's side of the helicopter. F:IXP*β10 affects front seat detection probabilities, $p_{1,f}$, and $p_{2,f}$ in models with effect of pilot experience.
11. B:C	β11	**Effect of an elk group being along the Centerline on back detection probability** • Each elk group's B:C covariate value depends on whether the elk group was under the center line of the flight path. B:C = 0 if the elk group was not under the center line of the flight path. B:C = 1 if the group was under the center line of the flight path. B:C*β11 is only included in both back seat detection probabilities $p_{1,b}$, and $p_{2,b}$ in models that include the effect of centerline.
12. V	β12	**Effect of Percent concealing vegetation on detection probabilities** • Each elk group's V covariate value is the midpoint of the range of percent concealing vegetation recorded in the field, expressed as a decimal. Possible values are 0, 0.13, 0.38, 0.63, and 0.88. V*β12 is included in all front and back detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models that include the effect of percent concealing vegetation.
13. H	β13	**Effect of Herbaceous cover type on detection probabilities** • Each elk group's value for H depends on the recorded cover type. H = 0 if the elk group was not in herbaceous vegetation. H = 1 if the elk group was seen in herbaceous vegetation. H*β13 is included in all front and back detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models that include the effect of herbaceous cover type.
14. F	β14	**Effect of Forest cover type on detection probabilities** • Each elk group's value for F depends on the recorded cover type. F = 0 if the elk group was not in forested vegetation. F = 1 if the elk group was seen in forested vegetation F*β14 is included in all front and back detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models that include the effect of forest cover type.

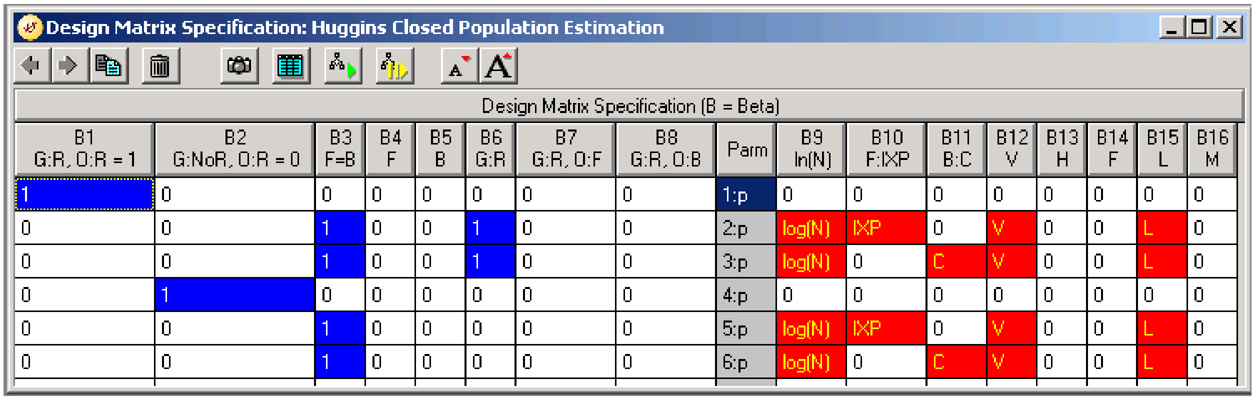
Covariate Number and Name	β #	**Description of the covariate*β product** • Guidelines for coding covariate values Comments about detection probabilities that may be influenced by the covariate*β product
15. L	β15	**Effect of flat Light on detection probabilities** • Each elk group's value for L depends on the recorded light condition. L = 0 if the elk group was in high contrast lighting conditions. L = 1 if the elk group was in flat lighting conditions. L*β15 is included in all front and back detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models that include the effect of light level.
16. M	β16	**Effect of Moving elk activity on detection probabilities** • Each elk group's value for M depends on the recorded elk activity condition. M = 0 if the activity of the elk group was categorized as "standing" or "bedded." M = 1 if the activity of the elk group was "moving." M*β16 is included in all front and back detection probabilities $p_{1,f}$, $p_{2,f}$, $p_{1,b}$, and $p_{2,b}$ in models that include the effect of Moving elk activity.

Design Matrices

Each j group's covariates can be considered to be a vector of values with 1 row and 16 columns, symbolized as $\boldsymbol{x}_j$; its 16 x 1 transpose is symbolized as $\boldsymbol{x}'_j$. The coefficients can also be considered to be a 16 x 1 vector, symbolized as $\boldsymbol{\beta}$; this vector has 16 rows and one column. The 6 row x 16 column design matrix that represents which covariate*β products are included in each of the six estimated probabilities is coded with ones, zeros, or continuous covariates; the design matrix is symbolized as $\boldsymbol{D}$. The product of $\boldsymbol{x}'_j$, $\boldsymbol{\beta}$, and $\boldsymbol{D}$ results in six vectors, each of which is the sum of one or more covariate*β values. These vectors are the logit link functions (the exponentiated terms in Equation C.1) for each of the six probabilities estimated by each model.

Within program MARK (White and Burnham 1999), the design matrix is prepared in the design matrix window, an example of which is show in Figure C.2. Because there are six probabilities to determine (Table C.1), and 16 possible covariates for the 15 highest ranked models (Table C.4), the design matrices were all structured as 6 x 16 matrices. In Figure C.2, each of the parameter rows, labeled 1:p, 2:p, 3:p, 4:p, 5:p, and 6:p, represents estimated detection probabilities: $p_{1,radio}$, $p_{1,f}$, $p_{1,b}$, $p_{2,radio}$, $p_{2,f}$, and $p_{2,b}$, respectively. Each probability is modeled as a logit link of the product of the numbered covariate and the numbered beta parameters (Equation C.1). For example, row 1:p reflects an equation that is modeled as a function of only one beta parameter, β1.

Rows in the design matrix refer to estimated detection probabilities. Columns refer to beta parameters, which either are or are not used in forming the logit link for each estimated detection probability. Zeros in any cell indicate that the beta parameter (column) is not used in the estimation of the detection probability (row). The placement of ones and zeros in rows for β1 and β2 reflect the detection probabilities set for the radio-telemetry observer, depending on whether the elk group is in category 1 (radio present; corresponding to row 1:p) or category 2 (no radio present; corresponding to row 2:p). Blue zero or one values in columns β3 through β5 reflect the model structure constraints for front and back observer detections. Blue zero or one values in columns β6 through β8 reflect the model structure of front and back observer heterogeneity effect; for the model shown in figure C.2, front and back heterogeneity effect is constrained to be equal. Red text in columns β9 through β16 causes a given β coefficient to be multiplied by the value of specified sighting covariates.



Design Matrix Specification: Huggins Closed Population Estimation

Design Matrix Specification (B = Beta)

B1 G:R, O:R = 1	B2 G:NoR, O:R = 0	B3 F=B	B4 F	B5 B	B6 G:R	B7 G:R, O:F	B8 G:R, O:B	Parm	B9 ln(N)	B10 F:IXP	B11 B:C	B12 V	B13 H	B14 F	B15 L	B16 M
1	0	0	0	0	0	0	0	1:p	0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	2:p	log(N)	IXP	0	V	0	0	L	0
0	0	1	0	0	1	0	0	3:p	log(N)	0	C	V	0	0	L	0
0	1	0	0	0	0	0	0	4:p	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	5:p	log(N)	IXP	0	V	0	0	L	0
0	0	1	0	0	0	0	0	6:p	log(N)	0	C	V	0	0	L	0

Figure C.2. Design matrix view in program MARK, showing the structure used for model {F=B + Hetero + ln(N) + F:IXP + B:C + V +L}. For this model, front and back detection probabilities for category 1 elk (rows 2:p and 3:p, respectively) are constrained to have the same intercept (F=B), heterogeneity effect (G:R), and effects of group size (ln(N)), concealing vegetation (V), and light (L); the probabilities differ only due to the potential influence of the inexperienced pilot effect (F:IXP) on front detection probabilities, and the potential influence of a centerline elk location (B:C) on back detection probabilities.

Based on performing the $\boldsymbol{x}_g'$ x $\boldsymbol{\beta}$ x $\boldsymbol{D}$ multiplication to find the logit link functions used within each of the six detection probabilities for model {F=B + Hetero + ln(N) + F:IXP + B:C + V + L}, the equations for those detection probabilities in this model shown in Table C.5. Calculations of these probabilities require the covariate values and the β parameter estimates for the model under consideration. The full set of estimated β coefficient values for each of the contributing models is presented in Table C.6

Table C.5. Equations for the six detection probabilities (Table C.1) according to model {F=B + Hetero + ln(N) + F:IXP + B:C + V + L}.and elk group *j*, having observed covariates (Table C.4) subscripted with *j*. The left column of the table is the row label for each probability, shown in the example design matrix (Figure C.2). In these equations, we do not show any values of the logit link terms that include any product with a zero.

Row label	Detection probability equation
1:p	$p_{1,radio,j} = \frac{e^{(G:Radio,O:Radio*\beta1)}}{1+ e^{(G:Radio,O:Radio*\beta1)}}$
2:p	$p_{1,f,j} = \frac{e^{(O:F=B*\beta3+G:Radio*\beta6+\ln(N)*\beta9+F:IXP*\beta10+V*\beta12+L*\beta15)}}{1+ e^{(O:F=B*\beta3+G:Radio*\beta6+\ln(N)*\beta9+F:IXP*\beta10+V*\beta12+L*\beta15)}}$
3:p	$p_{1,b,j} = \frac{e^{(O:F=B*\beta3+G:Radio*\beta6+\ln(N)*\beta9+B:C*\beta11+V*\beta12+L*\beta15)}}{1+ e^{(O:F=B*\beta3+G:Radio*\beta6+\ln(N)*\beta9+B:C*\beta11+V*\beta12+L*\beta15)}}$
4:p	$p_{2,radio,j} = \frac{e^{(G:No\ Radio,O:Radio*\beta2)}}{1+ e^{(G:No\ Radio,O:Radio*\beta2)}}$
5:p	$p_{2,f,j} = \frac{e^{(O:F=B*\beta3+\ln(N)*\beta9+F:IXP*\beta10+V*\beta12+L*\beta15)}}{1+ e^{(O:F=B*\beta3+\ln(N)*\beta9+F:IXP*\beta10+V*\beta12+L*\beta15)}}$
6:p	$p_{2,b,j} = \frac{e^{(O:F=B*\beta3+\ln(N)*\beta9+B:C*\beta11+V*\beta12+L*\beta15)}}{1+ e^{(O:F=B*\beta3+\ln(N)*\beta9+B:C*\beta11+V*\beta12+L*\beta15)}}$

Table C.6 Matrix of β coefficient estimates for each of the 15 contributing models used in model averaging. Model numbers and names are at the top of each column. These β estimates are saved in the project's /Analysis/ folder, in the Excel spreadsheet file "MT Rainier and OLYM Dbl Observer and Sightability Data Sept 2010, B.xlsm" in the worksheet tab called ModParms. In addition to the 16 rows of β parameters, the last row on this table presents the AIC_c model weights, w_k, used in model averaging.

	1. {F=B + Hetero + ln(N) + F:IXP + B:C + V + L}	2. {F=B + Hetero + ln(N) + F:IXP + B:C + V}	3. {F=B + Hetero + ln(N) + F:IXP + B:C + V + M}	4. {F/B*Hetero + ln(N) + F:IXP + B:C + V + L}	5. {F/B + Hetero + ln(N) + F:IXP + B:C + V + L}	6. {F/B*Hetero + ln(N) + F:IXP + B:C + V}	7. {F=B + Hetero + ln(N) + F:IXP + B:C + V + H}	8. {F/B*Hetero + ln(N) + F:IXP + B:C + V + M}	9. {F/B + Hetero + ln(N) + F:IXP + B:C + V}	10. {F/B + Hetero + ln(N) + F:IXP + B:C + V + M}	11. {F/B*Hetero + ln(N) + F:IXP + B:C + V + H}	12. {F=B + Hetero + ln(N) + F:IXP + B:C + V + F}	13. {F/B + Hetero + ln(N) + F:IXP + B:C + V + H}	14. {F/B*Hetero + ln(N) + F:IXP + B:C + V + F}	15. {F/B + Hetero + ln(N) + F:IXP + B:C + V + F}
β1	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
β2	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
β3	-0.232	0.033	0.004	0.000	0.000	0.000	-0.108	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.000
β4	0.000	0.000	0.000	-0.308	-0.280	-0.044	0.000	-0.073	-0.016	-0.045	-0.186	0.000	-0.156	-0.046	-0.018
β5	0.000	0.000	0.000	-0.148	-0.180	0.117	0.000	0.087	0.084	0.055	-0.025	0.000	-0.057	0.114	0.082
β6	-0.451	-0.464	-0.493	0.000	-0.454	0.000	-0.464	0.000	-0.467	-0.496	0.000	-0.467	-0.467	0.000	-0.469
β7	0.000	0.000	0.000	-0.207	0.000	-0.219	0.000	-0.246	0.000	0.000	-0.219	0.000	0.000	-0.222	0.000
β8	0.000	0.000	0.000	-0.700	0.000	-0.714	0.000	-0.746	0.000	0.000	-0.715	0.000	0.000	-0.716	0.000
β9	0.486	0.474	0.467	0.486	0.486	0.474	0.473	0.468	0.474	0.467	0.473	0.474	0.473	0.475	0.474
β10	-1.948	-1.959	-1.958	-1.885	-1.879	-1.895	-1.962	-1.896	-1.889	-1.888	-1.899	-1.959	-1.893	-1.895	-1.890
β11	-2.865	-2.878	-2.873	-2.989	-2.942	-3.001	-2.865	-2.996	-2.954	-2.949	-2.989	-2.878	-2.941	-3.001	-2.954
β12	-0.998	-1.007	-1.037	-0.999	-0.999	-1.008	-0.813	-1.039	-1.008	-1.038	-0.813	-1.032	-0.814	-1.031	-1.033
β13	0.000	0.000	0.000	0.000	0.000	0.000	0.203	0.000	0.000	0.000	0.204	0.000	0.202	0.000	0.000
β14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.022	0.024
β15	0.319	0.000	0.000	0.318	0.318	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
β16	0.000	0.000	0.288	0.000	0.000	0.000	0.000	0.290	0.000	0.287	0.000	0.000	0.000	0.000	0.000
w_k	0.15	0.11	0.10	0.09	0.08	0.07	0.06	0.06	0.06	0.06	0.04	0.04	0.04	0.02	0.02

Using the MORA Double-Observer Sightability Model in Reporting

The set of 15 highest-ranked models that contribute to the MORA double-observer sightability model are used in annual and four-year reports to adjust raw counts obtained for any surveyed trend count area, to account for detection biases. In analyses that follow from the theoretical background and model development, each elk group's model-averaged correction factor is applied to each group's size and composition. Bruce Lubow has developed the Excel spreadsheet file "Mt Rainier and OLYM Dbl Observer and Sightability data Sept 2010,B.xlsm" which can be used for convenient calculation of estimated model-averaged correction factors for any observed elk group, if the covariates are known. That spreadsheet, saved in the project's \Analysis\folder, can be used to calculate abundance estimates, and it figures in the bootstrapped variance estimation methods (see below, Estimating Variance in Abundance Estimates with Bootstrapping). The same calculations leading to estimated model-averaged correction factors for observed groups are performed by the database queries qry_Est_abundance and qry_Est_composition.

Applying the MORA Double-Observer Model to Estimate Abundance

In the following discussion, elk group category is subscripted with *g*, observer is subscripted with *h*, trend count area is subscripted with *i*, elk group is subscripted with *j*, and contributing model is subscripted with *k*. As noted in **Theoretical Background**, detection probabilities for radio telemetry observer are subscripted with *radio*, for front observer with *f*, and for back observer with *b*. Estimates are indicated by the presence of a 'hat' symbol ($\widehat{\ }$), and model-averaged estimates are indicated by the presence of a 'bar' symbol ($\bar{\ }$).

For every observed elk group in the data set, *j*, each of the *k* contributing models leads to an estimated unconditional detection probability for the radio-telemetry observer ($p_{radio,j}$), the front seat observer ($\hat{p}_{1,f,j,k}$) and back seat observer ($\hat{p}_{1,b,j,k}$), given the vector of covariate values recorded for each group ($\boldsymbol{x}_j$), the vector of β coefficient parameters for model *k* ($\boldsymbol{\beta}_k$), and the design matrix for model *k* ($\boldsymbol{D}_k$). The logit link functions for the six detection probabilities for each model (Table C.1) are the six vectors resulting from the matrix multiplication of $\boldsymbol{x}'_g$ x $\boldsymbol{\beta}$ x $\boldsymbol{D}$. Detection probability by the radio-telemetry observer is always 1 for groups with a radio collared animal, and 0 for groups with no radio collar. Considering all three observers, the estimated unconditional overall detection probability ($\hat{p}^*_{j,k}$) for elk group *j* and model *k* is one minus the probability that it was missed by all observers (Equation C.7). Note that, in Equation C.7, the estimated unconditional detection probabilities for front and back observers ($\hat{p}_{1,f,j,k}$ and $\hat{p}_{1,b,j,k}$) are used.

$$\hat{p}^*_{j,k} = 1 - (1-p_{radio,j})*(1-\hat{p}_{1,f,j,k})*(1-\hat{p}_{1,b,j,k}) \quad \text{(Equation C.7)}$$

The estimated group-specific correction factor for model *k* ($\hat{\theta}_{j,k}$), is the inverse of the group's estimated detection probability, given that model (Equation C.8).

$$\hat{\theta}_{j,k} = \frac{1}{\hat{p}^*_{j,k}} \quad \text{(Equation C.8)}$$

Note that elk groups with at least one radio-collared animal have p_{radio} = 1, so their $\hat{p}^*_{j,k}$= 1, and the correction factor for such groups in all contributing models is also $\hat{\theta}_{j,k}$= 1.

We use model-averaging, based on AIC_c weights, to account for model uncertainty (Burnham and Anderson 2002), but we limit our model averaging to include only well-supported models, i.e., models with $\Delta AIC_c \leq 4.0$. Each contributing model's weight, w_k, reflects the relative strength of support for that model, based on the data. Model weights sum to 1. For group j, the model-averaged group-specific correction factor ($\overline{\hat{\theta}_j}$) is the product of each model's AIC_c weight times its estimated correction factor (Equation C.9).

$$\overline{\hat{\theta}_j} = \sum \hat{\theta}_{j,k} * w_k \quad \text{(Equation C.9)}$$

Model-averaged correction factors can be thought of as the per-observed-elk contribution to the overall estimate of abundance; it is one, plus a corresponding number of unseen groups like it that it represents. The contribution to an abundance estimate coming from group j is the product of its group size (n_j) times its model-averaged, group-specific correction factor, $\overline{\hat{\theta}_j}$.

For surveyed trend count area i, the point estimate for the total abundance ($\hat{N}_i$) is the sum of the products of group size by group-specific correction factors, for all groups observed in that trend count area on a single survey (Equation C.10). Point estimates of $\hat{N}_i$ for each trend count area survey are presented in annual reports.

$$\hat{N}_i = (\text{for } j \text{ elk groups detected within } i \text{ survey; } \sum \overline{\hat{\theta}_j} * n_j) \quad \text{(Equation C.10)}$$

To calculate $\hat{N}_i$ for each survey, the database query, qry_Est_abundance, refers to all observations made during a survey of a given trend count area, then applies the specific values for each group's recorded covariates to the 15 vectors of beta parameters and design matrices for each model, to solve for to solve for 15 estimates of $p_{radio,j}$, $\hat{p}_{1,f,j,k}$, $\hat{p}_{1,b,j,k}$. These are used to estimate $\hat{p}^*_{j,k}$ and corresponding $\hat{\theta}_{j,k}$ for each model, which are weighted across all 15 contributing models obtain $\overline{\hat{\theta}_j}$. The query then sums the contributions of the $\overline{\hat{\theta}_j} * n_j$ products to find total abundance. The calculations leading to $\hat{N}_i$ are also performed in the Excel spreadsheet file, "Mt Rainier and Olympic NP Dbl Observer and Sightability Data Sept 2010, B.xlsm," which is saved in the project /Analysis/ folder.

If any elk groups could not have correction factors estimated because they lacked one or more recorded values for a sighting covariate, then the number of elk in such groups needs to be added to the total estimate for the appropriate survey. The number of such elk, for which the observed group sizes are not corrected for the effects of detection bias, should be noted in a footnote for any report or other presentation of the abundance estimates.

In OLYM, trend count areas are surveyed at most once per year. At MORA, however, there can be up to two complete surveys per year for each trend count area, so in each year there can be up to two reported values for $\hat{N}_{North}$ and for $\hat{N}_{South}$.

Example: Estimating Unconditional Detection Probability, for a Single Model

As a concrete example of the effect of the heterogeneity parameter on the unconditional detection probability estimate, consider an elk group j with no radio collared animals with observed covariates of: group size = 5, pilot was experienced, group was not on the center line, percent concealing vegetation was 26-50%, light was flat. For this example we will use the top-ranked model, {F=B + Hetero + ln(N) + F:IXP + B:C + V + L}, as shown in Figure C.2, to demonstrate the equations for front observer detection probability.

Equation C.13 describes the equation for probability $p_{2,f}$. A one is multiplied by the intercept coefficient, $\beta 3$. The natural log of group size is 1.609, which is multiplied by $\beta 9$. The concealing vegetation value is the decimal fraction for the midpoint of the range, 0.38, which is multiplied by $\beta 12$. Note that, because the pilot was experienced, and the group was not detected along the helicopter flight path centerline, zeros are multiplied by $\beta 10$ and $\beta 11$. In the mechanics of calculating these equations, the database (or Excel spreadsheet) also includes zeros multiplied by betas 1, 2, 4, 5, 6, 7, 8, 13, 14, and 16 in the exponent terms; for simplicity, we do not show those $0 * (\beta 1 + \beta 2 + \cdots + \beta 16)$ terms in the equations below. The specific values for the β coefficients are taken from Table C.6, under the column for model "1. {F=B + Hetero + ln(N) + F:IXP + B:C + V + L}."

$$p_{2,f,j,k} = \frac{e^{(1*\beta 3+1.609*\beta 9+0*\beta 10+0*\beta 11+0.38*\beta 12+1*\beta 15)}}{1+ e^{(1*\beta 3+1.609*\beta 9+0*\beta 10+0*\beta 11+0.38*\beta 12+1*\beta 15)}} = 0.620 \quad \text{(Equation C.13)}$$

However, including the effect of the heterogeneity parameter, β6, in the logit link turns this equation into the estimate for unconditional sighting probability for this same group, expressed in Equation C.14.

$$p_{1,f,j,k} = \frac{e^{(1*\beta 3+1*\beta 6+1.609*\beta 9+0*\beta 10+0*\beta 11+0.38*\beta 12+1*\beta 15)}}{1+ e^{(1*\beta 3+1*\beta 6+1.609*\beta 9+0*\beta 10+0*\beta 11+0.38*\beta 12+1*\beta 15)}} = 0.510 \quad \text{(Equation C.14)}$$

Only the latter probability, $p_{1,f,j,k}$, is the unconditional front observer detection probability. This, along with the calculated value of $p_{1,b,j,k}$ for the same elk group, is used for estimating the model-specific overall unconditional sighting probability for that group, $\hat{p}^*_{j,k}$ (Equation C.9).

Applying the MORA Double-Observer Sightability Model to Estimate Composition

The double-observer sightability model is also used to convert the observed number of cows, calves, and bulls in elk groups within 300 m of a trend count area's survey units into estimated composition for that trend count area. For each observed group, j, the observed numbers of cows ($n_{j,cow}$), calves ($n_{j,calf}$), and bulls ($n_{j,bull}$) are multiplied by the model averaged, group-specific correction factor ($\bar{\hat{\theta}}_j$) to estimate the group's contribution to the totals that are used in the composition estimate for the trend count area.

The database query qry_Est_composition yields the estimated composition ratios for each complete survey replicate of a trend count area. This query generally follows the analytical methods of the query used to estimate abundance (qry_Est_abundance), but it returns the estimated total number of calves, cows, and bulls for a given survey replicate of a trend count area, then uses those estimates to estimate the composition ratios. The estimated ratio of calves per 100 cows (Equation C.11) and ratio of bulls per 100 cows (Equation C.12) for one complete survey of a trend count area are based on estimated numbers of elk in each age and sex class.

Calves : 100 Cows = $100 * \left(\sum \overline{\hat{\theta}_j} * n_{j,calf} \right) \div \left(\sum \overline{\hat{\theta}_j} * n_{j,cow} \right)$ (Equation C.11)

Bulls : 100 Cows = $100 * \left(\sum \overline{\hat{\theta}_j} * n_{j,bull} \right) \div \left(\sum \overline{\hat{\theta}_j} * n_{j,cow} \right)$ (Equation C.12)

Estimating Variance in Abundance Estimates with Bootstrapping

Overview of bootstrapping procedure

The variance of abundance estimates are calculated from bootstrapped simulations of the data set (Wong 1996, Lubow et al. 2002), with methods outlined step by step in Table C.7. The motivation for the methods below comes from the notion that the observed elk groups were drawn from a larger set of elk groups that could have been observed. This larger set is considered to be a 'superpopulation,' in the statistical sense (Hartley and Sielken, 1975). We use the group-specific correction factors estimated from the double-observer sightability model to simulate a set of potentially observable groups in the superpopulation, having group size and other sighting covariate characteristics that are comparable to those in the observed data set. Each simulated elk group retains covariates corresponding to those in the actual data set, and retains its membership as belonging to a certain survey. From that putative superpopulation, we randomly draw observations that are included in the simulated data set, by testing whether each elk group, in turn, is detected by front, back or (if the group has a radio collared elk) radio-telemetry observer. Only simulated elk groups that are 'detected' by at least one of the observers is included in the simulated data set.

Each data set of simulated observations is used to fit the β parameter estimates and determine AIC_c for each of the 15 contributing models. These lead to group-specific, model-specific, correction factors ($\hat{\theta}_{j,k}$) for the simulated groups, which are multiplied by group sizes and summed to yield the model-specific abundance ($\hat{N}_k$) estimates for each simulated survey. The $\hat{N}_k$ values are weighted to give the overall simulated abundance for each survey, $\hat{N}$. We generate 100 such simulated observation data sets, estimate model parameters and weights for each data set, apply correction factors, and find model-weighted, estimated abundances from each. The coefficient of variation for the point estimate of abundance, CV($\hat{N}$), and associated confidence limits, are calculated based on the range of simulated abundance estimates.

Defining the Superpopulation of Available Groups

Observed groups 'represent' themselves as well as additional, undetected groups in the superpopulation. The correction factor, $\overline{\hat{\theta}_j}$, is a measure of how many groups each observed group represents. Each observed group, therefore, was replicated $\overline{\hat{\theta}_j}$ times, to define the superpopulation in each iteration. By definition, each elk group with one or more radio-collared elk has a $\overline{\hat{\theta}_j}$ value of one, because such groups are always detected via radio-telemetry. For each iteration of defining the superpopulation, though, decimal fractions of simulated groups were either included or not included, depending on comparison against a random number. Using as an example an observed group with an estimated correction factor of 0.4 and $\overline{\hat{\theta}_j}$ of 2.5, that group represents 2.5 comparable elk groups with identical covariates. A minimum of two elk groups would be added to the superpopulation in every iteration of the bootstrap data set creation. To account for the additional 0.5 fraction, another group would be added during each iteration only if a randomly generated number (uniform distribution ranging 0-1) were less than the remaining fraction (in this case, 0.5).

Simulating the Detection Data Set

Front, back, and radio-telemetry observer detections were simulated for each elk group out of the simulated superpopulation of elk groups. Each simulated elk group in the superpopulation was recorded as either detected or not detected by the simulated front observer, based on evaluating a random number against model-averaged estimates of detection probabilities for the front observer ($\overline{\hat{p}_{1,f}}$).This estimate of $\overline{\hat{p}_{1,f}}$ came from the MORA double-observer sightability model, with reference to the covariate values of the simulated elk group. Similarly, the simulated back observer either 'saw' or 'missed' the simulated elk group, based on comparison of a different random number against the estimated model-averaged back observer detection probability($\overline{\hat{p}_{1,b}}$). The simulated radio-telemetry observer was always simulated to detect groups with a radio collared elk, and to not detect those without a radio collared elk. The simulated observation data set for each iteration only included elk groups that were detected by at least one of the simulated observers.

Solving for Model Weights and Parameter Estimates

We used an optimization solver (Frontline Systems Inc., Incline Village, Nevada) in program Excel (Microsoft Corp., Redmond, Washington) to fit the AIC_c values and β parameter estimates for each of the 15 contributing models by maximizing the likelihood for each model. Based on the resulting model weights and matrix of parameter estimates, we then found the group-specific correction factors (via Equations C.4 – C.6, but using β estimates from the simulation), and resulting the abundance ($\hat{N}_{sim}$) estimates for each simulated survey (via Equation C.7). The coefficient of variation for the point estimate of abundance, CV($\hat{N}$), and associated confidence limits around the point estimate, was calculated based on the range of simulated abundance estimates.

Table C.7 Steps used to estimate variance of abundance estimates based on bootstrapping simulated data sets.

Verbal description of action	**Steps taken within Excel**
1. Simulate the superpopulation	
1A. For each observed group, evaluate how many simulated groups in the superpopulation it represents, based on its correction factor estimated from the double-observer model, $\bar{\hat{\theta}}_j$.	The simulated superpopulation and simulated observed data set is generated by Visual Basic code in the original data spreadsheet* and the results of that program are written to the SimPop page of that spreadsheet* before being copied and pasted to the bootstrap spreadsheet† for analysis.
i. For elk groups with one or more radio-collared animals, $\bar{\hat{\theta}}_j$. = 1; these groups are included exactly once in each simulated superpopulation	
ii. For each j elk group with no radio collared animals, replicate the covariate data for the group so that there are at least $\bar{\hat{\theta}}_j$ such groups in the simulated superpopulation, rounded down to the nearest whole number.	
iii. If $\bar{\hat{\theta}}_j$ is not an integer, evaluate the decimal fraction against a random number to determine whether or not to include one more simulated group with the same covariates in the simulated superpopulation.	
1B. For each simulated group in the superpopulation, evaluate whether it was seen or not by each observer, to form simulated capture histories	
i. Elk groups with radio collared elk are always recorded as having been detected by the radio-telemetry observer. Elk groups with no radio collared elk are always recorded as not having been detected by the radio-telemetry observer.	
ii. In evaluating whether a group was seen or not seen by each observer, evaluate a random number (uniform, in the range 0-1) against the unconditional, model-averaged detection probability estimated from the original data set. This is the model averaged $p_{1,f}$ for front observer, and $p_{1,b}$ for back observer.	
iv. Elk groups from the superpopulation that are not detected by any observer have a 000 capture history, so they are not included in the simulated observation data set used for model estimation	

Table C.7 (continued) Steps used to estimate variance of abundance estimates based on bootstrapping simulated data sets.

Verbal description of action	Steps taken within Excel
1C. Using the simulated observation data set, optimize model β parameters for each of the 15 contributing models, and determine AIC_c model weights	Bring the simulated data set over into the bootstrap spreadsheet† , in the Mt Rainier_data worksheet tab
i. Using that simulated data set, evaluate model β parameters, for each of the 15 models considered	In the bootstrap spreadsheet† , in the Bootstrap worksheet tab, use solver macro in Excel to optimize β parameters. Find AIC_c and apply resulting model weights to abundance estimates
ii. Model weights for the simulated observed data set are based on AIC_c values from the Huggins (1991) conditional likelihood formula.	
iii. Based on optimized parameter estimates for that simulated data set, find estimated abundance values for each of the identified survey estimates. Estimates from each bootstrap population are based on the weighted average across all of the refitted models.	
a. Base simulated abundance estimates for each survey on equations C.7 – C.10	
b. Any elk group with a radio collared animal has $\overline{\hat{\theta}_j}$=1	
c. For years in which there are two survey replicates of a MORA trend count area, also compute the arithmetic average of the abundance estimates across the two replicates for each bootstrap simulation	
iv. Save the abundance estimate values from each simulation.	Saved for each iteration in the bootstrap spreadsheet† , in the Bootstrap worksheet tab
2. Repeat Step 1 until 100 simulations have resulted in 100 simulated abundance estimates	Looping is set on the bootstrap spreadsheet†, in the Bootstrap worksheet tab
3. Based on 100 simulations, estimate the variance of the simulated abundance estimates, and for the average of abundance estimates if surveys are replicated in a single year.	

* This file is saved in the project's /Analysis/ folder as "Mt Rainier and Olympic NP Dbl Observer and Sightability Data Sept 2010, B.xlsm"

† This file is saved in the project's /Analysis/ folder as "Mt Rainier Dbl Observer and Sightability Data Sept 2010, Bootstrap.xlsm"

Future Modeling Analyses

Example 1. OLYM Summer Survey Data Compared to MORA Double-observer Sightability Model

A double-observer sightability model has not been developed yet for OLYM summer surveys. We will continue to collect double-observer sightability trial data and double observer data that can be used to test whether OLYM detection functions are comparable to MORA detection functions. Until there are enough data to perform this test, we will continue to report only the observed (uncorrected) counts and observed composition values for OLYM summer surveys.

The test will be relatively straightforward because aerial survey methods are identical at the two parks. We will include the newly collected OLYM double-observer sightability trial data and double-observer data in a combined data set that also contains the original MORA data. Data from these two parks will be input in program MARK as if they were coming from separate source populations, and then model structures will either treat all observations as if they came from the same population, or separate populations. We will use program MARK to structure some candidate models for detection probabilities that include only one set of parameters for both parks, and other models structured to reflect fitting separate parameters for each park. We may also include models that include some parameters in common for both parks and some parameters that are distinct; for example, a model may include a shared intercept parameter but differing effects of percent concealing vegetation. We will use AICc weights to assess the relative fit of the two categories of models, given the data from both parks.

If the predominant model weights are in support of models that have a single set of parameters for describing the effects of sighting covariates on observer detection probabilities, we will conclude that observer detection probabilities in summer OLYM surveys are comparable to those at MORA. In that case, then the MORA double-observer sightability model can be applied to the OLYM summer data collected since 2008. If that is the result, we would combine the two data sets and estimate a single double-observer sightability model, drawing from the larger data set of observations recorded at both parks.

If, on the other hand, the predominant model weights are in support of models that include separate parameters for two parks, we will conclude that the MORA double-observer sightability model should not be applied to correct for detection bias with OLYM summer survey observations. That result would argue for the estimation of a separate OLYM summer survey model, with parameter estimates based on double-observer sightability trial data and double-observer data from that park. Depending on the number of double-observer sightability trial data points from OLYM summer surveys at that time, it may be necessary to collect additional data before estimating a model. Once there are adequate data, the analysis would follow the same methods that were used to create the MORA double-observer sightability model.

Example 2: Creation of OLYM Spring Double-observer Sightability Model

Double-observer sightability models also have not been developed for OLYM spring surveys. Furthermore, it is not justifiable to apply double-observer sightability models derived on summer ranges to spring surveys. Hence, or consistency with the legacy data collected since 1983, we will continue to base future analyses of population trends of elk on spring trend count areas in OLYM on raw counts of observed elk. We will continue to collect data, however, that can be used to develop a model for correcting detection biases on spring ranges in OLYM as funding permits. Although it may be several years in the future, if we accumulate about100 double-observer sightability trials on spring ranges, we will estimate a double-observer sightability model for use on OLYM spring surveys. Methods will follow the same steps that were used in developing the MORA double-observer sightability model. The models must be separate because the two surveys do not take place in similar habitats, and the covariates recorded for spring surveys are not identical to those recorded during summer.

Example 3: Testing the Applicability of MORA Double-Observer Sightability Model with Future MORA Data

As part of four-year analyses, we will use the continuously collected double-observer data from MORA surveys, and any new double-observer sightability trial data, to test for changes in detection biases. The general model comparison framework would be similar to that used in Example 1, except that we will code the more recently collected MORA data (i.e., collected during 2011 – 2016) as if it came from a different source population than the original data collected in MORA from 2008-2010. We will then structure models either to treat observations from the two time periods as if they came from the same population, or from separate populations. We will use program MARK to structure some candidate models for detection probabilities that include only one set of parameters for both time periods, and other models structured to reflect fitting separate parameters for each time period. We will use AICc weights to assess the relative fit of the two categories of models, given the data from both time periods.

If the predominant model weights are in support of models that have a single set of parameters for describing the effects of sighting covariates on observer detection probabilities, we will conclude that observer detection probabilities in 2011-2016 surveys are comparable to those from the original data. In that case, then the original MORA double-observer sightability model can continue to be applied for making abundance estimates. If that is the result, we would combine the data from the two time periods and update the double-observer sightability model, drawing from the larger data set of observations.

If, on the other hand, the predominant model weights are in support of models that include separate parameters for two time periods, we will conclude that the original MORA double-observer sightability model should not continue to be applied to correct for detection bias. We will examine closely the differences in model averaged beta parameters for the two time periods, in order to diagnose the apparent causes of the change over time. Prescribed actions may include higher training levels for observers or rotation of observer positions, incorporation of recent double observer data into the double-observer sightability model, or reliance only on updated double-observer data to create a new double-observer sightability model.

If discrepancies between the two time periods are such that there is no overlap of the beta parameters for observer intercept, heterogeneity, and the effects of covariates on detection probability, then it may be necessary to estimate a new MORA summer survey model, with parameter estimates based on more recent double-observer sightability trial data and double-observer data. Such a model would use the originally collected double-observer sightability trial data, any additional double-observer sightability trial data that was available at MORA, and recently collected double-observer data, to estimate the model for detection bias.

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Appendix D. Photographs of Covariate Categories

Assigned values for percent concealing vegetation (**SOP 7: Conducting Helicopter Surveys**) should be based on experience and comparison against examples, for reference. Photographs in this appendix were rated according to percent concealing vegetation by a panel of 11 experienced observers from Muckleshoot Tribe, MORA, OLYM, US Geological Survey, and Washington Department of Fish and Wildlife, on June 15, 2010. The legend below each figure lists the consensus value for percent concealing vegetation that the panel concluded.

To assign a value for 'first seen percent concealing vegetation', consider an area that includes the single or multiple elk that were first seen, plus a 10 meter wide (~30 feet) buffer around them. Similarly, to assign a value for whole group percent concealing vegetation, consider the area occupied by all the visible elk in the group, plus a 10 meter wide buffer around them.

Figure D.1. Zero percent concealing vegetation, in herbaceous cover type.

Figure D.2. Zero percent concealing vegetation, in herbaceous cover type.

Figure D.3. Zero percent concealing vegetation, in herbaceous cover type.

Figure D.4. 1-25% concealing vegetation, in forest cover type.

Figure D.5. 1-25% concealing vegetation, in herbaceous cover type.

Figure D.6. 1-25% concealing vegetation, in forest cover type.

Figure D.7. 1-25% concealing vegetation, in forest cover type.

Figure D.8. One to 25 percent concealing vegetation, in forest cover type.

Figure D.9. 26-50% Concealing vegetation, in forest cover type.

Figure D.10. 26-50% concealing vegetation, in forest cover type. In this spring survey, snow is present.

Figure D.11. 26-50% Concealing vegetation, in forest cover type; high contrast light conditions. When considering this value for % concealing vegetation, note the elk in the upper right of the picture.

Figure D.12. 51-75% concealing vegetation, in forest cover type.

Figure D.13. 51-75% concealing vegetation; the panel noted that this degree of cover would be at the upper end of the 51-75% range. The cover type here is ‘open old growth.’

Figure D.14. 76-100% concealing vegetation, in old growth cover type.

Figure D.15. 76-100% concealing vegetation in old growth cover type.

Appendix E. Trend Count Areas and Survey Units

Summer trend count areas at MORA (Narrative, Figure 2 and Figure 3) and OLYM (Narrative, Figure 4) are divided into survey units (Figures E.1 – E.7), to aid in flight and survey logistics. Spring trend count areas at OLYM (Narrative Figure 5) are not subdivided into discrete survey units. Approximate times needed for survey (Table E.1) are based on the area enclosed within each trend count area or survey unit.

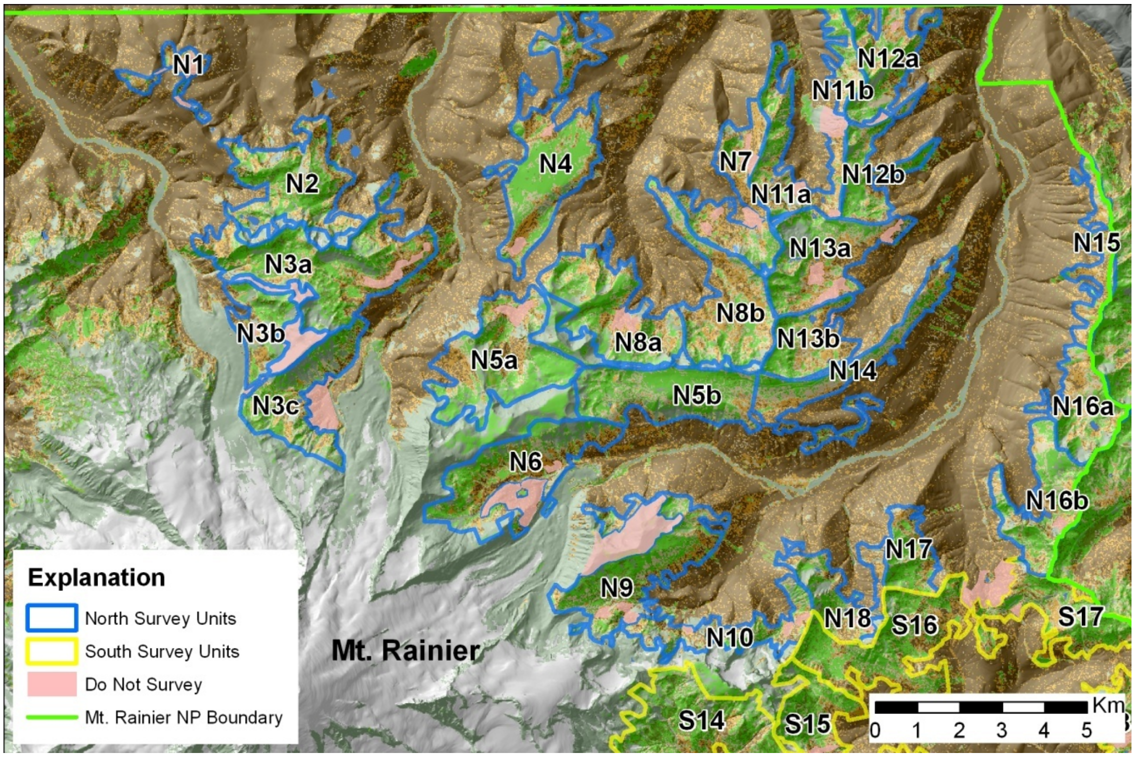

Figure E.1. Survey units within the North Rainier trend count area are outlined in blue, and labeled with unit numbers starting with "N".

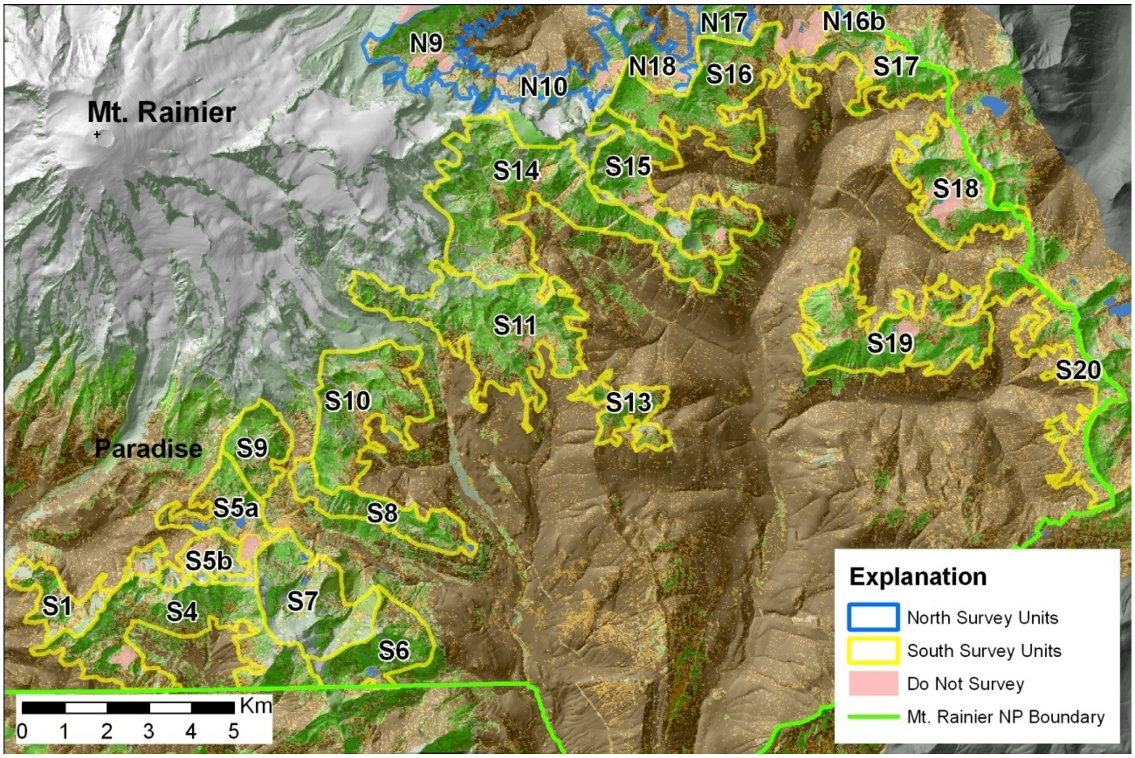

Figure E.2. Survey units within the South Rainier trend count area are outlined in yellow, and labeled with unit numbers starting with "S".

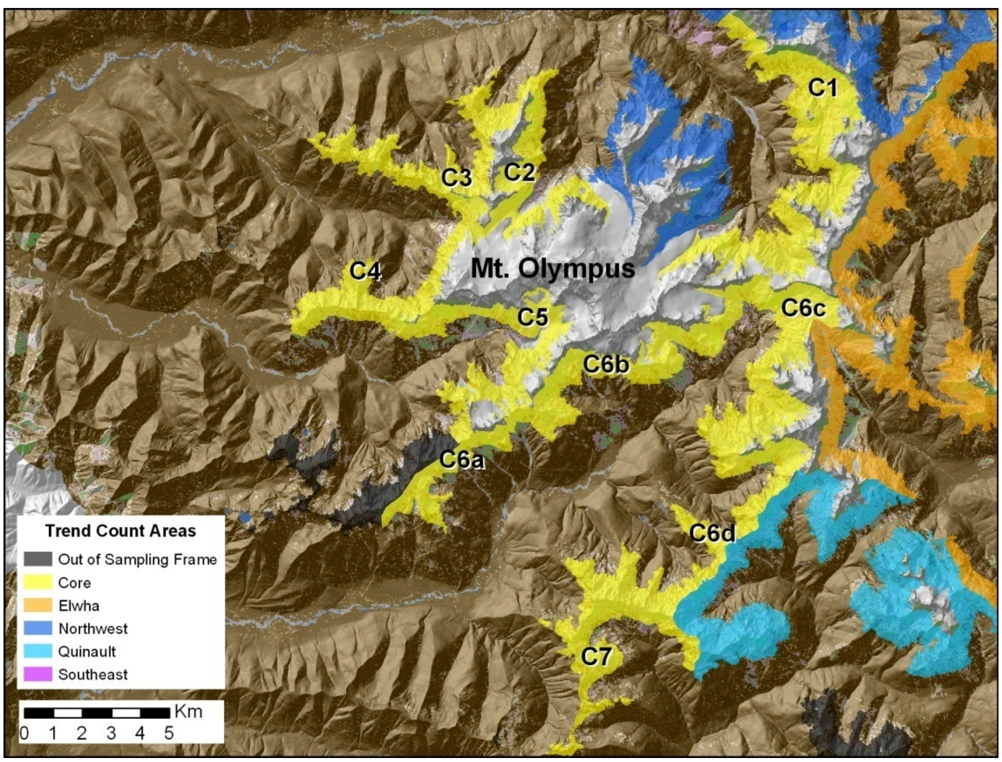

Figure E.3. Survey units within the OLYM Core trend count area are shaded in yellow, with different shading for each survey unit, and labeled with unit numbers starting with "C".

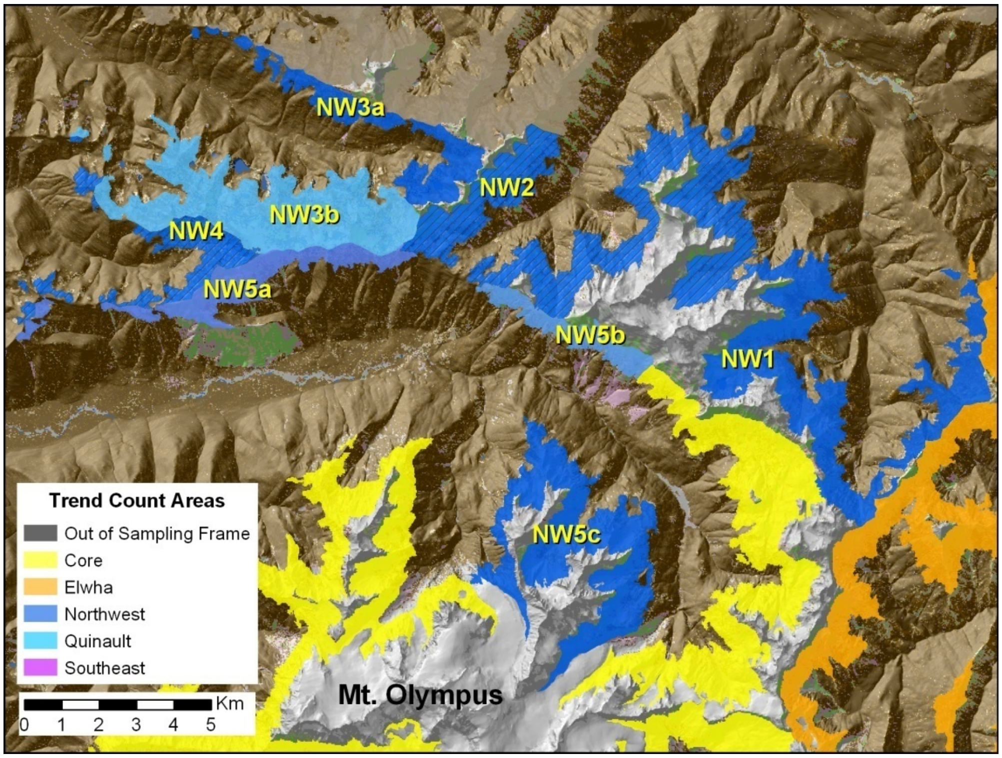

Figure E.4. Survey units within the OLYM Northwest trend count area are shaded in blue, with different shading for each survey unit, and labeled with unit numbers starting with "NW".

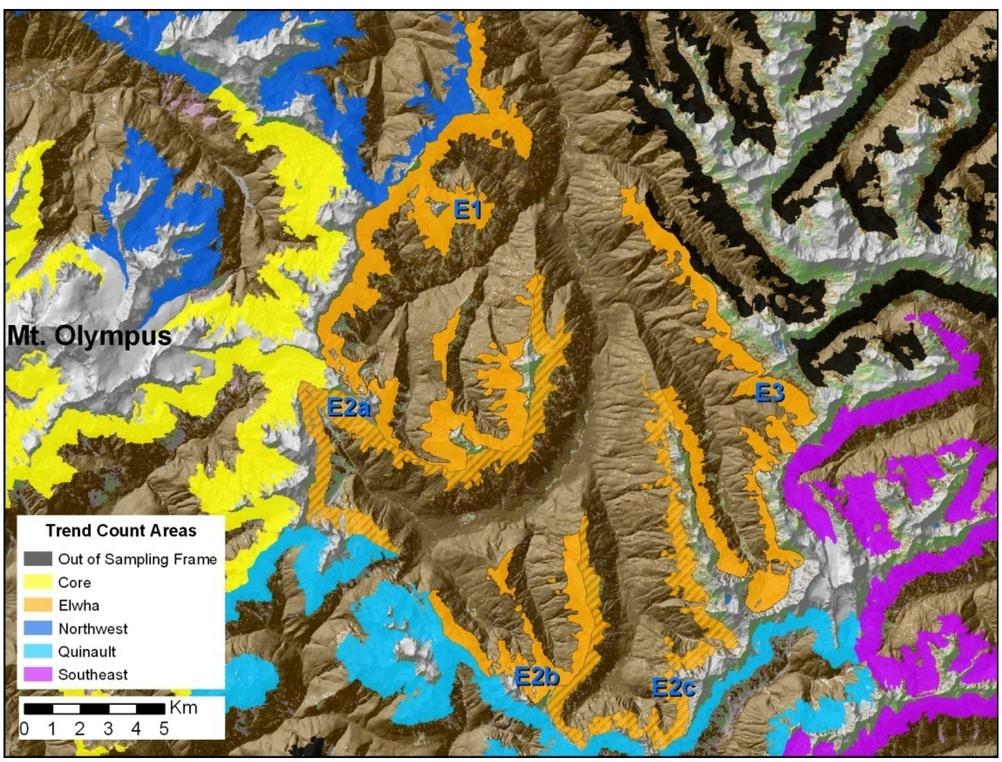

Figure E.5. Survey units within the OLYM Elwha trend count area are shaded in orange, with different shading for each survey unit, and labeled with unit numbers starting with "E".

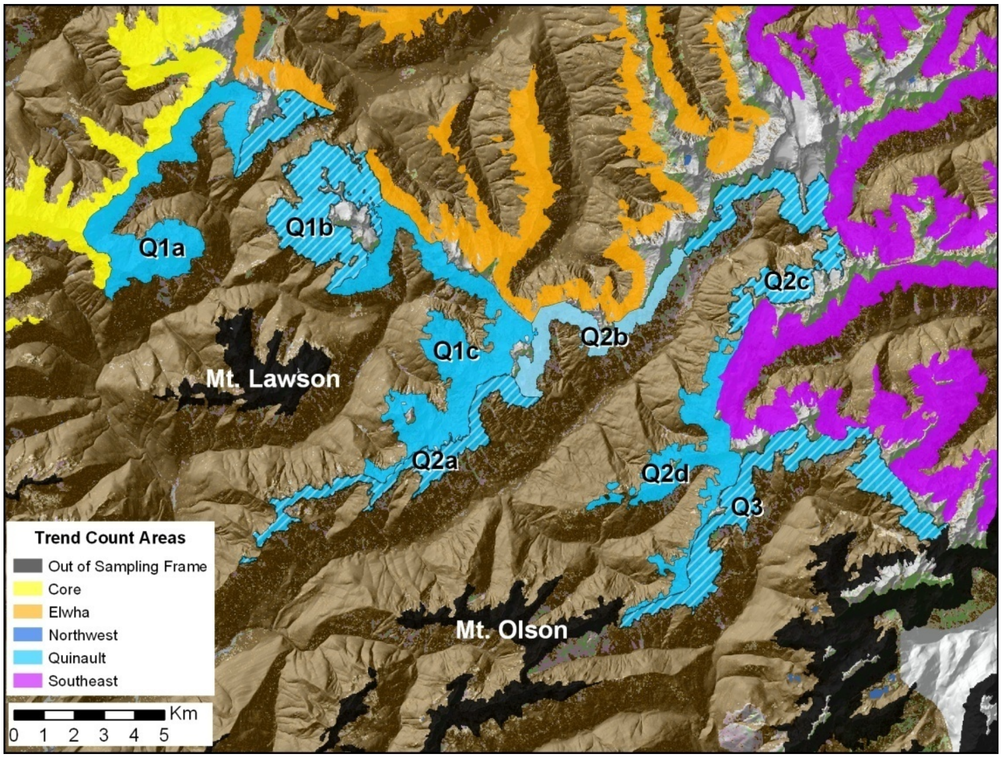

Figure E.6. Survey units within the OLYM Quinault trend count area are shaded in blue, with different shading for each survey unit, and labeled with unit numbers starting with "Q".

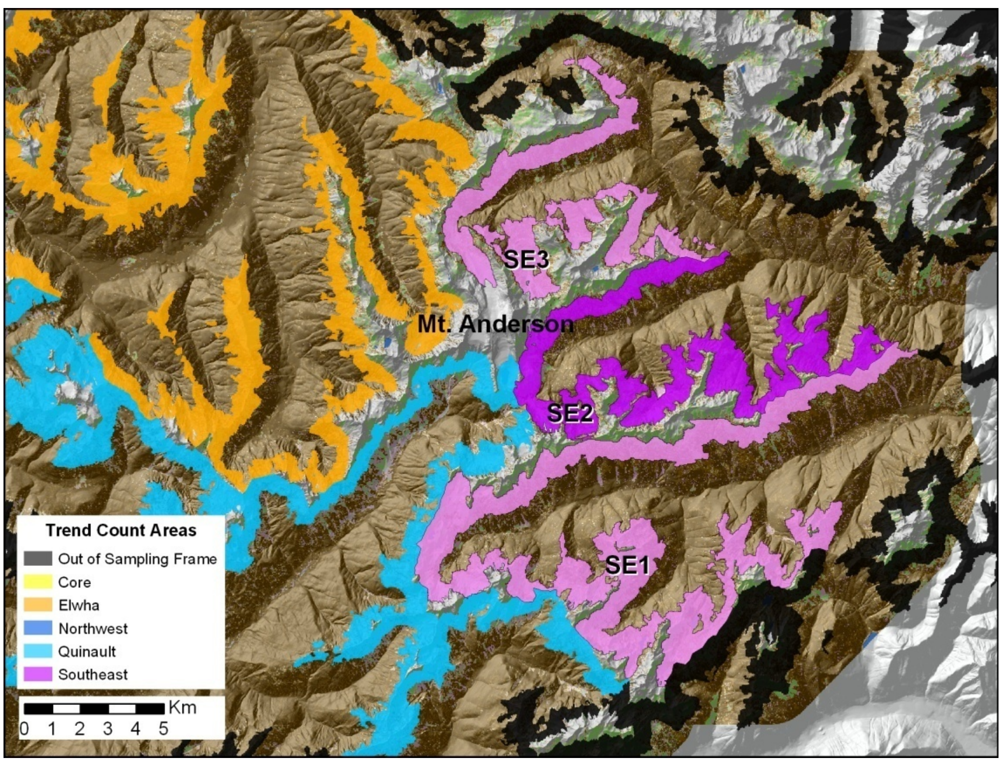

Figure E.7. Survey units within the OLYM Southeast trend count area are shaded in purple, with different shading for each survey unit, and labeled with unit numbers starting with "SE".

Table E.1. Area and approximate survey time needed for summer trend count areas and the survey units within them. Survey time is approximated based on 35 ha / minute for summer surveys, and 25 ha / minute for spring surveys. Survey times do not include ferry times of flight needed to reach or depart from survey units.

Summer trend count areas at MORA

	Area, km^2	Time, min		Area, km^2	Time, min
North Rainier trend count area	103.2	295	South Rainier trend count area	89.31	255
Survey Unit			Survey Unit		
N1	1.04	3	S1	2.1	6
N2	5.08	15	S4	8.48	24
N3a	7.83	22	S5a	2.44	7
N3b	2.3	7	S5b	2.15	6
N3c	4.03	12	S6	3.35	10
N4	6.68	19	S7	5.36	15
N5a	6.21	18	S8	3	9
N5b	5.11	15	S9	2.29	7
N6	5.67	16	S10	6.11	17
N7	3.93	11	S11	8.65	25
N8a	5.44	16	S13	1.87	5
N8b	5.12	15	S14	11.33	32
N9	5.71	16	S15	5.3	15
N10	2.9	8	S16	6.36	18
N11a	3.64	10	S17	4.08	12
N11b	1.35	4	S18	4.76	14
N12a	3.3	9	S19	6.98	20
N12b	2.54	7	S20	4.7	13
N13a	4.9	14			
N13b	2.68	8			
N14	3.84	11			
N15	2.19	6			
N16a	3.13	9			
N16b	3.89	11			
N17	1.86	5			
N18	2.83	8			

Table E.1. Area and approximate survey time needed for summer trend count areas and the survey units within them (continued). Survey time is approximated based on 35 ha / minute for summer surveys, and 25 ha / minute for spring surveys. Survey times do not include ferry times of flight needed to reach or depart from survey units.

Summer trend count areas at OLYM

	Area, km^2	Time, min		Area, km^2	Time, min
Core trend count area	93.13	266	Northwest trend count area	74.03	212
Survey Unit			Survey Unit		
C1	17.41	50	NW1	14.09	40
C2	6.37	18	NW2	17.73	51
C3	7.29	21	NW3a	5.24	15
C4	8.07	23	NW3b	13.12	37
C5	10.98	31	NW4	4.21	12
C6a	5.53	16	NW5a	5.04	14
C6b	8.62	25	NW5b	2.69	8
C6c	10.85	31	NW5c	11.91	34
C6d	10.64	30			
C7	7.37	21			

Quinault trend count area	79.81	228	Elwha trend count area	82.12	235
Survey Unit			Survey Unit		
Q1a	11.98	34	E1	17.18	49
Q1b	12.32	35	E2a	14.11	40
Q1c	15.89	45	E2b	8.83	25
Q2a	5.96	17	E2c	13.87	40
Q2b	5.41	15	E3	28.13	80
Q2c	8.22	23			
Q2d	9.12	26			
Q3	10.91	31			

Southeast trend count area	85.51	244
Survey Unit		
SE1	41.73	119
SE2	25.07	72
SE3	18.71	53

Spring trend count areas at OLYM

	Area, km^2	Time, min
Hoh trend count area	26.80	107
South Fork Hoh trend count area	11.09	44
Queets trend count area	23.74	95

Appendix F. Administrative Record

Overview

The following administrative history briefly summarizes key steps, meetings, and documentation associated with the development of elk monitoring protocols for Mount Rainier and Olympic National Parks. All of the references cited here are stored in the project folder: \Documents\Protocols\Administrative Record.

Choosing and Prioritizing Vital Signs for Long-Term Ecological Monitoring

In several stages, individual parks of the North Coast and Cascades Network (NCCN) identified topics (vital signs) and priorities for ecological monitoring. In the first stage, parks held 'Vital Signs' workshops during which each park identified and justified a list of potential vital signs and their associated monitoring questions. Three parks in the network, including Lewis and Clark National Historical Park, Mount Rainier National Park, and Olympic National Park identified elk monitoring as a high monitoring priority. For a more complete summarization of the process used to identify and prioritize Vital Signs see Weber et al. (2005).

Despite high ranking of elk monitoring by three individual parks, funding limitations, the expense of elk monitoring, and higher priorities delayed the initial development of elk monitoring protocols relative to others in the network. Two critical reviews of the NCCN monitoring program provided impetus leading to the development of this elk monitoring program. On 24-25 May 2005, the network convened a scientific panel to review the draft monitoring plan, and make recommendations on how to allocate available funding. The Panel recommended increasing funding for elk monitoring due to the high management concern, public interest, and strong ecological effects of elk in park ecosystems (Anonymous 2005).

Additionally, in 2007, the National Park Service's Inventory and Monitoring Program and the USGS Status and Trends Program joined in conducting an interagency operational review of the network's monitoring program to identify the status of ongoing monitoring programs funded by the network, to review the status of USGS involvement working with the network in developing monitoring protocols, and identify any unmet protocol development needs. One key outcome of the meeting was the recommendation to proceed with funding the development of elk monitoring within the network (Anonymous 2007). The development of this protocol for monitoring elk in Olympic and Mount Rainier National Parks is a direct outcome of that decision and subsequent commitments of funding by the USGS Status and Trends Program, the NCCN, the Muckleshoot Indian Tribe (MIT), the Puyallup Tribe of Indians (PTOI) and the Washington Department of Fish and Wildlife (WDFW).

In 2007, the network ranked all protocols as belonging to either a Tier-1 of protocols that would be guaranteed funding at the highest priority, or to Tier-2 protocols that would be funded provisionally as funding allowed. In April of 2008, the network's Board of Directors approved elk monitoring as a Tier-2 protocol. Although this limited both the amount of funding available and the security of long-term funding, the NCCN made the decision to move forward in developing this monitoring protocol. The Wildlife working group of the NCCN decided to develop a ground-based pellet and road survey protocol for implementation in Lewis and Clark National Historical Park and this aerial survey protocol for implementation in Mount Rainier and Olympic National Parks.

Scientific Scoping and Proposals

As elaborated in the protocol narrative, there has been a long history of elk monitoring in both Olympic and Mount Rainier National Park that provided the foundation for this monitoring protocol. In June 2007, the USGS and the National Park Service jointly hosted a workshop to review elk monitoring methods that have been used in the network parks and provide suggestions for future monitoring development. We invited a panel of six elk monitoring specialists and biometricians, as well as over 20 elk monitoring practitioners from the network's parks, from three sovereign tribes, and from WDFW. Each of the workshop participants was provided general information on the network's monitoring program and specific information on historical and current elk monitoring procedures used in each of the NCCN parks. Workshop participants provided a written set of recommendations for future elk monitoring in the NCCN parks, which were summarized in a memo to the NCCN (Jenkins 2007), and which provided the basis for proposal development.

In August 2007, we also submitted a proposal to the USGS Status and Trends Program, National Parks Monitoring Project, to support this protocol development from 2008 to the present (Jenkins et al. 2007). That proposal was awarded funding for Fiscal Years 2008-2010 which, combined with funding from the NCCN I&M program, LEWI, MORA, OLYM, MIT, PTOI, WDFW, and non-governmental organizations, fully funded this protocol development and testing beginning in 2008.

Protocol Development

This protocol was developed as a cooperative project among Mount Rainier and Olympic National Parks, the Muckleshoot Indian Tribe, the Puyallup Tribe of Indians, and the Washington Department of Fish and Wildlife. Each year we conducted meetings of project participants to reach consensus on survey design and methodologies, and to coordinate logistics for upcoming aerial surveys and sightability trials. Key steps in chronicling the protocol development were the preparation of a protocol development summary (Anonymous, 2008), a protocol monitoring brief (Anonymous 2009), notes from annual meetings with project participants, and annual progress reports submitted to the USGS Status and Trends Program, National Parks Monitoring Project (Jenkins and Griffin 2008, Griffin and Jenkins 2009, 2010) and National Park Service (Griffin et al. 2009).

Protocol development has proceeded as scheduled from the beginning, but for only one logistical issue. In 2008-2009, we experienced a complete failure of GPS radio-collars in Olympic National Park, which delayed development of an aerial elk sightability model for Olympic National Park. As described in the protocol, the manufacturer of the faulty lot has replaced these collars and they will be used to develop the sightability model during the first years of project implementation.

Protocol Review and Revision

Prior to submission for peer review, the protocol was reviewed sequentially by all of the authors, and by the NCCN Monitoring Coordinator. Peer review was managed by the Forest and Coastal Research Manager of USGS Forest and Rangeland Ecosystem Science Center. Reviews by two anonymous peer reviewers, the Regional Monitoring Coordinator of NPS, the NPS Pacific West Region I&M Program Manager, and the Director of the USGS Stats and Trends Program were received in August 2011. The protocol was revised in August 2011; the NCCN I&M Monitoring

Coordinator and MIT, PTOI, and WDFW coauthors reviewed and commented on the revision in September 2011. The revised protocol was resubmitted to the USGS peer review manager and to the NPS Regional Monitoring Coordinator in September 2011. The protocol was approved in October 2011.

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Jenkins, K. J. 2007. Elk monitoring review in the North Coast and Cascades Network. Unpublished summary of findings from the USGS/NPS Elk Monitoring Workshop, June 4-5, 2007. US Geological Survey, Port Angeles, Washington. *Memo summarizes key findings and contains individual comments of six invited elk monitoring specialists participating in the workshop.*

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Appendix G. Job Hazard Analysis

OLYMPIC NATIONAL PARK **Job Safety Analysis**	**Job Title: Various**	**Date: Aug 3 2011** **Analysis by: Patti Happe**
Division: NCCN	**Wildlife: Elk Aerial Survey**	**Reviewed by: Bill Baccus**
Location: Olympic National Park, Mount Rainier National Park	**Who does job: Qualified Park and NCCN Staff** **Supervisor: Patti Happe**	**Approved by:**
Personal Protective Equipment: Nomex flight suits, nomex gloves, helicopter helmet, leather boots at least 8"tall, ear protection		
Training and/or certifications: varied depending on task; see aviation safety plan		**Permits**: Aviation safety plan approved by Park aviation manager.

A. SEQUENCE OF BASIC JOB STEPS	**B. POTENTIAL JOB HAZARDS**	**C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT**
Identify steps and sequence of work activities	Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	Determine specific controls and safe behaviors for each hazard.
Travel to Field Locations in Vehicle	Driving hazards; i.e., accident	Use defensive driving techniques **Expect oncoming traffic on one-lane roads in park**
	Drive on unfamiliar dirt roads	Be alert for potential snow or black ice when temperatures are near freezing **Watch for deer, elk and other wildlife, and adjust speeds to safely operate around areas of high use** **Look out for hazards such as rocks and soft shoulders** **Lock vehicles and leave as few valuables as possible** Obey traffic laws and wear seatbelt at all times Do not drive when fatigued, be familiar with route or prepare for unknown route Do not talk on radio or cell phone while driving Do not put hot drinks on your lap Be familiar with the vehicle and its operation Check gauges, tires, wipers, fluids and replace when necessary Check vehicle has spare tires, jumper cable and jack with all parts.

A. SEQUENCE OF BASIC JOB STEPS	B. POTENTIAL JOB HAZARDS	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT
Performing surveys in a Helicopter	Hazard from rotor blades while loading and unloading	All crewmembers must be current in aviation training. B3 is the minimum requirement, and that is allowed only if there is a qualified helicopter manager on site. Most members will have current helicopter crewmember training (S271). Perform a safety briefing at the beginning of each day; follow all the guidelines in the safety briefing. Items covered include: personal protection equipment, methods for approaching and departing the aircraft, transport of items from aircraft, location of emergency equipment, crash procedures, securing loose items in aircraft.
	Aviation hazards while flying	Prepare and have an approved aviation safety plan for each survey. All crewmembers, pilot and park dispatch are familiar with the plan Follow the aviation safety plan at all times during the flight, this includes location of known aviation hazards, communication and flight following procedures, and a risk analysis (including Go-No Go decisions made by pilot and experienced managers). Perform current load calculations for flights whenever conditions change.

NPS 105/112382, 149/112382, January 2012

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U.S. Department of the Interior

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