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Natural Resource Stewardship and Science

Alpine and Subalpine Vegetation Monitoring Protocol for the North Coast and Cascades Network

Natural Resource Report NPS/NCCN/NRR—2012/570

ON THE COVER
Heather meadow in Olympic National Park, Easy Ridge in North Cascades National Park Service Complex, Lou Whiteaker monitoring Alpine Legacy plots in Mount Rainier National Park, lush herbaceous meadow in Mount Rainer NP, and heather community on Muir Corridor in Mount Rainier NP (clockwise from upper left)

Photographs courtesy of: Olympic National Park, North Cascades National Park Service Complex, Mount Rainier National Park.

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Natural Resource Report NPS/NCCN/NRR—2012/570

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Abstract

Subalpine and alpine areas are ecologically important zones that provide popular recreational opportunities for visitors to Mount Rainier (MORA), North Cascades (NOCA), and Olympic (OLYM) National Parks. The subalpine parkland is a mosaic of tree clumps and herbaceous meadows extending from forestline to treeline. The sparsely vegetated alpine zone continues up to the permanent ice and snow cover the peaks of the Cascades and Olympics. Collectively, the subalpine and alpine zones comprise the alpine treeline ecotone – a transition between the closed canopy forests below and bare rock or ice covering the mountain or ridge tops. Vegetation distribution and composition in this zone is primarily determined by low temperatures, snow depth, and duration of snow cover and therefore is very sensitive to climate change.

The overarching goal of the Alpine and Subalpine Monitoring Protocol is to provide accurate information regarding the status and trends of vegetation in the alpine treeline ecotone in order to inform management decisions affecting these areas. Specific objectives of the protocol are to:

1. Determine the status and trends in vegetation composition and structure of alpine vegetation in MORA, NOCA, and OLYM.
2. Determine the status and trends in vegetation composition and structure of subalpine vegetation in MORA, NOCA, and OLYM.
3. Determine the status and trends in vegetation composition and structure of legacy (historic, non-random) vegetation plots in MORA.
4. Determine the status and trends in soil temperature and snow cover period in subalpine and alpine communities in MORA, NOCA, and OLYM and at legacy plots in MORA.
5. Determine status and trends in the structure and condition of whitebark pine stands in MORA, NOCA, and OLYM.

The protocol utilizes a general random tessellation stratified sample (GRTS) of sites to monitor status and trends of vegetation, soil temperature, and snow pack in subalpine and alpine zones. The target population includes subalpine and alpine areas on gentle slopes within 1.5 km of trails and roads. Boundaries of target populations were developed to include the range of environmental variation in the alpine treeline ecotone while keeping safe travel times to monitoring sites within reasonable hiking distances. Detailed standard operating procedures (SOPs) for field data collection, data management, data analysis, and reporting are included to standardize methods for long-term monitoring.

Acknowledgments

We would like to thank the field crews who tested, refined, and retested the monitoring methods for whitebark pine; conducted pilot surveys on subalpine vegetation; and conducted office and field review of the GRTS points. Mark Buffo assisted with review of whitebark pine monitoring methods and development of data sheets and SOPs. Natalya Antonova assisted with GIS preparation of field maps for whitebark pine in the early stages of this protocol. David Pillmore and Ronald Holmes assisted John Boetsch in the development of the whitebark pine components of the database.

Introduction

This protocol narrative outlines the rationale, sampling design and methods for monitoring alpine and subalpine vegetation in the North Coast and Cascades Network (NCCN). The primary mission of the National Park Service (NPS) is to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations. In 2000, the NPS Inventory and Monitoring Program (I&M) was established to provide scientifically sound information on natural resources by documenting the current status and long term trends in the composition, structure, and function of park ecosystems and to determine how well current management practices are sustaining those ecosystems (National Park Service 2001, Fancy et al. 2009). The I&M Program is organized nationally around 32 monitoring networks including approximately 270 park units. Each network identifies key indicators or "vital signs" to track the overall condition or "health" of park natural resources and to provide early warning of situations that require intervention (Davis 1989, 2005, Fancy et al. 2009). As one of these networks, the NCCN is composed of seven NPS units including three with significant high-elevation vegetation: Mount Rainier National Park (MORA), North Cascades National Park Service Complex (NOCA), and Olympic National Park (OLYM) (Figure 1).

Since 1997, numerous monitoring workshops and meetings have been conducted in the NCCN to identify key park ecosystem components, core indicators within each ecosystem component, and finally to allocate funding to the development and implementation of monitoring protocols (Weber et al. 2009). Vegetation was identified as one of ten vital signs for the network; the other nine were landscape dynamics, climate, mountain lakes, glaciers, landbirds, water quality, intertidal, fish assemblages, and elk. Vegetation monitoring focuses on documenting vegetation change along the elevation and climate gradients spanned by network parks: lowland prairies, forests, and alpine/subalpine vegetation. The structure and content of this protocol adhere to the outline and recommendations adopted by the NPS in Oakley et al. (2003). Methodological details of the protocol are addressed in a set of standard operating procedures (SOPs) found at the end of the document, along with appendices containing additional supporting materials referred to in the narrative.

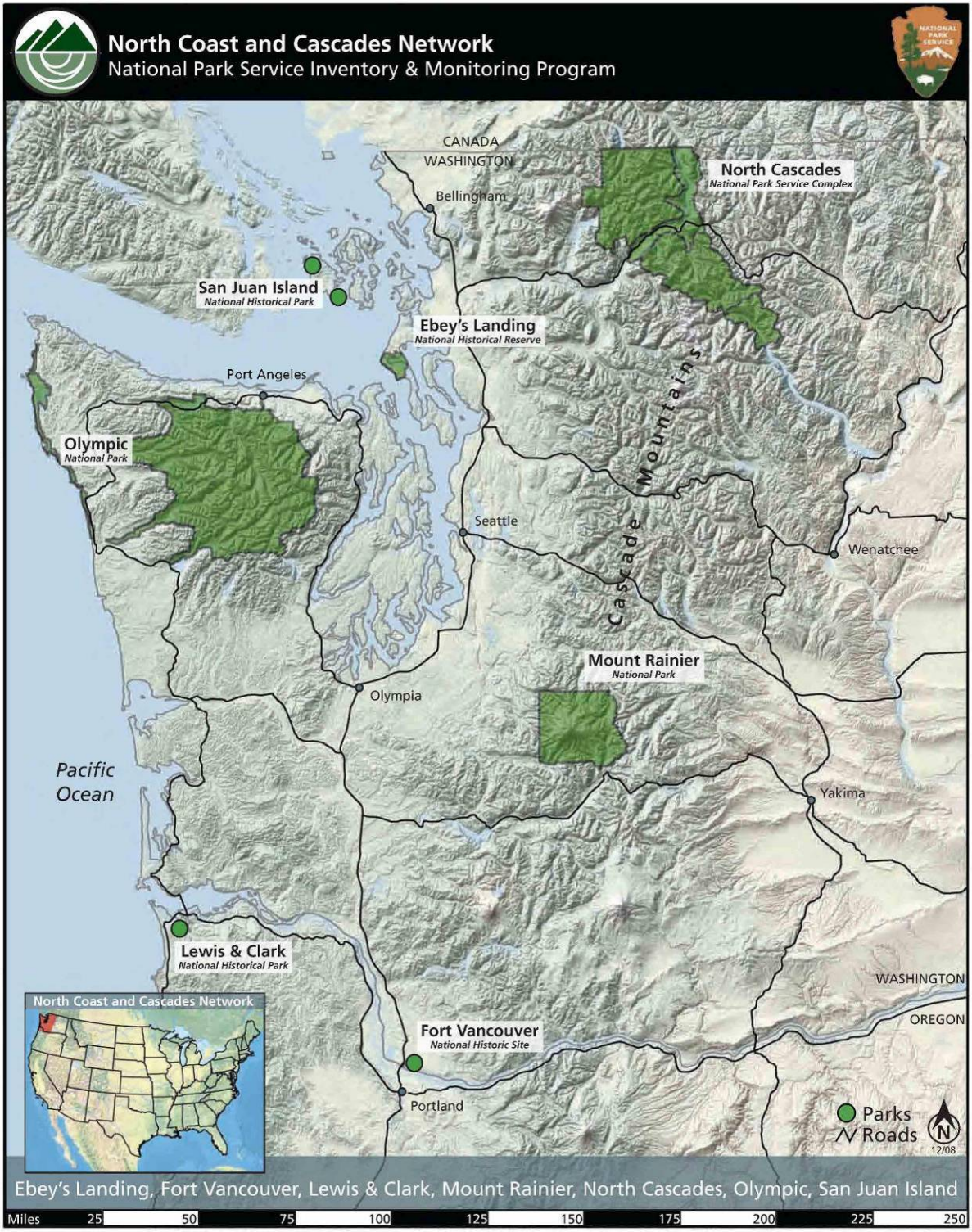


Figure 1. Map illustrating the location of park units within the North Coast and Cascades Network.

1. Background and Objectives

A. Background

Subalpine and alpine areas are ecologically important zones that provide popular recreational opportunities for visitors to Mount Rainier, North Cascades, and Olympic National Parks (Johnson et al. 1991, Rochefort et al. 1994, Rochefort and Peterson 1996). The subalpine parkland extends from closed canopy forest (forest line) up to the highest elevation of upright trees (treeline). The alpine zone continues from treeline up to permanent snow and ice or mountain peaks of the Cascades and Olympics. The entire area, from forest line up to permanent snow, is a broad transition zone, often referred to as the alpine treeline ecotone (Malanson et al. 2007, Stueve et al. 2009). Vegetation composition, structure, and spatial distribution reflect climate and topography (Douglas and Bliss 1977, Holtmeier and Broll 2005, Malanson et al. 2007). Low temperatures are a primary determinant of the distribution of alpine and subalpine areas and therefore, these areas are very sensitive to climate warming (Körner and Larcher 1988, Lesica and Steele 1996, Pauli et al. 2007). Dramatic changes in tree distribution and herbaceous species composition are predicted (Bachelet and Neilson 2000, Grace et al. 2002, Holtmeier and Broll 2007) and have recently been documented in some mountain ranges (Kullman 2002, Canonne et al. 2007, Pauli et al. 2007, Beckage et al. 2008, Lenoir et al. 2008).

Review of Alpine and Subalpine Vegetation and Environmental Conditions

Alpine and subalpine vegetation communities in the NCCN are quite diverse spatially and over 90 plant communities have been documented as occurring in this zone (Crawford et al. 2009). Physical characteristics of a site may change over very short distances, and although these differences may seem minor, they may result in steep gradients in soil moisture, temperature, and length of growing season (Douglas 1970, Canaday and Fonda 1974, Henderson 1974). The maritime climate is characterized by long winters with abundant snowfall and moderate temperatures and short, cool summers with low precipitation. Thus nearly all the moisture available for plant growth comes from melting snowpacks, which are greatly influenced by topography and elevation.

In the Pacific Northwest, the subalpine parkland is a broad zone, often extending 300 to 500 meters in elevation (Franklin and Dyrness 1988). Vegetation cover is generally continuous and consists of a mosaic of tree clumps, individual trees, ericaceous dwarf-shrublands, and herbaceous meadows (Douglas 1970, Henderson 1974, Franklin and Dyrness 1988). The alpine zone is a narrower band and vegetation is sparsely distributed and includes patches of sedge-turf communities, subshrubs, or krummholz trees interspersed between snowfields, talus slopes, and fellfields (Douglas and Bliss 1977, Edwards 1980). Elevations of forestline (closed canopy forest) and treeline (highest elevation with upright trees) vary with both latitude and aspect reflecting the rugged topography of the Cascade and Olympic Mountains (Douglas 1972, Franklin and Dyrness 1988). In the northern Cascades, continuous forest ends at 1,280 m on northern slopes and 1,580 m on southern slopes (Douglas 1972, Douglas and Bliss 1977). Variations in forestline and treeline elevations are similar in the Olympics and in Mount Rainier. Kuramoto and Bliss (1970) noted that subalpine communities occur from 1,350 m in “snow-laden” north-central Olympics to 2,000 m in drier northeastern areas. In Mount Rainier National Park, forestline ranges from 1,646 m at Paradise (south) to 1,951 m at Sunrise in the northeast portion of the park. Treeline elevations vary from 2,100 m at Paradise to 1,840 m at Spray Park in the northwest section of the park (Edwards 1980).

Although a number of tree species occur in the alpine treeline ecotone (Crawford et al. 2009), whitebark pine (*Pinus albicaulis*) has been the focus of an increasing number of studies in the past decade due to population declines associated with the introduction of white pine blister rust (*Cronartium ribicola*) (Kendall and Keane 2001, Tomback et al. 2001, Murray and Rasmussen 2003, Shoal and Aubry 2006, Aubry et al. 2008, Rochefort 2008, Smith et al. 2008). Whitebark pine has been referred to a keystone species in high-elevation areas of western North America (Tomback et al. 2001). Within the NCCN, it is found primarily in the northeast portion of MORA, eastern areas of NOCA and in a few small populations in the northeastern corner of OLYM. Pilot surveys conducted in MORA and NOCA revealed disappointing 5 year trends (2004-2009) in the condition of whitebark pine stands (Appendix B). In MORA, the proportion of uninfected trees (>2.54 cm diameter at breast height, dbh) decreased from 39% to 29% while infection rates rose from 15% to 18% and mortality increased from 46% to 52%. In NOCA, the proportion of uninfected trees decreased from 54% to 40% and infection rates increased from 29% to 31% while mortality increased from 16% to 29%. Infection rates in saplings (individuals taller than 50 cm but <2.54 cm dbh) increased in both parks (25% to 43% in MORA and 17% to 21% in NOCA), although live sapling density remained stable. Incidence of mountain pine beetle was fairly low in each park (1% of sites in NOCA and <1% of sites in MORA).

B. Rationale for Monitoring the Alpine and Subalpine Vegetation in the NCCN

The velocity of climate change and the associated responses of the biota will vary across global and local landscapes, but the alpine treeline ecotone is expected to respond fairly quickly to projected changes (Holtmeier and Broll 2005, Canonne et al. 2007, Loarie et al. 2009). Climate models for the Pacific Northwest project increases in average annual temperatures of 1.1° C by the 2020s, 1.8° C by the 2040s, and 3.0° C by the 2080s (Mote and Salathé 2010). Snowpack has already declined by approximately 15-35% since the 1930s, and warming future temperatures will continue to reduce the duration of snow cover and the April 1 snow water equivalent, altering length of the growing season and available soil moisture in high-elevation areas (Hamlet et al. 2005, Mote et al. 2005, Mote et al. 2008).

The mountainous landscape of the Pacific Northwest is often associated with beautiful subalpine meadows and fields of flowers, but true subalpine and alpine ecosystems comprise only a small portion of the region, and the majority of these areas are managed by federal agencies (Figure 2, Table 1). High-elevation NCCN parks have a responsibility to monitor changes in this ecotone both to inform our management and to provide reference points for comparison with altered environments (Weber et al. 2009). Park management will need to rely on the development of active adaptive management strategies and tactics that are closely linked to on-going monitoring programs, considering the magnitude of projected ecosystem changes in response to climate change (Lawler 2009, Lawler et al. 2009). The overarching vision for NCCN Alpine and Subalpine Vegetation Monitoring Program is to understand the response of vegetation within the alpine treeline ecotone to climate change and to utilize this information for the development of park management policies.

Shifts in spatial distribution of flora and fauna will alter the appearance of park landscapes in the NCCN, influencing visitor experiences, ecosystem services, wildlife habitat, and park management (Rochefort and Peterson 1996, Fischlin et al. 2007, Cole et al. 2008, Lawler et al. 2009). Broad biome shifts are predicted altering geographic distributions of forests, prairies, subalpine parklands, and alpine meadows (Woodward and Williams 1987, Woodward et al.

2004, Gonzalez et al. 2010). Expansion of tree islands in the subalpine parkland and rising treelines may be the most visible changes in high-elevation landscapes. Palaeoecological studies provide evidence that altitudinal treeline locations have fluctuated throughout the Holocene in response to climate with advances during warm periods and retreats during cooler climates (e.g., LaMarche 1973, Markgraf and Scott 1981, Kearney and Luckman 1983, Rochefort et al. 1994). Contemporary studies have documented expansion of tree islands in subalpine areas (Klasner and Fagre 2002, Bekker 2005, Harsch et al. 2009, Stueve et al. 2009) and illustrated that species interactions and microtopography interact with climate to influence spatial distribution and periodicity of tree establishment (Germino et al. 2002, Alftine et al. 2003, Maher et al. 2005, Resler et al. 2005, Malanson et al. 2007, Haugo and Halpern 2010).

Changes in temperature, water availability, disturbance regimes, air pollution, and introduced pests may also influence the condition of arboreal plant communities (van Mantgem and Stephenson 2007, van Mantgem et al. 2009). Recently, a number of studies have reported increased tree mortality in unmanipulated forests of western North America over the last several decades (e.g., van Mantgem and Stephenson 2007, van Mantgem et al. 2009). Although tree mortality occurs throughout the life of forest stands, mortality in early successional stages often results from competition with other trees while mortality in late-successional stands is frequently attributable to external environmental factors (Franklin et al. 1987, Oliver and Larson 1990, Franklin et al. 2002). The NCCN Forest Vegetation Monitoring Protocol (Acker et al. 2010) was developed to monitor mortality and species composition changes caused by environmental drivers in late-successional, coniferous forests. In subalpine areas, warming temperatures may increase mortality of whitebark pine by enhancing both the spread of blister rust from needles to bole and expanding the elevational distribution of native mountain pine beetles (*Dendroctonus ponderosae*) to stressed trees at higher elevations (Larsen 2010, Logan et al. 2010). Loss of whitebark pine, as an early successional species, may alter the resilience of these areas to climate change because its role in facilitating establishment of other species will be reduced (Resler and Tomback 2008).

Shifts in distributions of herbaceous vegetation, shrubs, and sedges may not be apparent to the casual observer, but observational studies and manipulative experiments suggest dramatic future changes above treeline (Theurillat and Guisan 2001, Walther et al. 2002, Grabherr et al. 2004). Over the last century, studies have documented increased vascular plant species richness on European mountain summits as a result of upward plant migrations (Walther et al. 2005, Pauli et al. 2007, Odland et al. 2010). Interestingly, these migrations have resulted in increased species richness of individual areas (alpha diversity), but decreased spatial heterogeneity and beta-diversity (i.e., similarity among summits) (Jurasinksi and Kreyling 2007, Odland et al. 2010). Experimental warming of tundra plant communities have documented increased height and cover of graminoids and deciduous shrubs and decreased growth of mosses, lichens, and forbs (Chapin et al. 1995, Harte and Shaw 1995, Arft et al. 1999, Walker et al. 2006). Cannone et al. (2007) assessed vegetation change in the European Alps between 1953 and 2003 and found that patterns of vegetation change varied with altitude and functional types. Shrub cover increased between 2,230 and 2,500 m in elevation, grasslands shifted upward, and wetlands decreased at lower elevational bands, suggesting responses to decreased duration of snow cover and changing soil moistures. Although there are general trends in the response of functional types across many studies, these studies also document differences between species, elevations, and localities. Walker et al. (2006) found tundra growth responses occurred rapidly following two seasons of

temperature increases of 1-3° C, but Price and Walker (1998, 2000) found that four years of warming had no effect on subalpine plant communities (i.e., species richness or distribution). Kudo et al. (2010) used open-top-chambers to increase temperatures in fellfield and snowbed communities by 1.1-1.8° C over seven years in northern Japan. They found that vegetation height and canopy volume increased at fellfield sites, but not at snowbed sites. They concluded that duration of snow cover, which they had not manipulated, was still the limiting factor for snowbed communities rather than mean summer temperature. They did see a difference between low and high elevation fellfields; deciduous shrubs increased at the lower site and graminoids at the upper elevation site.

Projections of future herbaceous vegetation composition are difficult to develop for high-elevation areas because vegetation response is influenced by growth limiting factors which vary by species, elevation, slope, topography, plant functional group, and species growth strategies (Chapin and Shaver 1985, Klanderud 2008). Limiting factors may change over time as warming temperatures increase nutrient availability and alter community structure and dynamics (e.g., competition for light) (Chapin et al. 1995, Klanderud and Totland 2005). Alpine and subalpine landscapes in the NCCN are extremely heterogeneous due to varied topography, elevation range, and climate patterns across the Cascades and Olympics. This protocol was developed to provide methods to monitor vegetation change in the alpine treeline ecotone including changes in herbaceous plant communities, whitebark pine stands, and tree establishment in subalpine and alpine meadows.

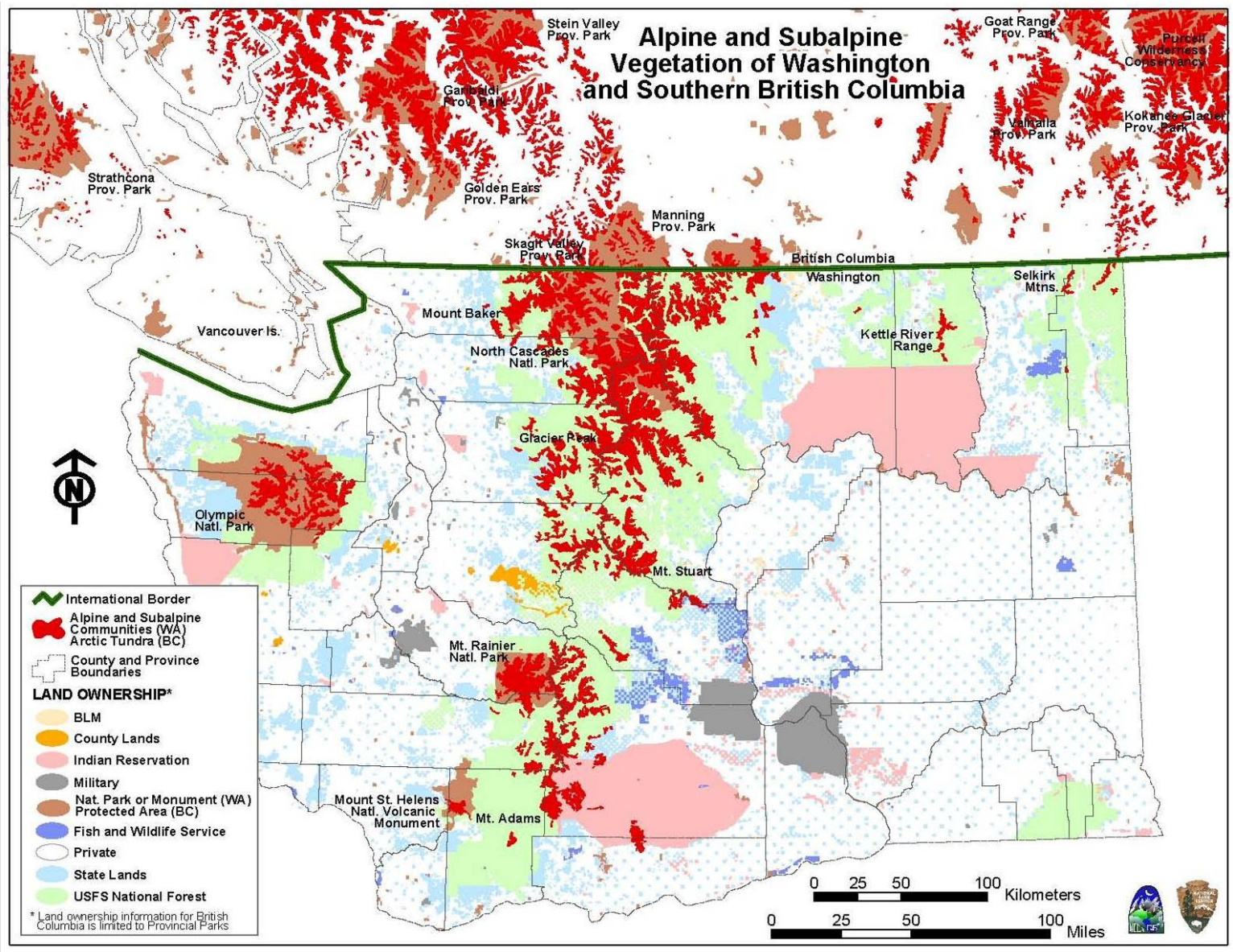


Figure 2. Alpine and subalpine habitat in Washington and southern British Columbia.

Table 1. Ownership of alpine and subalpine areas of Washington[1].

Ownership	Washington Hectares (%)[2]
Bureau of Indian Affairs	25,868 (3.0)
Bureau of Land Management	323 (<0.1)
USFWS	1,148 (0.1)
NPS	235,721 (27.7)
USFS	562,519 (66.2)
State lands	13,901 (1.6)
Private lands	10,170 (1.2)
Total Subalpine/ Alpine	849,651
Permanent Snow and Ice	55,113(6.5)
Total Area in State	17,486,061 (4.9)[3]

[1] data compiled from Washington Department of Fish and Wildlife 1999 and BECWeb 2011

[2] % of total alpine or subalpine area, within the state, under this management

[3] % of state that is subalpine and alpine

C. Measurable Objectives

The goal of the Alpine and Subalpine Vegetation Monitoring Program is to provide accurate information on the status and trends of vegetation in the alpine treeline ecotone in order to inform management decisions affecting these areas. Specific monitoring objectives are to:

1. Determine the status and trends in vegetation composition and structure of alpine vegetation in MORA, NOCA, and OLYM
2. Determine the status and trends in vegetation composition and structure of subalpine vegetation in MORA, NOCA, and OLYM
3. Determine the status and trends in vegetation composition and structure of legacy (historic, non-random) vegetation plots in MORA
4. Determine the status and trends in soil temperature and snow cover period in subalpine and alpine communities in MORA, NOCA, and OLYM and at legacy plots in MORA.
5. Determine status and trends in the structure and condition of whitebark pine stands in MORA, NOCA, and OLYM

Linkages with Park Management

We developed our NCCN subalpine and alpine monitoring objectives to provide answers to current and future questions regarding the status and trends of vegetation in the alpine treeline ecotone. We identified monitoring questions from different perspectives including those of park managers, members of the general public, and scientists. We compared the results of current research with hypothetical projections of future conditions 10, 20, or 30 years from present and then asked ourselves, what elements should be essential components of our monitoring plan. Organization and presentation of our data in a format useful, accessible, and quickly reportable to park management was one of our highest priorities. Table 2 summarizes the elements of our project and while not specifically stated, results presented in the status and trends columns may provide launch points for future collaborations with the research community in addition to meeting NCCN monitoring needs.

Table 2. Summary of monitoring objectives and links to park management.

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
1. Composition and structure of alpine vegetation 2. Composition and structure of subalpine vegetation	Species cover organized by growth form: trees, shrubs, forbs, sedges, grasses, moss, lichen	• Individual park and organized by: - alpine - subalpine - alpine treeline ecotone (ATE)[2] • Network and organized by: - alpine - subalpine - alpine treeline ecotone	• Proportion of each cover type by alpine or subalpine vegetation for each park • Proportions across alpine or subalpine vegetation in NCCN • Comparison of patterns between NCCN parks	• Change in proportions within alpine & subalpine vegetation by park • Change across alpine or subalpine in the NCCN • Comparison of rates of change across parks	• Identification of parks, or areas where rates of change are most rapid • Areas where recreational opportunities may be changing • Quality of wildlife habitat • Change in landscape connectivity patterns • Adaptation guidelines
	Native species richness Exotic species richness		• Locations of exotic species • Description of patterns of species richness by vegetation type, park, elevation, aspect	• Rate or magnitude of changes in species richness by park, vegetation type, elevation, or aspect	• Recommendations for exotic plant management • Estimate of ecological integrity of areas based on exotic species • Evaluation of Wilderness character

Table 2. Summary of monitoring objectives and links to park management (continued).

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
2. Composition and structure of subalpine vegetation (cont.)	Cover of individual species	• Plot • Species distribution • Park - alpine - subalpine - alpine treeline ecotone • NCCN - alpine - subalpine - alpine treeline ecotone	• Average and variation in cover • Distribution by elevation or park	• Change in cover within park or between parks	• Development of adaptation guidelines • Informing desired future conditions • Informing wildlife studies
	Plot classification and elevation		• Average and range of elevation of plots classified as alpine or subalpine	• Change in number of plots that have succeeded to a different type (alpine or subalpine)	• Indication of rate of change in alpine treeline ecotone: subalpine to forest or alpine to subalpine
3. Composition and structure of alpine legacy plots	Cover type: trees, shrubs, forbs, sedges, grasses, moss, lichen Native species richness Exotic species richness Species cover of individual species	• Plot	• Proportion of each cover type • Number of native and exotic species per vegetation plot • Cover of individual species	• Changes in proportion of cover types within each plot • Change in exotic and native species richness • Change in cover of individual species	• Provide a perspective on 30+ years of change in select alpine environments • Early warning of changes that may be expected in plots

Table 2. Summary of monitoring objectives and links to park management (continued).

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
4. Soil temperature and snow cover	Soil temperature	• Individual park and organized by: - alpine - subalpine - alpine treeline ecotone • Network and organized by: - alpine - subalpine - alpine treeline ecotone	• Patterns of soil temperature by day, month, growing season • Snow melt as estimated by soil temperature	• Change in average daily or monthly soil temperature • Change in snow melt date and growing season	• Change in snow cover patterns in alpine treeline ecotone – application to recreational opportunities, rates of vegetation change • Development of adaptive management strategies for natural resources
5. Whitebark pine	Whitebark pine tree status – infected, dead, uninfected Whitebark pine – diameter, height All other tree species- diameter, height	• Park • NCCN	• % live, dead, infected • Basal area/ha by species • Tree density/ha by species • Average and distribution of height by species	• Rate of change in mortality and infection rates • Changes in composition • Changes in structure	• Development of adaptive management or restoration strategies for whitebark pine in parks of NCCN • Compare status of whitebark pine with other parks and forests in Pacific West Region and Rocky Mountains • Identification of potentially resistant trees • Decisions on whether and where to control mountain pine beetles with pheromones
	Saplings, seedlings		• Sapling density/ha by species • % whitebark pine saplings infected with blister rust • Seedling density/ha by species	• Changes in structure and composition of saplings and seedlings • Rate of change in infection rates of whitebark pine saplings • Rates of recruitment by tree species	

Table 2. Summary of monitoring objectives and links to park management (continued).

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
5. Whitebark pine (cont.)	Evidence of mountain pine beetles		• Incidence of mountain pine beetles by plot, park, elevation	• Trends in beetle occurrences in parks	
	Cankers		• Percent of trees with bole or branch cankers – severity of infection • Percent of trees with active or inactive cankers	• Changes in percent of trees with cankers • Progression of blister rust – change in % trees with bole cankers	
	Crown kill on whitebark pine		• Average crown kill per tree	• Rate of change in crown kill	
	Dwarf mistletoe		• Number of trees /ha with mistletoe • Pattern of mistletoe incidence in crown	• Change in proportion of trees with mistletoe • Change in distribution of mistletoe within crowns	
	Understory vegetation		• Average cover by species • Classification of whitebark pine communities	• Change in understory plant composition	

[1] Vegetation within the target population as described in Chapter 2, Section B

[2] Alpine treeline ecotone calculations will be based on all plots within the alpine and subalpine zones to describe status or trends in all areas above closed canopy forests (i.e., forestline)

2. Sampling Design

A. Rationale

Approach

As a first step in developing the alpine and subalpine monitoring protocol we developed a list of relevant ecological principles and desired monitoring project characteristics:

- Alpine and subalpine landscapes are emblematic of Pacific Northwest parks and as environmental ecotones are expected to change rapidly with changing climates.
- Changes in vegetation patterns within the alpine treeline ecotone will be dramatic and will influence patterns of recreational use and park management.
- Alpine and subalpine areas are extremely diverse within and across MORA, NOCA, and OLYM and rates of vegetation change will vary with elevation, slope, and aspect.
- The protocol must allow statistical inference of status and trends within and across parks with sufficient power to provide useful data to park management.
- The protocol should serve park management needs and to document the influence of climatic warming on mountain landscapes in subalpine and alpine areas.
- Whitebark pine is a keystone species in the alpine treeline ecotone, threatened by an introduced fungus, and we should understand its population status.
- NCCN study sites can provide a foundation upon which other researchers can initiate short and long-term research to address more detailed questions than we can support.
- Crew safety and accessibility of plots must be considered because we are monitoring in large wilderness parks with steep terrain and limited trail access.

Following the development of this list, we conducted a review of prior research and monitoring that had occurred within the NCCN. We also consulted with other NPS networks to understand their approaches to monitoring these ecosystems, learn from their experiences, and apply their methodology when appropriate.

Prior Research and Monitoring

Descriptive studies of subalpine and alpine vegetation in Mount Rainier, North Cascades, and Olympic National Parks were conducted in the 1970s and early 1980s. Henderson (1974) described and mapped subalpine vegetation communities in MORA. Hamann (1972) described subalpine and alpine communities primarily on the east side of the park while Edwards (1980) focused on alpine vegetation community structure, composition, and distribution. In addition, Edwards studied the impact of recreational use on these communities. Subalpine communities of the Olympics were described during the same time period by Kuramoto and Bliss (1970). Douglas (1972) studied the subalpine communities of the northern Cascades and then expanded to describe the alpine plant communities (Douglas and Bliss 1977). Most of these studies looked at distribution and composition of high-elevation plant communities and included analyses of environmental conditions and soils associated with the plant communities.

Functional studies built on these early studies by looking at the role of snowpack on community patterns and plant production (Canaday and Fonda 1974, Evans and Fonda 1990). Concurrently, in the 1970s, park management at MORA became concerned that trees were growing in the subalpine parkland and destroying the views of the iconic wildflower meadows. In response to

these concerns, Franklin et al. (1971) looked at patterns of tree establishment, linking them to climatic variability. In OLYM, Agee and Smith (1984) studied the role of fire on the establishment of subalpine trees. With predictions of warming climates (Schlesinger and Mitchell 1987, Schneider 1989, Mote and Salathé 2010), a renewed interest in tree establishment in the alpine treeline ecotone led to studies in MORA and OLYM on the pattern and abundance of tree establishment (Little et al. 1994, Woodward et al. 1995, Rochefort and Peterson 1996).

Very few of these study sites were permanently marked and those that were had been designed to address very specific management issues in subjectively selected locations. Brockman (1959, 1960) established permanent sites at MORA to study the effects of recreational use and development (i.e., buildings) on subalpine meadows. Permanent plots were installed at MORA and OLYM for future evaluations of trends in tree establishment and growth (Woodward et al. 1995, Rochefort and Peterson 1996). Whitebark pine surveys conducted in MORA and NOCA in the 1990s did not utilize permanent plots, although permanent plots were established later (Rochefort 2008). Schreiner (1994) marked plots to evaluate the influence of introduced goats at OLYM. Edwards (1985) developed methods to document and monitor human impacts (i.e., campsites) in the alpine zone and established permanent transects in four alpine areas of MORA to monitor changes in vegetation composition (Figure 3).

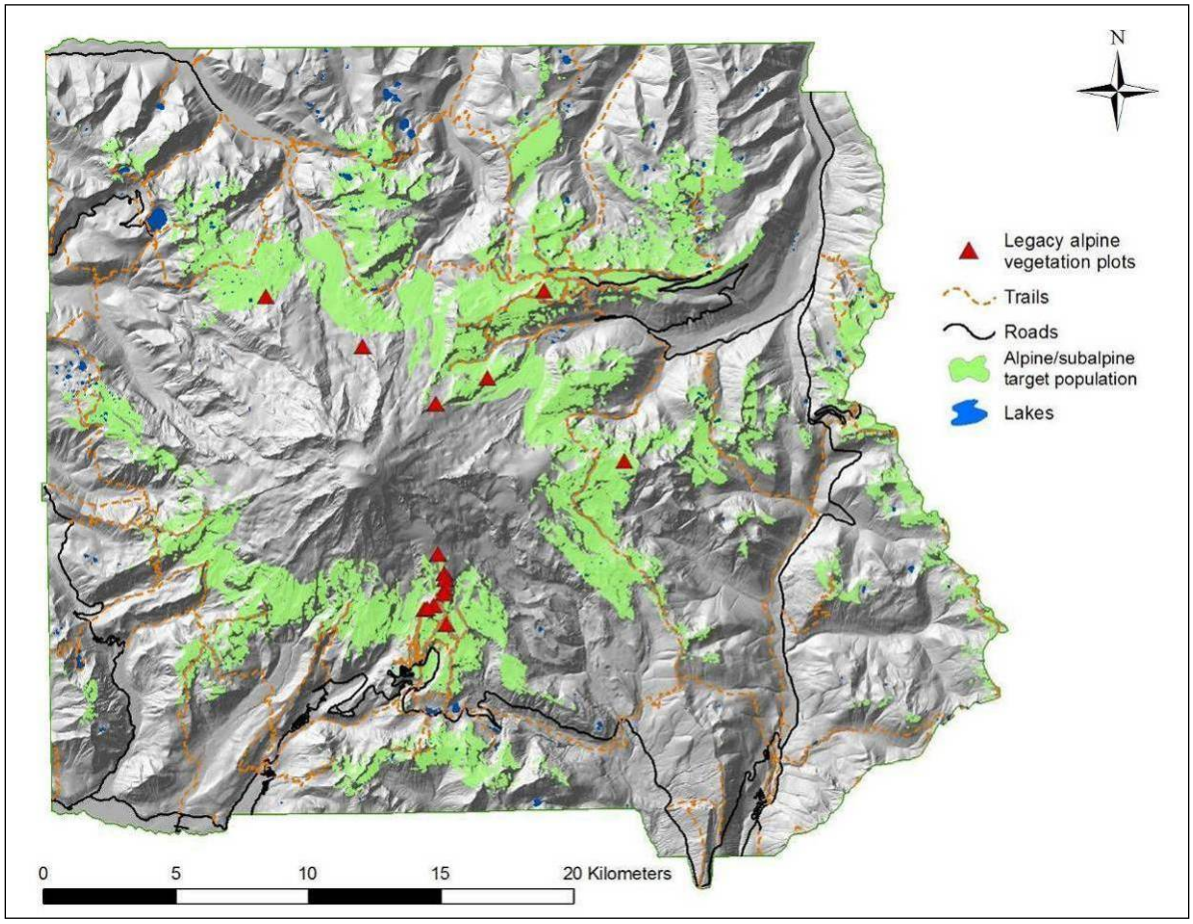


Figure 3. Location of alpine plots (legacy plots) established by Ola Edwards in Mount Rainier National Park in 1983-1984.

Although the locations of Edwards' plots were selected subjectively (i.e., by community type and location), they do provide a broad perspective and record of alpine vegetation over the past 30 years in the alpine zone of Mount Rainier National Park.

B. NCCN Target Population and Sample Frame

Although we did not have vegetation maps of high-elevation areas, we knew that topography is quite diverse across the NCCN mountain landscapes and influences precipitation and in turn vegetation patterns. We used the Washington GAP Analysis v.5 (GAP) (Cassidy 1997) and the Pacific Meridian Resources (PMR) (PMR 1996) data to create polygons of potential subalpine and alpine vegetation for each park. We then plotted these areas on maps of each park with the output from the PRISM (Parameter-elevation Regressions on Independent Slopes Model) (2009) to examine potential target populations for each park (Figures 4, 5, 6). Review of these maps reinforced our initial view that in order to provide data relevant to park management on high-elevation areas, we would need to develop a sample frame that extended across the range of elevations, precipitation gradients, and vegetation within the NCCN.

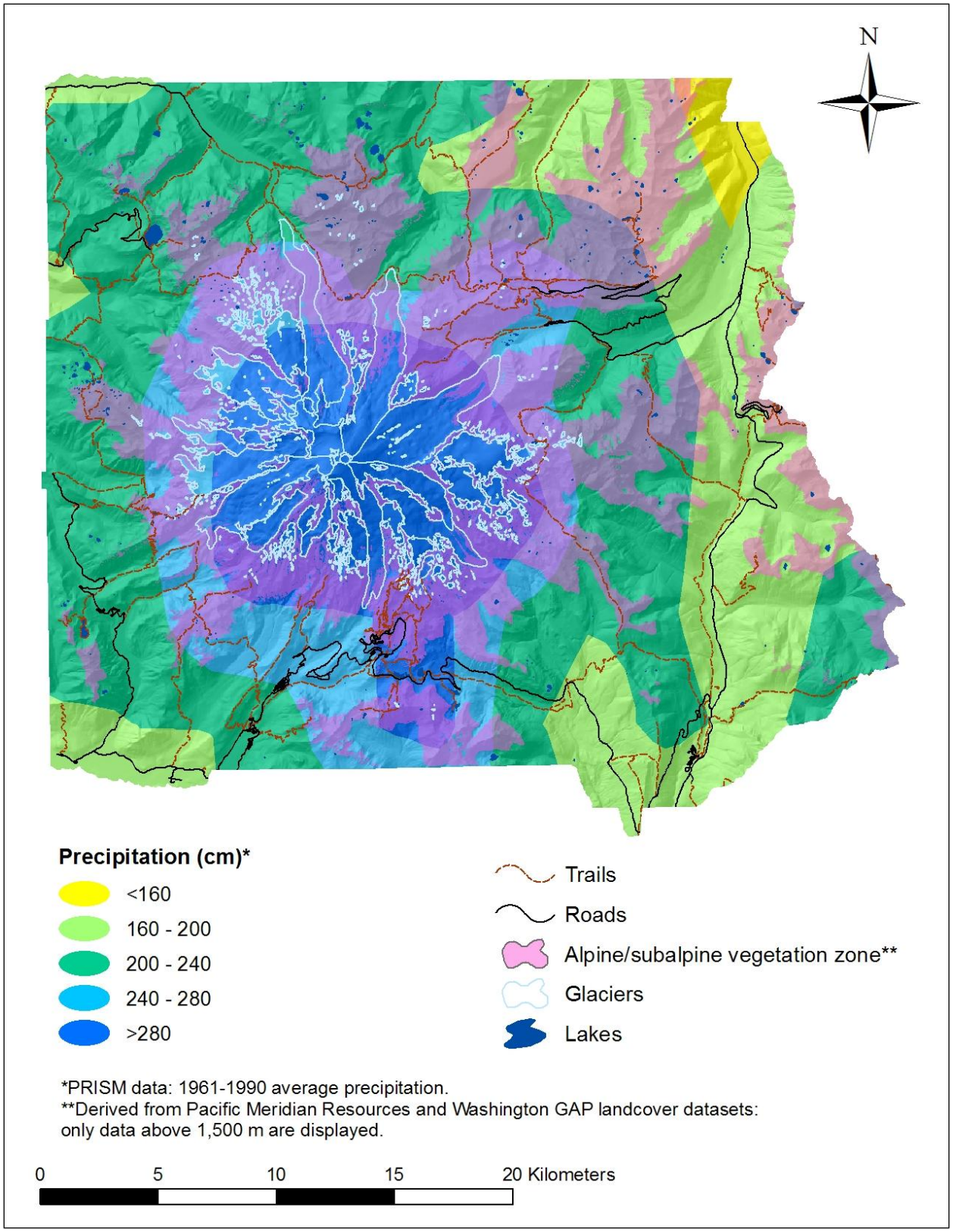


Figure 4. Alpine/subalpine vegetation zone, topography, and precipitation patterns in Mount Rainier National Park.

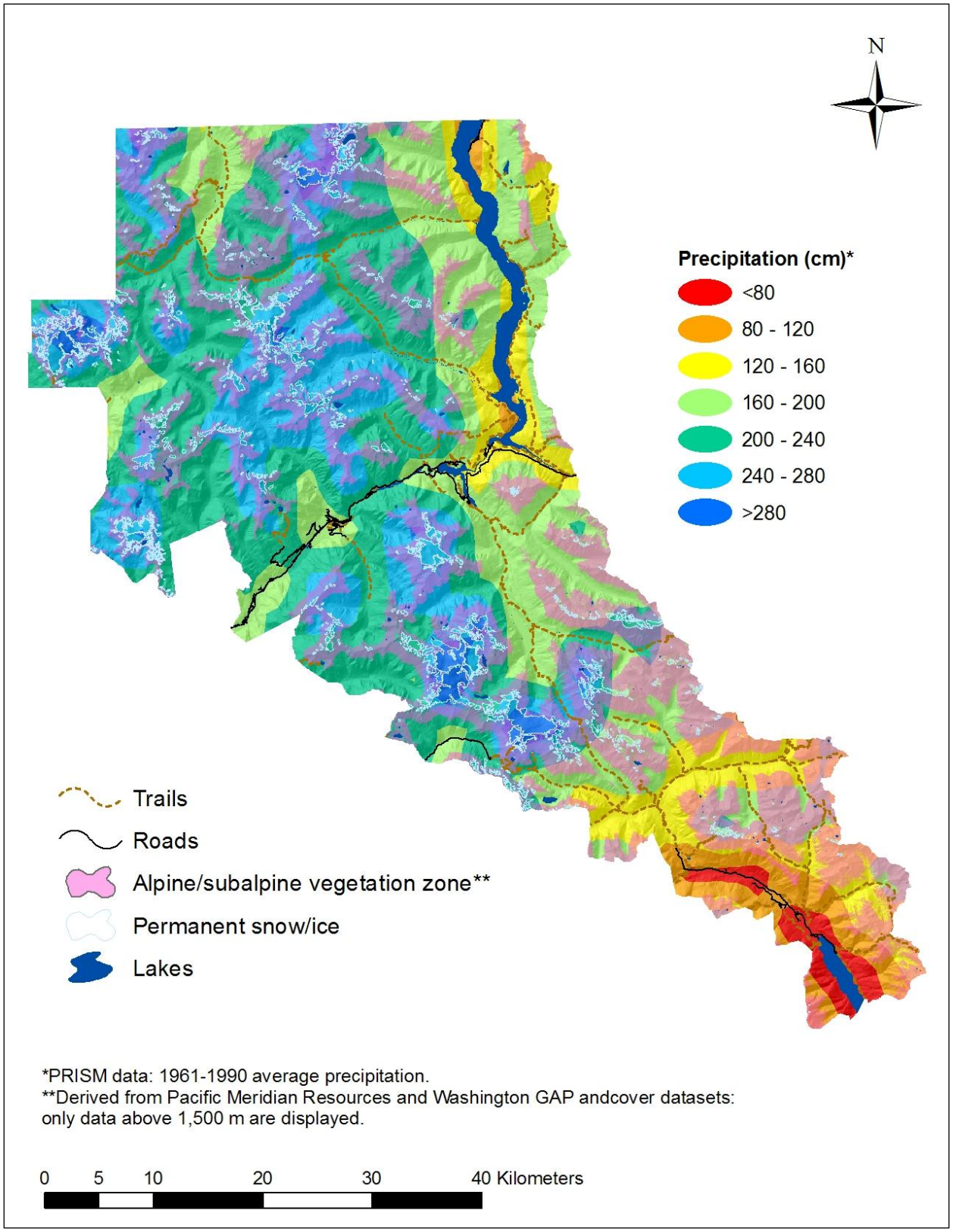


Figure 5. Alpine/subalpine vegetation zone, topography, and precipitation patterns in North Cascades National Park.

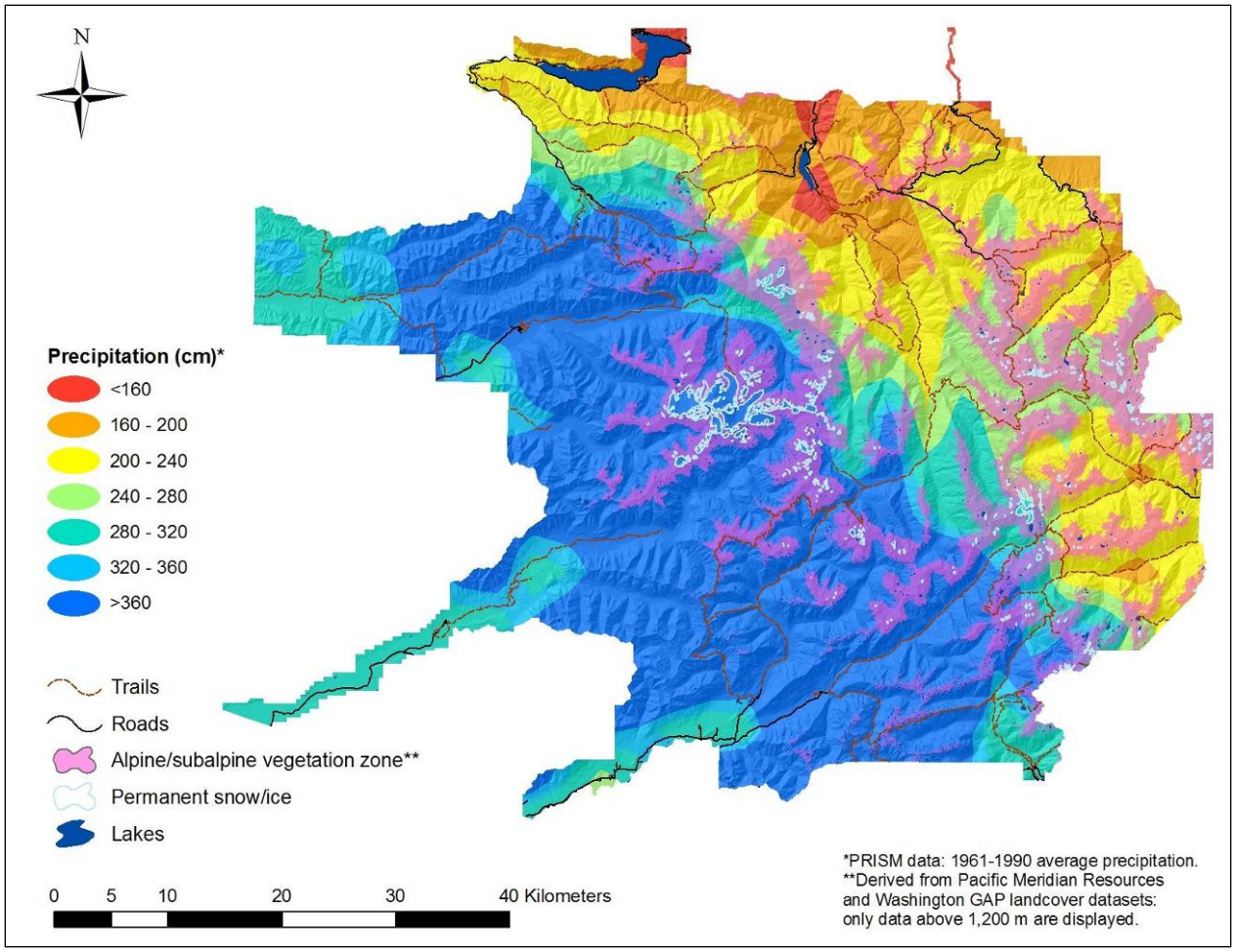


Figure 6. Alpine/subalpine vegetation zone, topography, and precipitation patterns in Olympic National Park.

The alpine treeline ecotone is a significant component of NCCN mountain parks. It encompasses approximately 34% of MORA, 36% of NOCA, and 19% of OLYM (Table 3). The monitoring target population of alpine and subalpine vegetation in the NCCN was delineated to encompass the range of variation in alpine and subalpine environments that is safely accessible within a reasonable amount of time (i.e., travel time while hiking). Therefore, the target population for monitoring status and trends in alpine and subalpine vegetation and whitebark pine stands (objectives 1, 2, 4 and 5) is limited to areas within 1.5 km of trails and roads where the slope is ≤35° (see Appendix E). The target population captures 12.5% of MORA, but only 3.5% of NOCA and OLYM because trail and road access is so limited (Figures 7, 8, 9).

Table 3. Percentage of park area in alpine and subalpine zone and in target population.

	MORA	NOCA	OLYM
Park area (ha)	95,150.4	275,691.0	369,653.6
Alpine/subalpine zone (ha)	31,927.8	100,683.2	70,742.7
% of park area in alpine/subalpine zone	33.6	36.5	19.1
Sample frame area (ha)	11,879.2	9,652.2	12,987.7
% of park area in sample frame	12.5	3.5	3.5
% of alpine/subalpine zone captured by sample frame	37.2	9.6	18.4

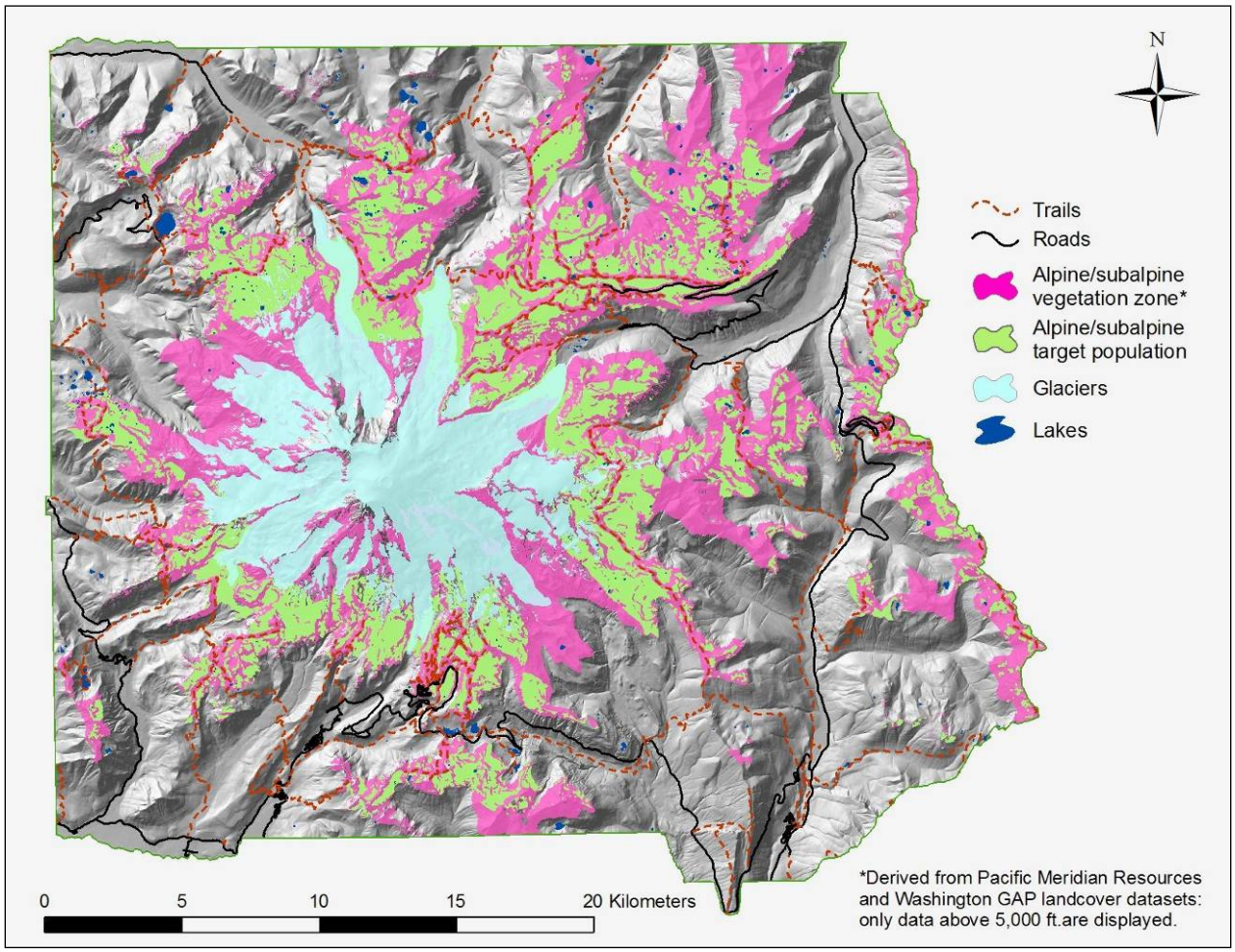


Figure 7. Alpine/subalpine vegetation zone and target population in Mount Rainier National Park.

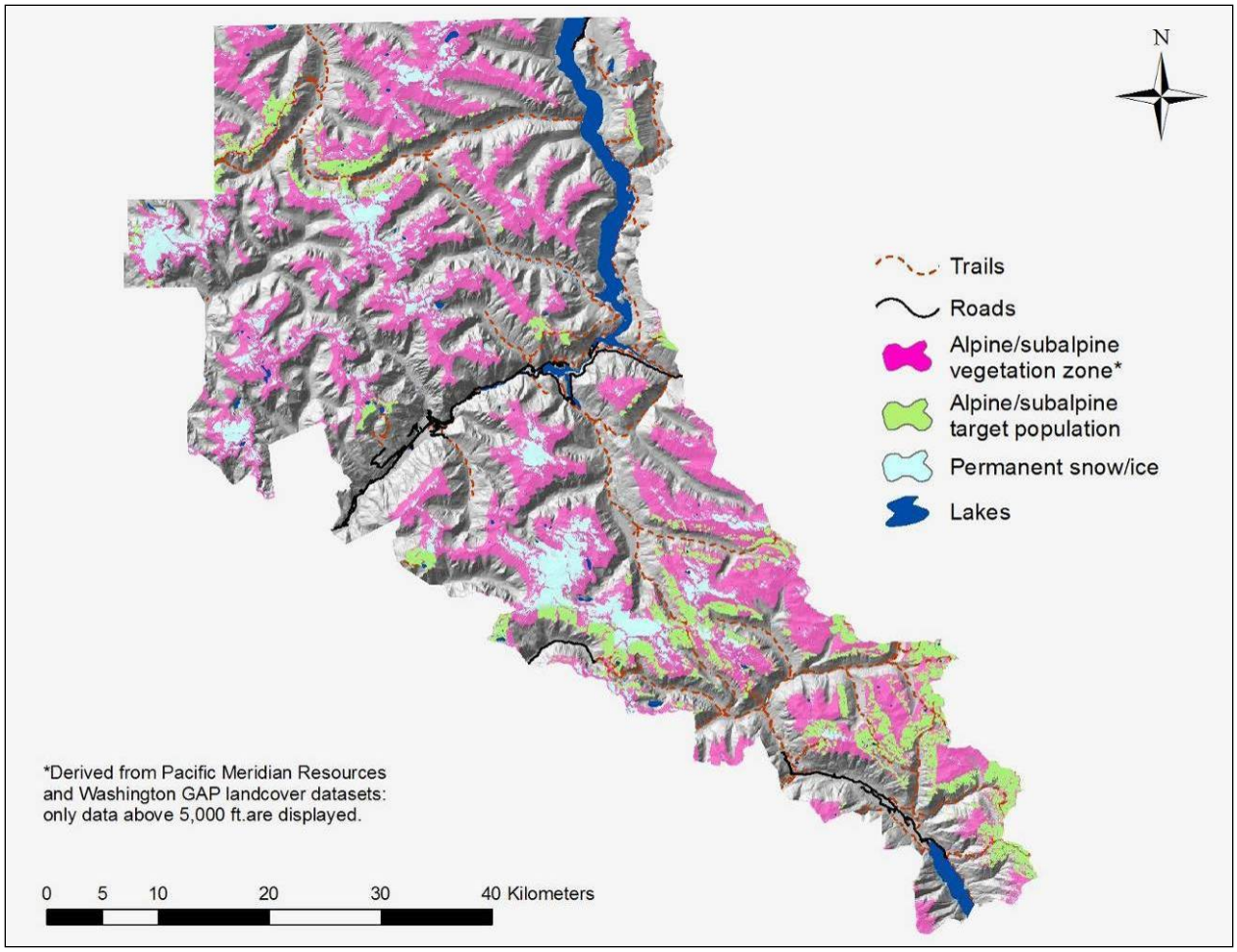


Figure 8. Alpine/subalpine vegetation zone and target population in North Cascades National Park.

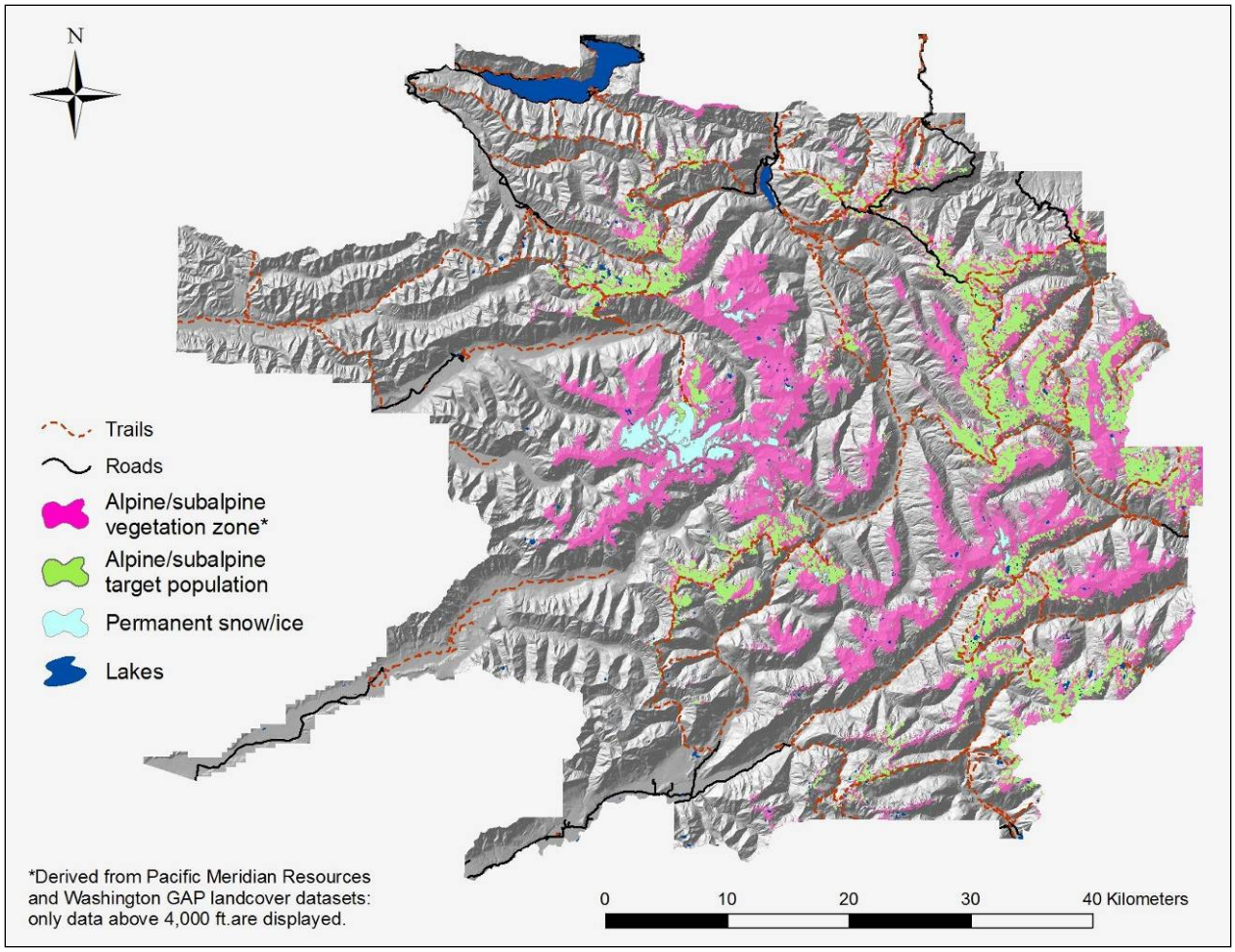


Figure 9. Alpine/subalpine vegetation zone and target population in Olympic National Park.

A probability-based sample design was created for monitoring the ATE of MORA, NOCA, and OLYM. A Generalized Random Tessellation Stratified (GRTS) sample was drawn for each park to produce a spatially balanced, random sample (Stevens and Olsen 2004). The sample frame was developed by overlaying a grid of points spaced 10 m apart across the target population. Survey sites were selected from within the sample frame using a GRTS design (Stevens and Olsen 2004) in R with the 'spsurvey' package (Kincaid and Olsen 2009). Points that fell within the boundaries of the target population were output to enumerate a sample frame of points for the park. In MORA, NOCA, and OLYM there were 297,244; 241,297; and 324,556, respectively in the sample frame. These points comprise the population from which the sample was drawn. Sampling points will be selected in the order they occur on the list. If a sample point does not meet the predefined criteria for the sample, it will be rejected and the next point on the list used as replacement. The GRTS design allows for points to be added or removed without sacrificing the spatial balance.

The sample frame we present in this protocol for whitebark pine is a revision of the sample frame originally developed in 2004 (Appendix B). The 2004 sampling strategy was based on areas where we knew whitebark stands were historically present (National Park Service 1936) or where recent observations were reported by field personnel (Rochefort 2008, Appendix B). We

delineated these stands as polygons on maps of MORA and NOCA and decided that our sample unit would be the polygon and each polygon would have subsamples. Sample size was based on the number of units (polygons) that we could access in each park. The number of subsamples per polygon was based on power analyses using data from preliminary surveys. Sample stands were selected systematically with a random start in each park (counterclockwise in MORA and north to south in NOCA). Sample stands were established in 2004 and resurveyed in 2009. After developing our sample frame for herbaceous vegetation in subalpine and alpine areas, we decided that revising the design of the initial whitebark pine sample frame would better serve the long-term assessment of the species. Our revised sample frame will allow for a comprehensive sampling of the species' distribution in the alpine treeline ecotone, allow us to add monitoring plots (e.g., increased budgets or complete mortality in plots), will expand the inference and sampling area of whitebark pine to unmapped stands, and will be robust to changes in whitebark pine distribution with climate change. During this process, we changed our sample unit from polygon to plot and also improved our monitoring methodology in each plot. We plan to establish new GRTS-based plots in 2014 and will additionally monitor just whitebark pine in the original legacy plots at that time to evaluate trends over 15 years (Table 4).

Status and trends observed in the alpine legacy plots at MORA (objective 3), established by Dr. Ola Edwards, will only have statistical inference to the vegetation communities in which they were established, but this will provide a historical perspective on changes in the alpine zone.

C. Site Selection

Each sample point must meet a set of predefined criteria. All points must be accessible by field crews, and subalpine or alpine vegetation must have <25% canopy cover of trees. Whitebark pine sample sites can have ≥25% tree cover, but must have a minimum of 10 whitebark pine trees ≥2.54 cm dbh. The canopy cover criterion complements the NCCN Forest Monitoring Protocol which requires ≥25% canopy cover at sample points. All points must have <25% cover by open water or tall shrubs. Points are prescreened in the office for accessibility, safety, and water cover and if they pass the office screening, they are reviewed for acceptability in the field (**SOP 7: Screening and Reconnaissance for Selection of Alpine/Subalpine Vegetation and Whitebark Pine Plots**). If a GRTS point is accepted for alpine or subalpine vegetation monitoring during field review, it is then classified as subalpine or alpine based on tree form. Sample points are classified as subalpine if the point is located above forestline and below treeline (upright trees). If a point is located above upright trees, it is classified as alpine; alpine areas are often recognized by the presence of krummholz growth forms. Points will remain in the subalpine or alpine strata through time even if they transition from one "type" to another (e.g., subalpine to forest or alpine to subalpine).

D. Sampling Frequency and Replication

The GRTS points were assembled into 6 panels of 250 points per panel and per park. Panels 1, 2, and 3 will be used initially to screen and select plots for alpine/subalpine monitoring and whitebark pine monitoring (Table 4). The remaining points will provide either an oversample or additional panels should the monitoring program expand. Whitebark pine site selection will begin with panel 1, but if acceptable sites are not found after screening all 250 points, screening will continue in panel 2. Based on the difficulties we encountered locating acceptable sites in our previous whitebark pine monitoring project, we anticipate needed that we will need a large oversample for revised whitebark monitoring (see Appendix B). If a GRTS point is acceptable

for both alpine/subalpine and whitebark pine monitoring plots, the two plots will be offset so that monitoring activities will not damage vegetation. Sample points will be monitored on a five year frequency; whitebark pine and alpine legacy plots will each be monitored in one year, but sampling for subalpine and alpine vegetation will be conducted over three years.

NCCN vegetation crews work on both forest and alpine/subalpine monitoring; staffing for the Prairie Protocol at San Juan Island National Historical Park (SAJH) utilizes personnel stationed at SAJH. Therefore, sampling frequency, number of plots, and annual work schedules are influenced by our NCCN vegetation budget. Currently, we estimate that we can support 45 payperiods, per year, to conduct monitoring for two vegetation monitoring protocols: 1) forest and 2) alpine/subalpine.

The Forest Monitoring Protocol utilizes 3 two-person crews to conduct annual tree mortality checks for four years in a row utilizing 21 payperiods per year (e.g., 2009-2012, 2014-2017). During the fifth year (e.g., 2013, 2018) a complete census is made of all trees in each plot, requiring 42 payperiods (Table 5). Scheduling of subalpine and alpine vegetation monitoring will complement forest monitoring since the same crews will work on both protocols. During “forest years 1-4” (i.e., 2009-2012 and 2014-2017) 24 payperiods will be available for data collection in alpine and subalpine areas. During “forest year 5” (i.e., 2013, 2018) only 3 payperiods will be available for alpine and subalpine monitoring. We will schedule the bulk of alpine and subalpine vegetation monitoring (including whitebark pine, GRTS based points, and legacy plots) during the 4 years that we have 24 payperiods available. Work during the fifth year (i.e., complete forest census year) will be minimal (e.g., collection of data loggers or MORA alpine legacy plots) unless alternate funding is obtained. A representative work schedule is presented in Table 5.

Crews will be stationed in MORA, NOCA, and OLYM to allow flexibility in response to weather. Generally, forest monitoring will be conducted between June and mid-July, and at the end of the field season. Alpine and subalpine monitoring will be initiated as soon as snow melt and plant phenology allows and will commence prior to the first snow. Generally, the field season is 4-6 weeks in length (mid July to the end of August) for herbaceous vegetation and potentially another 4 weeks for whitebark pine (end of September). Whitebark pine monitoring will have more flexibility within a season because understory vegetation surveys are not as central a component to this task, in contrast to subalpine and alpine vegetation monitoring which focus on cover and species richness of herbaceous species.

Table 4. Schedule of vegetation monitoring activities.

	Year																			
Task	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A&S 1[1]	M[4]					M					M					M				
A&S 2[1]	R[5]	M					M					M					M			
WBP[2]		R		M					M					M					M	
WBP Legacy				M																
A&S 3[1]				R	M					M					M					M
Forest[3]	A	A	F	A	A	A	A	F	A	A	A	A	F	A	A	A	A	F	A	A
Alpine Legacy			M					M					M					M		

[1] A&S: indicates panel 1, 2, or 3 of alpine and subalpine monitoring plots

[2] WBP: indicates whitebark pine monitoring plots

[3] Forest: Forest monitoring annual mortality checks ('A') or full census monitoring ('F')

[4] M: indicates monitoring of plots and in initial year includes establishment

[5] R: indicates site review of potential sample points for alpine & subalpine or whitebark pine monitoring

Table 5. Payperiods allocated among three vegetation monitoring projects for years 2011-2030.

Protocol	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Prairie	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Forest	21	21	42	21	21	21	21	42	21	21	21	21	42	21	21	21	21	42	21	21
Alpine & Subalpine	24	24	3	24	24	24	4	3	24	24	24	4	3	24	24	24	4	3	24	24

E. Sample size

Subalpine and Alpine

Subalpine and alpine sampling sites required identification of the number of plots per park and within those plots, the number of subsamples (quadrats) per 100. We calculated the sample sizes based on pilot sampling in 2005 in four subalpine areas: Badger Valley (BV) in OLYM, and three sites in NOCA: Easy Ridge (ER), Fisher Basin (FB), and Mineral Valley (MV). In each pilot sampling area, plant cover was sampled in 0.25 m^2 quadrats distributed in a 20 m x 20 m plot.

Determination of the number of plots per park and vegetation type (i.e., alpine and subalpine), was based on the power to detect a trends of 1%, 3%, and 5% annual change in forb, shrub, and graminoid cover. In these simulations, we also looked at a combined category of graminoids and sedges because values were so small. After reviewing the current cover values to determine the change we would like to detect over 5 and 10 years, we decided to base our sample size on the detection of a 3% increase per year with 90% probability (Figure 10). The recommended sample size is 20-30 plots in alpine and 20-30 plots subalpine per park to obtain 80-90% power with 90% confidence. Sampling will be conducted over three years and realized sample size (annual and total) will be a function of travel time between sites and weather. We suspect that we will

have a larger sample size in MORA than NOCA or OLYM because travel distances are significantly shorter.

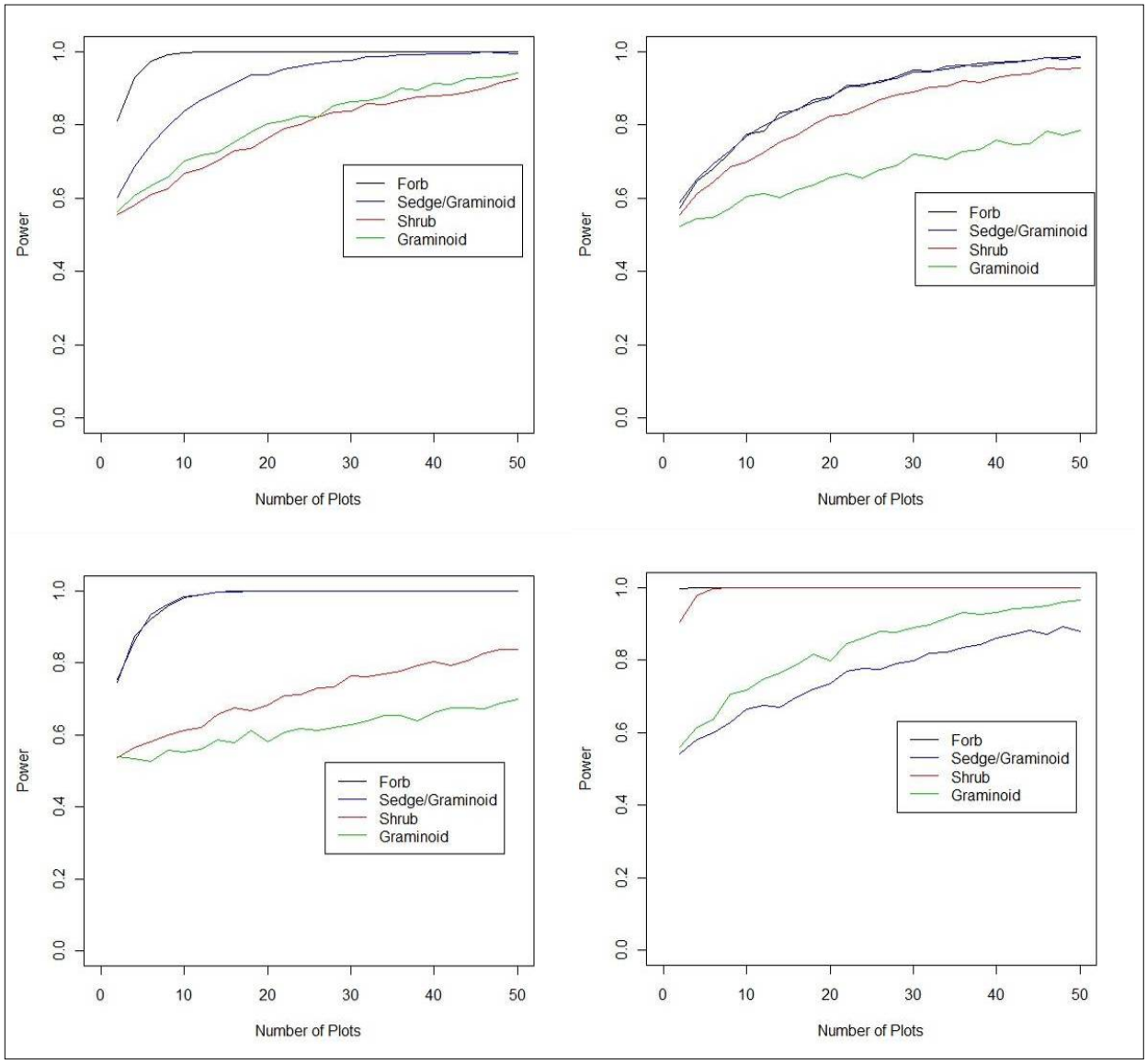


Figure 10. Simulations of the power to detect a 3% annual increase in cover of forbs, sedge/graminoids, shrubs, graminoids based on our four pilot study areas. Badger Valley (BV) in the upper left, Easy Ridge (ER) in the upper right, Fisher Basin (FB) in the lower left, and Mineral View (MV) in the lower right.

To determine the number of quadrats per sample plot, we resampled quadrats with varying intensity (5 to 100 quadrats) 1000 times. For each replication of the simulation, we estimated the size of the 95% confidence interval halfwidth for percent cover of forbs, shrubs, graminoids, and sedges and graminoids combined (Figure 11). Based on these simulations and our estimate of the time to conduct this monitoring, our recommendation for subsample size is 20 quadrats. This number may be reduced to 16 quadrats if completing 20 quadrats is too time consuming. We are planning to spend one day per plot, excluding travel time to the site.

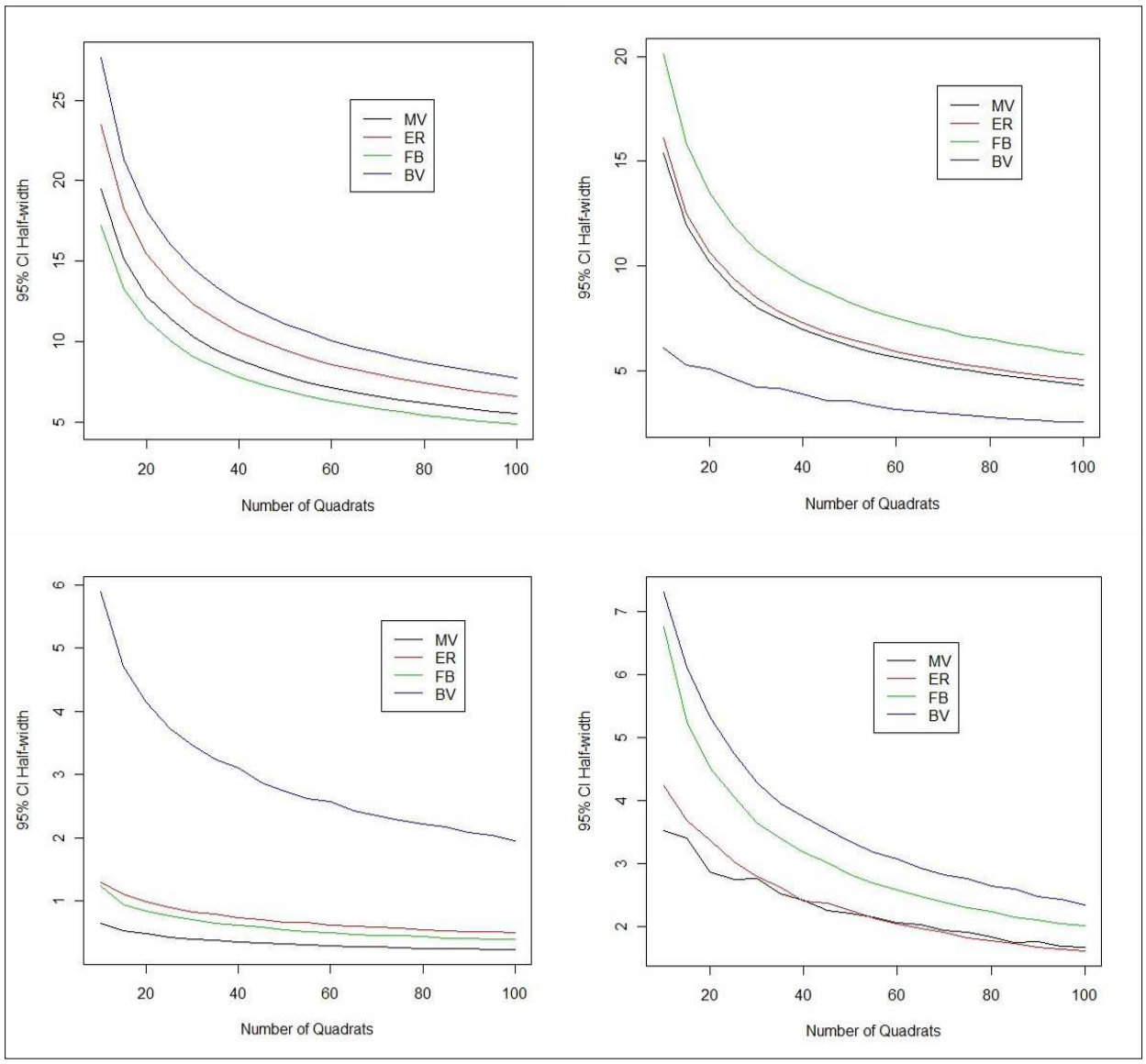


Figure 11. Subsample size estimates for alpine and subalpine plots based on 95% confidence interval half-width for percent cover of forbs (top left), shrubs (top right), graminoids (bottom left), and sedge/graminoids (bottom right).

Whitebark Pine

Sample size for whitebark pine was determined by calculating the power to detect a trend of 1%, 3%, and 5% annually in mortality and infection for sample sizes of 2 to 50 plots. We estimated the variance based on simple random sampling (SRS) to obtain a conservative estimate of trends as opposed to the variance that would be obtained with the proposed GRTS sampling design (Stevens and Olsen 2003, Theobald et al. 2007). We generated 2500 random values with the observed mean and variance for the MORA and NOCA 2004 and 2009 data. Our calculations are based on the power to detect a trend over 10 years with 90% confidence with a sampling frequency of five years (Figure 12). To select the sample size for each park, we started with the 2009 status estimates and projected infection and mortality rates in five years, given an annual rate of increase of 1%, 3%, and 5% (Table 6). Based on the simulation results, and the current

status of whitebark pine, we determined we would like to be able to detect at least a 3% increase in the parameters in infection and mortality rates. A sample size of 24 plots in each park would provide adequate power to detect these trends.

Table 6. Projections of mortality and infection rates in 5 years for MORA and NOCA based on 1%, 3%, and 5% annual rate of increase from the 2009 status estimates.

Park	**Mortality %**				**Infection %**			
	2009	1%	3%	5%	2009	1%	3%	5%
MORA	52	55	60	66	26	27	30	33
NOCA	29	30	33	37	39	41	45	49

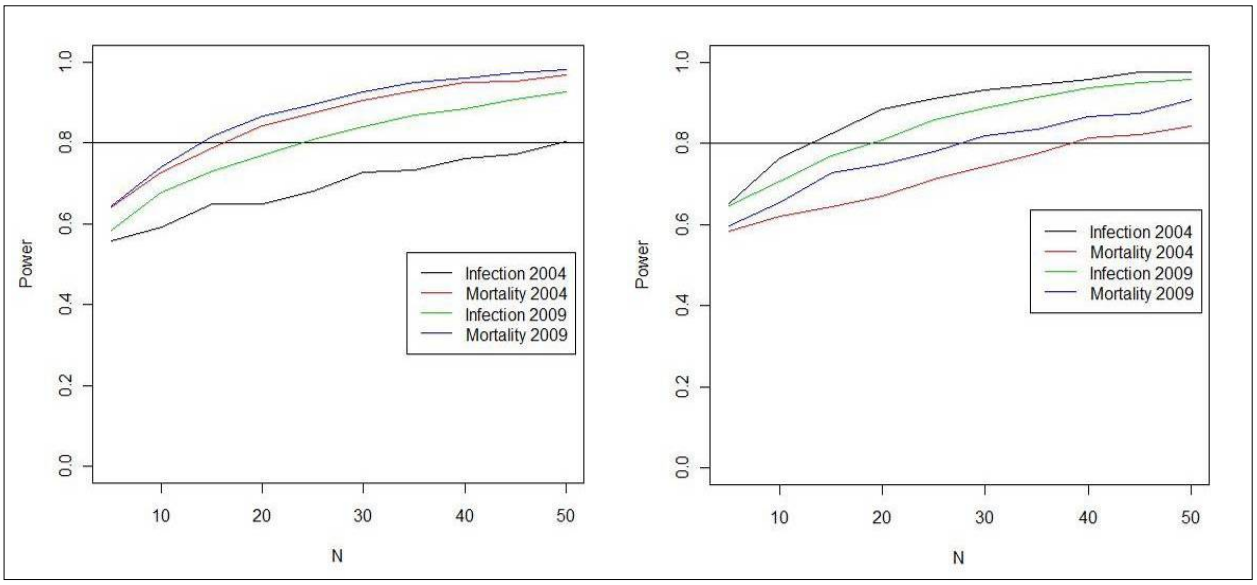


Figure 12. Power to detect a 3% annual increase in infection and mortality rates for Mount Rainier (left) and North Cascades (right) for sample sizes (number of plots) from 2 to 50. Horizontal line indicates 80% power.

Next, we looked at our pilot data to determine the minimum number of trees required per plot to achieve our monitoring objectives. For each park, we resampled the whitebark pine tree pilot data from 2004 and 2009 to determine the minimum number of trees per plot to estimate mortality rates and the minimum number of live trees per plot to estimate infection rates. We resampled the pilot data with 5 to 75 trees per plot, 1000 times. For each replication of the simulation, we estimated the size of the 95% confidence interval half-width for percent of live trees infected with blister rust and percent of all trees within the plot that were dead. The size of the confidence interval half width decreases with increasing number of trees (Figure 13). Based on these simulations, we recommend at least 10 live whitebark pine trees per plot.

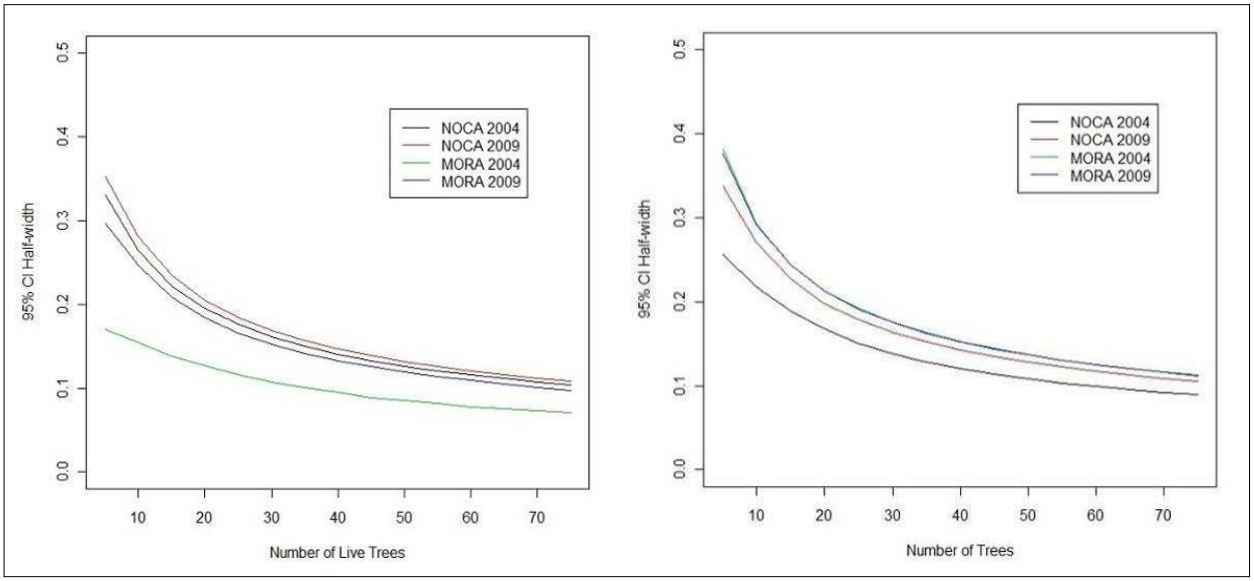


Figure 13. Minimum number of trees per whitebark pine plot based on 95% confidence interval half-width for number of infected live trees (left) and dead trees (right).

F. Plot Design

The primary subalpine and alpine vegetation monitoring plots is a 100 m^2 plot (10 m x 10 m). The cover and location of trees, saplings, and tall shrubs (>0.5 m in height) will be monitored in the entire plot (Figure 14, SOP 8). Nested in this larger plot will be twenty, 0.25 m^2 (0.5 m x 0.5 m) subsamples in which tree seedlings, herbaceous vegetation, and subshrubs will be monitored. Subsamples will be located systematically within the plot (Figure 14). Data loggers will be buried 7-10 cm below the soil surface in two to five locations within the plot to monitor soil temperature and snow cover. Alpine legacy plots will be monitored following Edwards' design of a transect with 0.25 m^2 subsamples located every other meter along the transect (SOP 10).

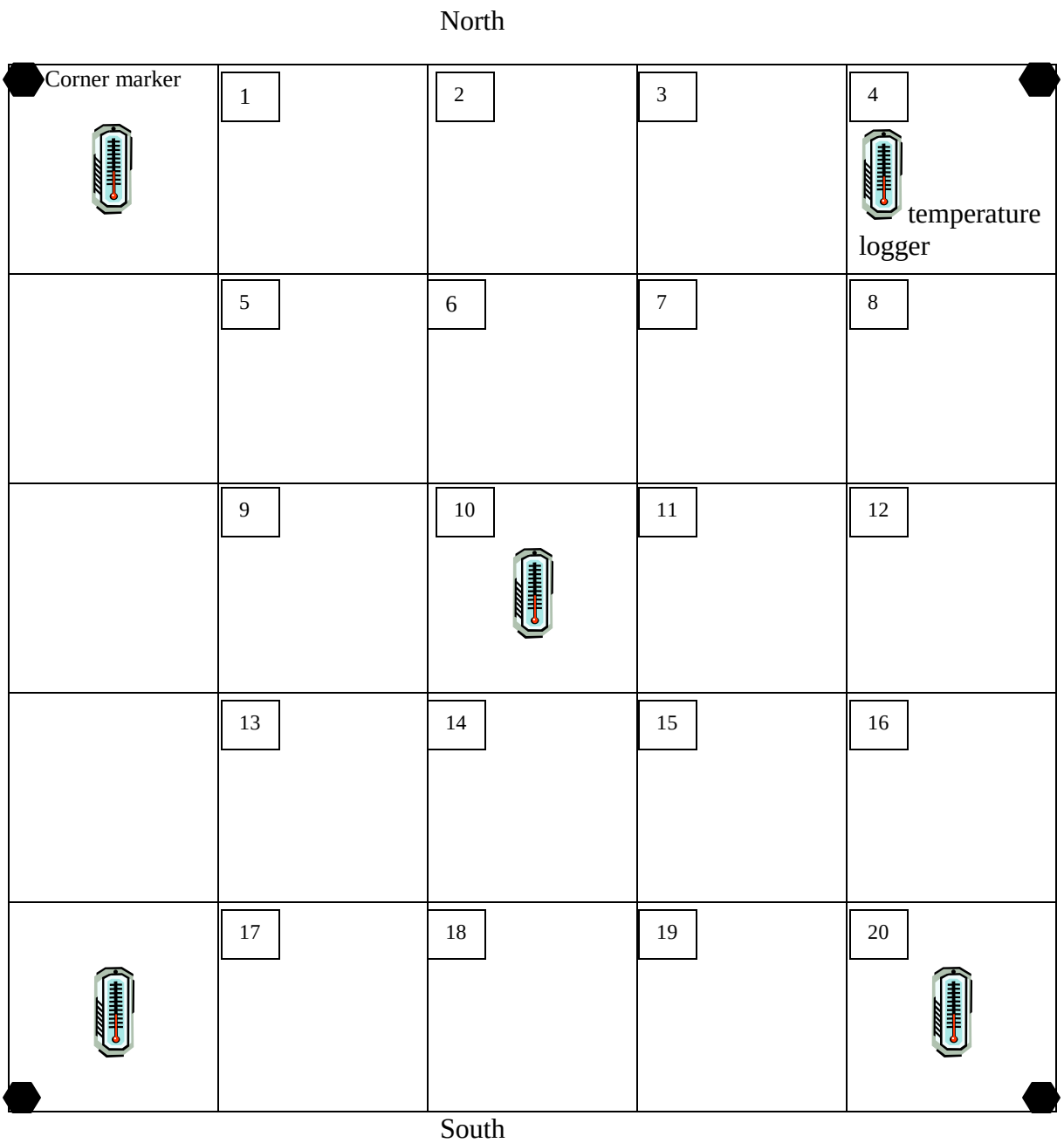


Figure 14. Diagram illustrating the 10 x 10 m plot used to monitor subalpine and alpine vegetation.

Whitebark pine will be monitored using a circular, nested plot design (Figure 15). Trees are measured in a 0.1 ha (17.84 m radius) plot, understory vegetation cover is estimated in one 400 m^2 (11.3 m radius) plot in the center of the tree plot, and saplings and seedlings are measured in five 20 m^2 (2.52 m radius), and (Figure 15, SOP 9). This plot design is a revision of the plot design used during inventories and legacy whitebark pine plots in MORA and NOCA (Rochefort 2008, Appendix B). In developing our initial monitoring strategy, we reviewed the methods developed by the Whitebark Pine Foundation (Tomback et al. 2003) and utilized by the Greater Yellowstone Whitebark Pine Monitoring Working Group (2007). During our preliminary

surveys (1994-1999 as described in Rochefort 2008), we compared the belt transects recommended by the Whitebark Pine Foundation (10 m x 50 m) and circular plots that had been recommended by Dr. Robert Keane (USFS). We found that the narrow configuration of the belt transect was not effective in sampling the sparse and clumped distribution of whitebark pine in our area. We found that circular plots were easily set up and monitored, but often we needed a larger plot because we encountered so few whitebark pine trees within our 11.3 m radius plot. Therefore, we utilized a fixed plot for monitoring whitebark pine community variables (e.g., basal area by species, tree density, understory cover) and a variable radius plot for estimation of percent blister rust infection and mortality in whitebark pine stands. In revising our methods for this protocol, we reviewed literature on the effects of plot size and shape on monitoring efficiency (specifically, Scott 1998, Keeley and Fotheringham 2005, Kangas 2006) and decided to enlarge our original plot from 0.04 ha to 0.1 ha and to revise our seedling and sapling monitoring to utilize 5 subplots rather than the entire 0.04 ha plot.

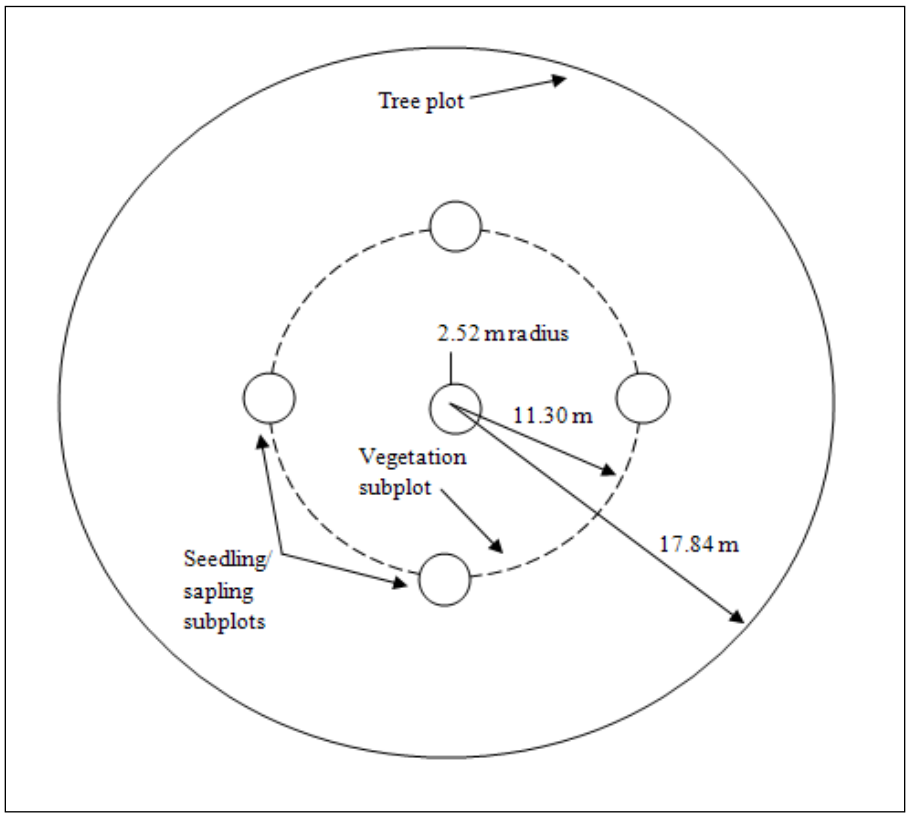


Figure 15. Whitebark pine monitoring plot.

3. Field Methods

A. Field Season Preparations and Equipment Setup

The first step in the field season is to recruit and hire a well-qualified crew. In addition to having botanical experience - preferably with the flora of the Pacific Northwest - the crew should be very physically fit and comfortable spending extensive time in the backcountry. Every reasonable effort should be made to rehire the previous year's crew members, though it is likely that at least some new hires will be required every year. We recommend beginning the recruiting process in December to ensure that maximally experienced, qualified observers can be found and background checks completed by the beginning of the field season. Once the crew has been hired, they should be sent species lists and other materials that will enable them to be as familiar as possible with the flora prior to training. See **SOP 3: Hiring Guidelines and Procedures** and **SOP 2: Preparing for the Field Season** for more detail.

Beginning in February or March, equipment should be inventoried, including testing of breakable items such as GPS units, radios and water filters, and any needed items should be purchased. Data forms and task lists from the previous year should be copied on waterproof paper and topographic maps for the year's targeted plots should be printed and assembled. We have not included precise locations for plots in this protocol document to avoid compromising the security of the plots. Precise locations and directions are maintained in the project database and are provided to field crews as necessary in the Navigation Report (see **SOP 2: Preparing for the Field Season**). Crew housing needs to be secured at each of the parks, and housing, campsites, and other logistic arrangements for the training session need to be made. NPS personnel knowledgeable about backcountry conditions in each park should be consulted to determine whether conditions such as washed out bridges, road or trail closures, or unusually heavy snowpack may present logistical problems. This may be done in concert with staff planning logistics for other monitoring projects involving backcountry travel (See **SOP 2: Preparing for the Field Season**).

B. Sequence of Events During Field Season

Note: Refer to **Appendix C: Yearly Project Task List** for a schedule of annual tasks.

Field crew training will be conducted for this project each year during the last half of May. Crew members will also be encouraged to participate in parts of the seasonal training programs conducted by the large parks for other seasonal staff, which usually occurs in mid-June. Data collection will occur from June through September in usually 4- or 8-day tours, including one office day every 8 work days for data management and equipment maintenance. One crew each will be stationed at each of the large parks. Plots will be grouped into geographic tours and will be visited beginning at low elevations and working up. The Project Lead (NOCA) or Park Plant Ecologist (MORA and OLYM) will be available at the beginning and end of each tour to hear feedback, answer questions, and address concerns (see Chapter 6).

C. Permitting and Compliance

This monitoring project will be categorically excluded from further analysis under the National Environmental Policy Act (NEPA) because (a) it is not controversial, and (b) it involves nondestructive methods with negligible impacts to the environment. The following categorical exclusion applies: (6) Nondestructive data collection, inventory (including field, aerial, and

satellite surveying and mapping), study, research, and monitoring activities (this is also a Departmental CE).

Most of our monitoring sites will fall within designated wilderness. Therefore, aside from NEPA, if study sites are located in designated wilderness, then compliance with the Wilderness Act and NPS policies regarding scientific research in wilderness must be considered. Scientific activities are an important component of wilderness stewardship, and this long-term monitoring project will help to answer important questions that cannot be reasonably addressed in a non-wilderness setting. Therefore, this project clearly meets the minimum requirement for administration of wilderness. There will be no mechanized tools or equipment needed to conduct this research, so there are no minimum tool concerns that need to be evaluated. In short, this activity will fully comply with the spirit and intent of the Wilderness Act. Permanent plot markers will follow guidelines of each park; compliance will be documented prior to implementation of this protocol and it will be re-visited at the beginning of each measurement interval (years 2015, 2020, etc.) or if methods are significantly revised.

D. Overview of Taking Measurements

Alpine and Subalpine Vegetation Plots

Selection of metrics to monitor vegetation change over time requires a careful consideration of available resources (i.e., time, funding) and objective, precise, and repeatable methods (Elzinga et al. 2001, McCune and Grace 2002, Vittoz and Guisan 2007, Wilson 2011). Visual estimate of canopy cover has been a popular method for both inventories and monitoring because cover can be assessed rapidly and the method is more sensitive to detection of rare species than point-grid or line-point intercept methods (Dethier 1993, Godínez-Alvarez et al. 2009, Vittoz et al. 2010). While all cover estimates are subject to observer bias, line-point intercept and point-grid methods are generally more objective than ocular estimates, but require significantly more time (Vittoz and Guisan 2007, Godínez-Alvarez et al. 2009, Vittoz et al. 2010, Wilson 2011). Everson et al. (1990) found that detecting a 20% change in species with a low distribution frequency (e.g., 5%) requires more than 1,200 points. In addition, Miller et al. (2007) found that the line-point intercept method resulted in more damage to monitoring plots. After reviewing these studies, we decided that use of canopy cover and frequency would provide the best response variables for monitoring herbaceous vegetation and subshrubs. In order to minimize observer error, canopy cover will be estimated in cover classes, cover will be estimated by two observers, and pre-season training will include an emphasis on calibration of ocular estimates (Sykes et al. 1983, Vittoz and Guisan 2007, Vittoz et al. 2010).

Alpine and subalpine vegetation is monitored in a 100 m^2 (10 x 10 m) plot. Cover of trees (≥2.54 cm dbh), tall shrubs (i.e., shrubs ≥0.5 m in height), and krummholz trees are documented in the large plot by mapping canopy cover. In addition, dbh of all trees is recorded along with the number of upright stems on krummholz trees (Figure 16). Upright stems (i.e., tree leaders that ascend at least 50 cm above the estimated mean krummholz patch height) provide an indication of favorable climatic conditions for tree development, and while they may reflect short-term conditions, they could also be an indication of changing long-term conditions (Weisberg and Baker 1995, Holtmeier and Broll 2005).

Canopy cover and frequency of herbaceous vegetation and subshrubs are monitored in twenty 0.25 m^2 quadrats located systematically within the 100 m^2 plot (**SOP 8: Monitoring Permanent Alpine/Subalpine Vegetation Plots)**. The condition of the quadrat is described at two scales or resolutions. The first "scale" provides a general description of the quadrat by estimating the cover of six broad cover types (in one plane): rock, gravel, bare soil, litter and dead plants, moss and lichen, and vascular plants. The second scale is a detailed description of all plant and lichen species in the plot using two metrics: frequency and cover. Frequency will be monitored using the nested frequency method. Four sub-quadrats will be superimposed over the 0.25 m^2 quadrat for frequency estimation: #1 is a 5 cm x 5 cm square in the northwest corner of the quadrat, #2 is a 25 cm x 25 cm square, # 3 is 25 cm x 50 m (half the 50 cm x 50 cm quadrat), and # 4 encompasses the entire quadrat. For each species the smallest sub-quadrat in which the plant occurs will be recorded. Cover will be estimated using eleven cover classes: 1 (>0-5), 2 (>5-10), 3 (>10-20), 4 (>20-30), 5 (>30-40), 6 (>40-50), 7 (>50-60), 8 (>60- 70), 9 (>70-80), 10 (>80-90), 11 (>90-100). All vegetation species, both vascular and non-vascular, should be recorded and assigned a minimum of >0-5% cover. Finally, the permanent plot and each quadrat will be photographed during each monitoring time period to provide a visual record of the status of the site.

Spatial and temporal patterns of snow-melt and soil temperature will be measured using data loggers buried 7-10 cm below the soil surface in an open area; temperatures will be collected hourly. Due to the influence of microtopography on spatial variability in snow-melt, we would like to deploy two to five data loggers per site (Lundquist and Lott 2008).

Figure 16. Alpine area in Mount Rainier National Park illustrating krummholz with *Abies lasiocarpa* (right side of clump) and *Pinus albicaulis* (left side).

Whitebark Pine Plots

Whitebark pine will be monitored in 0.1 ha circular plots (radius = 17.84 m). Height and dbh will be recorded for all trees (≥2.54 cm dbh) and whitebark pine will be assessed for signs of blister rust, mountain pine beetles, mistletoe, fire scars, animal gnawing (often a sign of blister rust), crown kill, and presence of cones. Seedlings and saplings of all trees will be recorded in five 20 m^2 (2.52 m radius) circular plots located at the plot center and 11.3 m from the center on the four cardinal directions. Understory vegetation will be estimated using cover classes in a 0.04 ha (11.3 m radius) circle around the center. All whitebark pine trees will be tagged at dbh both to insure accuracy in diameter measurements, to facilitate recognition of resistant trees, and to allow estimation of the time from infection to mortality in individuals. Photographs of each plot will be taken to provide a record of the plot condition and to aid in relocation during future visits.

E. End-of-Season Procedures

End of season procedures are described in **SOP 16: End of Season Debriefing and Close-out**. The equipment will be put away and anything that is damaged or missing will be documented. In addition, Field Crew Leads will prepare a brief field season report enumerating which plots were sampled and describing any logistic difficulties that arose and how they were addressed. The report must clearly document and explain any diversions from established protocols. Finally, it should point out any interesting observations and provide suggestions for improving the training or field season procedures for the future. These reports will be archived.

The Program Lead, NCCN Vegetation group members, Data Manager, and GIS Specialist will hold an end of season meeting each year. The purpose of the meeting will be to discuss the results of the current year, review methods, discuss data analysis, and develop recommendations for upcoming seasons. These meetings will be particularly important during the first five years and during the five year review because field and analysis methods may need some revisions during this initial period.

4. Data Management, Analysis and Reporting

This chapter describes the procedures for data management, 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 17. Specific yearly information management tasks for this project and their timing are described in **Appendix C: Yearly Project Task List**. Readers may also refer to each respective chapter section for additional guidance and instructions.

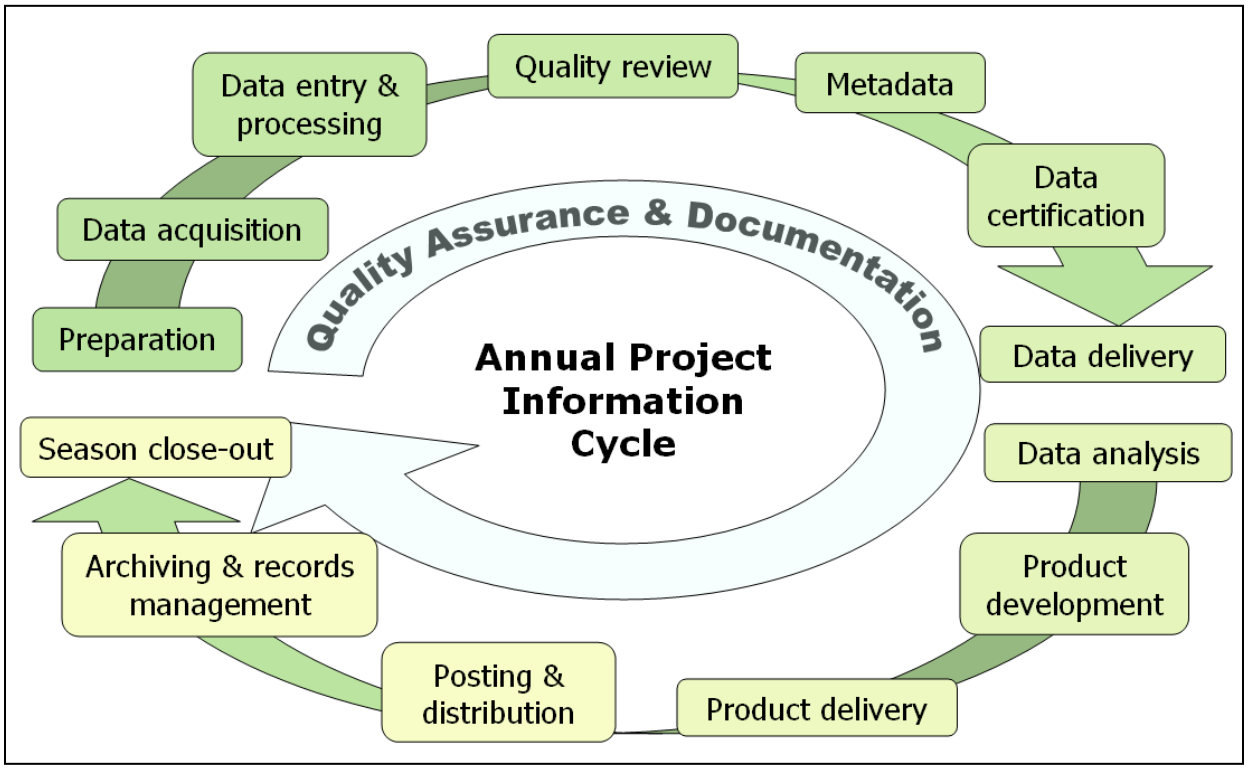


Figure 17. Idealized flow diagram of the cyclical stages of project information management, from pre-season preparation to season close-out. Note that quality assurance and documentation are thematic and not limited to any particular stage.

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.
- *Data acquisition* – Field trips 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 a networked file server 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 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 6: 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 D: Alpine and Subalpine Vegetation Monitoring Protocol 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, the 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.

Technicians should enter data as soon as possible after each field trip 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 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 15: 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 Field Lead should inspect the data being entered to check for completeness and perhaps identify avoidable errors. The Field Lead 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 17: 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 forms are to be scanned as PDF documents and archived (see the product delivery specifications in **SOP 18: 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 covers photographic images collected by project staff or volunteers during the course of conducting project-related activities. Images that are acquired by other means – e.g., downloaded from a website or those taken by a cooperating researcher – are not project records and should be filed and named in such a way that they will not be confused with project records.

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 document a particular feature or perspective for the purpose of site relocation
- To capture site characteristics and possibly to document gross structural changes over time
- 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. Other photographs – e.g., of field crew members at work, or photographs showing the morphology or phenology of certain plant species – may also be retained but are not necessarily linked with database records.

Refer to **SOP 14: Managing Photographic Images** for details on how to handle and manage image files.

GPS Data Procedures

The following general procedures should be followed for GPS data (see **SOP 6: GPS Use** and **Appendix C: Yearly Project Task List**):

1. GPS data should be downloaded by the field crew from the units at the end of each field trip and stored in the project workspace (see **SOP 1: Project Workspace and Records Management**).
2. Raw files should be sent in a timely manner to the GIS Specialist 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 Field Lead 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 17: 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 D: Alpine and Subalpine Vegetation Monitoring Protocol 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 C: 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 18: 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 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 C: Yearly Project Task List**. Refer to **SOP 17: Data Quality Review and Certification** and the delivery specifications in **SOP 18: Product Delivery, Posting and Distribution** for specific instructions.

H. Data Analysis

Note: Refer to **Appendix C: Yearly Project Task List** for the specific analysis tasks and their timing.

Annual Status Estimates

Estimates for each parameter in Table 2 will be summarized annually using measures of central tendency and spread. Inference will be made to each plot for responses that are replicated within the plot (e.g., quadrats). The simplest estimates of current status involve calculating the mean, standard deviation, and coefficient of variation (= standard deviation / mean) of the response using values measured in the plot. An estimate of the variation in a parameter is the standard deviation and CV of the individual numbers. A 95% confidence interval for the true mean response can be made using normal approximations if the measurements are approximately normally distributed. If a particular response is not approximately normal, bootstrap methods (Manly 1997) should be employed to construct appropriate confidence intervals. Frequency of each species will be calculated using the sub-quadrat size in which the species frequency values are between 30 and 70% since this size will provide good sensitivity to change (Elzinga et al. 1998).

Regional inferences will be made using multiple plots within the region using the parameter's mean and an associated confidence interval. A region can be defined as a park, strata (e.g., alpine vs. subalpine), or group of parks (e.g., network, Cascades vs. Olympics). Assuming one measurement of a response is taken on each plot, an estimate of the current average of a parameter is simply the average of that parameter's value over all sampled plots in the region. Variation of the average parameter estimate can be estimated with the *spsurvey* package (Kincaid

et al. 2009) in R using the neighborhood variance estimator of Stevens and Olsen (2003). Differences between regions can be estimated with mixed linear models incorporating fixed region effects.

Trend Estimates

Regression on time can be calculated for single plots to estimate a trend. A simple mixed or fixed effect linear model for trend includes all responses recorded on the site. The coefficient vector is estimated using an appropriate technique (either least-square, the REML method for correlated data, or blocked bootstrap) and inference about the single slope parameter is made. If the slope parameter is significantly different from zero, significant trend has been detected. Changes in species frequency can be tested using a chi-square test to test changes over time within plots (Elzinga et al. 1998).

Regional trends can be estimated using all plots that have been visited at least twice. Assuming approximately normal response values, the trend analysis proposed by Piepho and Ogutu (2002) views responses as repeated measures and estimates a mixed linear model. Using REML, it is possible to obtain an estimate of the fixed overall slope parameter accounting for correlation in the random effects of year and plot, and test whether or not the slope is significantly different from zero. If the slope is significantly different from zero, significant trend has been detected. Regional differences in trends can also be evaluated in this model with the inclusion of a fixed region effect (e.g., park, strata, group of parks).

I. Reporting and Product Development

Refer to **SOP 18: Product Delivery, Posting and Distribution** for the complete schedule for project reports and other deliverables and the people responsible for them.

Report Content

We will produce a detailed annual summary report and a cumulative five-year summary report after all panels have been monitored an equal number of times. Information for annual summary reports will be extracted from the NCCN Alpine Treeline Ecotone Monitoring Database, and graphed in the statistical program R by the data analyst. The finished report will be posted to NRInfo.

The annual report will:

- Summarize the number and types of plots established and monitored
- Summarize environmental and vegetation characteristics of plots (i.e., elevation, species richness, dominant species) by park, zone, and NCCN
- Summarize plant reference collections made during the year
- Summarize status of whitebark pine
- Report challenges or difficulties in establishing or monitoring plots
- Summarize revisions to the protocol
- Provide a summary of questions raised by monitoring observations or data and recommendations for research to complement or expand upon the monitoring effort
- Be published in the appropriate NPS Report series

The five-year report will:

- Summarize patterns and trends in the subalpine and alpine plot data

- Report on trends in whitebark pine infection and mortality rates
- Trend for other variables will be reported in the second and subsequent five-year reports
- Evaluate operational aspects of the monitoring project
- Be published in NPS Technical Reports and peer-reviewed journals

Detailed reporting guidelines and table structures are provided in **Appendix G: Annual Report Template**.

Standard Report Format

Annual reports and trend analysis reports will use the NPS Natural Resource Publications templates, which are pre-formatted Microsoft Word template documents based on current NPS formatting standards. Annual reports will use the Natural Resource Technical Report (NRTR) template. Trend analysis and other peer-reviewed 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.

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 and in **SOP 19: Sensitive Information Procedures**. 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.

J. Identifying and Handling Sensitive Information

Certain project 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. 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://home.nps.gov/applications/npspolicy/DOrders.cfm).

These guidelines apply to all NCCN staff, cooperators, 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.

Additional details for identifying, handling and protecting sensitive information are described in **SOP 19: Sensitive Information Procedures**.

K. Product Delivery, Posting and Distribution

Refer to **SOP 18: 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.

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 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 4J, Identifying and Handling Sensitive Information** for more information.

L. 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://home.nps.gov/applications/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 4J, Identifying and Handling Sensitive Information**.

M. Season Close-out

After the conclusion of the field season, the Project Lead, 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.

5. Personnel Requirements and Training

A. Roles and Responsibilities

The roles associated with this protocol are Project Lead, Data Analyst, Park Plant Ecologists, Field Crew Lead, Field Technician, Data Manager, GIS Specialist, Network Program Manager, and Park Curator. One person may take on several roles. Specific responsibilities associated with the roles are found in Table 7, and the information management task list associated with these roles and responsibilities are found in **Appendix C. Yearly Project Task List**.

Table 7. Roles and responsibilities for Alpine and Subalpine Vegetation Monitoring in the NCCN.

Role	Responsibilities	Position/name
Project Lead	• Project administration, operations, and implementation • Track project objectives, budget, requirements, and progress toward meeting objectives • Coordinate and ratify changes to protocol • Lead training of field crews • Maintain and archive project records • Certify each season's data for quality and completeness • Complete reports, metadata, and other products according to schedule	NOCA/NCCN I&M Plant Ecologist
Data Analyst	• Perform data summaries and analysis, assist interpretation and report preparation	NOCA Science Advisor; NOCA/, MORA/ and OLYM/NCCN I&M Plant Ecologists
Park Plant Ecologists	• Facilitate logistics planning and coordination • Review reports, data and other project deliverables • Assist with training and ensuring safety of field crew • Insure compliance is up-to-date	NOCA/ and OLYM/NCCN I&M Plant Ecologists, and MORA Plant Ecologist
Field Crew Lead	• Assist in training and ensuring safety of field crew • Plan and execute field visits • Acquire and maintain field equipment • Oversee data collection and entry, verify accurate data transcription into database • Complete a field season report	Seasonal technicians (GS-7)
Field Technician	• Collect, record, enter and verify data	Seasonal technicians, (GS-5), volunteers and interns
Data Manager	• Consult on data management activities • 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 • Coordinate with GIS Specialist on upload of GPS coordinate data to database	NCCN Data Manager

Table 7. Roles and responsibilities for Alpine and Subalpine Vegetation Monitoring in the NCCN (continued).

GIS Specialist	• Consultant on spatial data collection, GPS use, and spatial analysis techniques • Facilitate spatial data development and map output generation • Work with Project Lead and Data Analyst to analyze spatial data and develop metadata for spatial data products • Primary steward of GIS data and products • Prepare GPS units for field season, provide training to Field Lead and crew	NCCN GIS Specialist
Network Program Manager	• Review annual reports for completeness and compliance with I&M standards and expectations	NCCN I&M Network Program Manager
Park Curator	• Receive and archive copies of annual reports, analysis reports, and other publications • Facilitate archival of other project records (e.g., original field forms, etc.)	Park Curators and Collections Managers at OLYM, NOCA and MORA

B. Qualifications

The Field Lead each year should have experience with plant identification, preferably in plants of the Pacific Northwest. Familiarity with one or more of the NCCN parks is also desirable. Ideally, the Field Lead will have supervised backcountry field crews before and/or previously served as an NCCN Alpine and Subalpine Vegetation monitoring crew member. Finally s/he must be physically fit and prepared to spend extended periods of time in the backcountry.

The other crew members should have prior botany experience, including substantial experience with the Pacific Northwest flora or with demonstrated ability to quickly learn plant identification. They must also be physically fit and prepared to spend extended periods of time in the backcountry. Substantial backpacking experience is desirable. See **SOP 3: Hiring Guidelines and Procedures** for more detail.

C. Training Procedures

Training will be accomplished during the first weeks of the field season in conjunction with the Forest Monitoring Protocol and the first week of field sampling (if needed). Training should be planned to allow for ample time for any required meetings between the Field Crew, Field Lead, Project Lead, Data Manager and GIS Specialist. The following general topics will be covered (See **SOP 4: Orientation and Training of Field Crews** for details):

- Background on project objectives, sampling design, and data analysis
- Plant identification
- Orienteering
- Establishing and sampling vegetation plots
- Office procedures – administrative procedures, data entry and QA/QC, IT security, voucher collection and processing, handling and scanning of data forms, GPS use and data download, etc.

Training will be accomplished by conducting a number of training exercises including navigating and collecting data with a GPS and establishing and sampling a vegetation plot.

D. Safety

Personal safety is the number one priority at all times in the field and office. At no time are staff expected to participate in operations that appear dangerous or risky. The alpine treeline ecotone can present a number of challenges for field crews: high altitudes, steep slopes, irregular ground surfaces, long travel times, and weather extremes (e.g., direct sunlight, rain, lightening, and rapidly changing weather). Awareness of weather, environmental conditions, wildlife, and the whereabouts of crew members is crucial to safe working conditions at high elevations. All field personnel are required to participate in an annual field safety program that covers standard safe field practices in the alpine treeline ecotone (See **SOP 4: Orientation and Training of Field Crews** for details).

6. Operational Requirements

A. Annual Workload and Field Schedule

A detailed schedule for project activities is found in **Appendix C: Yearly Project Task List**. In brief, hiring of field crews is conducted from December through March. The three crews of two members conduct data collection, entry and download from mid-July until early September. In preparation for the field season, new or replacement equipment orders will be placed prior to June 1each year, and the computer workspace and database set-up will be completed by June 1. Field crew training will occur during the last week of May and again in the first or second week of July, with field work conducted from mid-July to the end of the field season. Following the field season, the Project Lead and other NPS staff members will evaluate the protocol and assess whether changes are needed. The Project Lead is responsible for data certification by the end of November so that the Data Manager can upload the data during December and January, and complete metadata by March. Data will be analyzed and a report generated by the project lead during February to April, to be delivered to the NCCN Program Manager by April 30. The project will require help from GIS staff for GPS training, downloading of GPS units during the field season, and generating occasional map output.

B. Facility and Equipment Needs

This project requires a moderate amount of special facilities and equipment. The crew will require housing in the vicinity of each park (MORA, NOCA, OLYM) for the duration of the field season (early May to mid-September which will include the field time for the forest protocol). Vehicles will be available at each park for transportation to plots or trailheads while on the job. Crew members will be provided with some backpacking gear and will provide some of their own backpacking gear. Computer access for field crew members is necessary during the training session, and throughout the season for data entry. Equipment requirements for each task in the protocol are listed as appropriate in the SOPs.

C. Startup Costs and Budget Considerations

This project has relatively low start-up costs because most equipment is shared with the on-going forest monitoring project (Table 8). However, there will be a recurring purchases of data loggers ($6,000) and the annual equipment replacement costs each year as equipment is damaged or wears out, amounting to $200 to $3,500 (i.e., GPS units or range finder replacement).

Annual costs of fieldwork will be relatively low and based on 4 payperiods of field work for years 1 through 4 and 3 payperiods in year 5 to sample the legacy plots (see Tables 4, 5).

Table 8. Alpine and Subalpine Vegetation monitoring protocol projected budget.

Project Stage / Budget Category	Personnel	Grade	Alpine/Subalpine & Whitebark Pine (Years 1-4)[1]		Alpine Legacy Plots (Year 5)[1]	
			Pay periods	Cost	Pay periods	Cost
Preparation	Project Lead	GS-12	1	4,205	0	0
	MORA Plant Ecologist[2]	GS-12	0.3	1,330	0.1	443
	OLYM Park Plant Ecologist	GS-12	0.3	1,280	0	0
	Data Manager	GS-11	0.4	1,360	0.1	340
	GIS Specialist	GS-9	0.5	1,435	0.1	287
Data Acquisition	Project Lead	GS-12	2	8,410	0	0
	MORA Plant Ecologist	GS-12	1	4,434	1	4,434
	NOCA Science Advisor[2]	GS-13	1	5,000	0.1	500
	OLYM Plant Ecologist	GS-12	1	4,266	0	0
	Data Manager	GS-11	0.1	340	0.1	340
	Field Crew Lead (3)[3]	GS-7	10.5	17,994	1.4	2,399
	Field Technician (3)[3]	GS-5	10.5	14,525	1.4	1,937
Data Entry, Processing, & Quality Review	Project Lead	GS-12	0.4	1,682	0	0
	MORA Plant Ecologist	GS-12	0.2	887	0.1	443
	OLYM Plant Ecologist	GS-12	0.2	853	0	0
	Data Manager	GS-11	0.1	340	0.1	340
	Field Crew Lead (3)	GS-7	1.2	2,056	0.1	171
	Field Technician (3)	GS-5	1.2	1,660	0	0
	GIS Specialist	GS-9	0.1	287	0.1	287
Data Certification & Documentation	Project Lead	GS-12	0.2	841	0	0
	Data Manager	GS-11	0.3	1,020	0.3	1,020
	GIS Specialist	GS-9	0.4	1,148	0.4	1,148
Data Analysis	Project Lead	GS-12	1	4,205	0	0
	MORA Plant Ecologist	GS-12	0.2	887	0.4	1,774
	NOCA Science Advisor	GS-13	2	10,000	0.4	2,000
	OLYM Plant Ecologist	GS-12	0.2	853	0	0
	Data Manager	GS-11	0.1	340	0.1	340
	GIS Specialist	GS-9	0.1	287	0.1	287
Reporting & Product Development	Project Lead	GS-12	1	4,205	0.1	421
	MORA Plant Ecologist	GS-12	0.2	887	0.2	887

Table 8. Alpine and Subalpine Vegetation monitoring protocol projected budget (continued).

Project Stage / Budget Category	Personnel	Grade	Alpine/Subalpine & Whitebark Pine (Years 1-4)[1]		Alpine Legacy Plots (Year 5)[1]	
			Pay periods	Cost	Pay periods	Cost
	NOCA Science Advisor	GS-13	1	5,000	0.1	500
	OLYM Plant Ecologist	GS-12	0.2	853	0.1	427
	Data Manager	GS-11	0.1	340	0.1	340
	NCCN Program Manager	GS-13	0.1	500	0.1	500
	GIS Specialist	GS-9	0.2	574	0.1	287
Archiving, Posting & Records Management	Project Lead	GS-12	0.1	421	0	0
	MORA Plant Ecologist	GS-12	0	0	0.1	443
	Data Manager	GS-11	0.1	340	0.1	340
Season Close-out	Project Lead	GS-12	0.1	421	0	0
	MORA Plant Ecologist	GS-12	0.1	443	0.1	443
	NOCA Science Advisor	GS-13	0.1	500	0.1	500
	OLYM Park Plant Ecologist	GS-12	0.1	427	0	0
	Field Crew Lead (3)	GS-7	0.3	514	0.1	171
	Field Technician (3)	GS-5	0.3	415	0	0
	Data manager	GS-11	0.1	340	0.1	340
	GIS Specialist	GS-9	0.1	287	0.1	287
Field Personnel			24	37,164	3	4,679
Total Personnel			35	79,023	5	12,009
Contributed Personnel			6	29,368	3	12,368
Travel				3,000		3,000
Vehicles				2,000		2,000
Supplies				6,500[4]		200
Total[5]				**108,391**		**24,377**
Statistical Assistance for 5 year reports				**14,000**		

[1] Monitoring is conducted annually for four years and during the fifth year, forest monitoring and alpine legacy plots are monitored (See Tables 4 and 5)

[2] In-kind support from NOCA, MORA

[3] (3) Indicates that there will be three GS-7 and three GS-5 field positions

[4] Includes cost for 50 data loggers @ $120 each

[5] Total excluding contributed personnel and statistical assistance every five years.

Literature Cited

Acker, S. A., A. Woodward, J. R. Boetsch, K. Hutten, M. Bivin, R. Rochefort, C. C. Thompson, and L. Whiteaker. 2010. Forest vegetation monitoring protocol for the North Coast and Cascades Network. Natural Resource Report NPS/NCCN/NRR_2010/242. National Park Service, Fort Collins, CO.

Agee, J. K., and L. Smith. 1984. Subalpine tree establishment after fire in the Olympic Mountains, Washington. Ecology 65:810-819.

Alftine, K. J., G. P. Malanson, and D. B. Fagre. 2003. Feed-back driven response to multidecadal climatic variability at an alpine treeline. Physical Geography 24:520-534.

Arft, A. M., M. D. Walker, J. Gurevitch, J. M. Alatalo, M. S. Bret-Harte, M. Dale, M. Diemer, F. Gugerli, G. R. H.Henry, M. H. Jones, and others. 1999. Responses of tundra plants to experimental warming: Meta-analysis of the international tundra experiment. Ecological Monographs 69:491-511.

Aubry C., D. Goheen, R. Shoal, T. Ohlson, T. Lorenz, A. Bower, C. Mehmel, and R. Sniezko (compiled by). 2008. Whitebark pine restoration strategy for the Pacific Northwest Region 2009-2013. USDA Forest Service, Pacific Northwest Region, Olympia, WA. Available online at http://www.fs.fed.us/r6/genetics/publications/detail/pub802 (accessed 9 June 2011).

Bachelet, D., and R. P. Neilson. 2000. Biome redistribution under climate change. Pages 18-44 *in* L. Joyce and R. Birdsey, editors. The impact of climate change on America's forests. USDA Forest Service General Technical Report RMRS-GTR-59. U.S. Department of Agriculture, U.S. Forest Service. Rocky Mountain Research Station, Fort Collins, CO.

Beckage, B., B. Osborne, D. G. Gavin, C. Pucko, T. Siccama, and T. Perkins. 2008. A rapid upward shift of a forest ecotone during 40 years of warming in the Green Mountains of Vermont. Proceedings of the National Academy of Sciences 105:4197-4202.

Bekker, M. F. 2005. Positive feedback between tree establishment and patterns of subalpine forest advancement, Glacier National Park, Montana, U.S.A. Arctic, Antarctic, and Alpine Research 37:97-107.

Boetsch, J. R., B. Christoe, and R. E. Holmes. 2009. Data management plan for the North Coast and Cascades Network Inventory and Monitoring Program (2005). Natural Resource Report NPS/NCCN/NRR—2009/078. National Park Service, Fort Collins, CO.

British Columbia Ministry of Forests and Range (BECWeb). 2011. Biogeoclimatic Ecosystem Classification Program, GIS Products. Data available online at http://www.for.gov.bc.ca/hre/becweb/resources/maps/gis_products.html (accessed 29 March 2011).

Brockman, C. F. 1959. Ecological study of subalpine meadows, Yakima Park and Tipsoo Lake areas, Mount Rainier National Park, Washington, summer 1960. Unpublished report, Mount Rainier National Park, Longmire, WA.

Brockman, C. F. 1960. Ecological study of sub-alpine meadows, Paradise Valley area, Mount Rainier National Park, Washington, summer 1959. Unpublished report, Mount Rainier National Park, Longmire, WA.

Canaday, B. B., and R. W. Fonda. 1974. The influence of subalpine snowbanks on vegetation pattern, production, and phenology. Bulletin of the Torrey Botanical Club 101:340-350.

Canonne, N., S. Sgorbati, and M. Guglielmin. 2007. Unexpected impacts of climate change on alpine vegetation. Frontiers in Ecology and the Environment 5:360-364.

Cassidy, K. M. 1997. Washington Gap Project 1991 land cover for Washington State. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA.

Chapin III, F. S., and G. R. Shaver. 1985. Individualistic growth response of tundra plant species to experimental manipulations in the field. Ecology 66:564-576.

Chapin III, F. S., G. R. Shaver, A. E. Giblin, K. J. Nadelhoffer, and J. A. Laundre. 1995. Responses of arctic tundra to experimental and observed changes in climate. Ecology 76:694-711.

Cole, D. N., L. Yung, E. S. Zavaleta, G. H. Aplet, F. S. Chapin III, D. M. Graber, E. S. Higgs, R. J. Hobbs, P. B. Landres, C. I. Millar, and others. 2008. Naturalness and beyond: protected area stewardship in an era of global environmental change. The George Wright Forum 25 (1):36-36.

Crawford, R. C., C. B. Chappell, C. C. Thompson, and F. J. Rocchio. 2009. Vegetation classification of Mount Rainier, North Cascades, and Olympic National Parks. Natural Resource Technical Report NPS/NCCN/NRTR—2009/211. National Park Service, Fort Collins, CO.

Davis, G. E. 1989. Design of a long-term ecological monitoring program for Channel Islands National Park. Natural Areas Journal 9:80-89.

Davis, G. E. 2005. National Park stewardship and 'vital signs' monitoring: a case study from Channel Islands National Park, California. Aquatic Conservation: Marine and Freshwater Ecosystems 15:71-89.

Dethier, M. N., E. S. Graham, S. Cohen, and L. M. Tear. 1993. Visual versus random-point percent cover estimations: ‘objective’ is not always better. Marine Ecology Progress Series 96:93-100.

Douglas, G. W. 1970. A vegetation study in the subalpine zone of the western North Cascades, Washington. Thesis. University of Washington, Seattle, WA.

Douglas, G.W. 1972. Subalpine plant communities of the western North Cascades, Washington. Arctic and Alpine Research 4:147-166.

Douglas, G. W., and L. C. Bliss. 1977. Alpine and high subalpine plant communities of the North Cascades region, Washington and British Columbia. Ecological Monographs 47:113-150.

Edwards, O. M. 1980. The alpine vegetation of Mount Rainier National Park: structure, development and constraints. Dissertation. University of Washington, Seattle, WA.

Edwards, O. M. 1985. Human impact on the alpine ecosystem of Mount Rainier. Unpublished report submitted to Mount Rainier National Park, Contract No. CX-9000-3-E060. University of Washington, Seattle, WA.

Elzinga, C. L., D. W. Salzer, J. W. Willoughby. 1998. Measuring and monitoring plant populations. BLM Technical Reference 1730-1. Denver, CO.

Evans, R. D., and R. W. Fonda. 1990. The influence of snow on subalpine meadow community pattern, North Cascades, Washington. Canadian Journal of Botany 68:212-220.

Everson, T. M., G. P. Y. Clarke, and C. S. Everson. 1990. Precision in monitoring plant species composition in montane grasslands. Vegetatio 73:47-51.

Fancy, S. G., J. E. Gross, and S. L. Carter. 2009. Monitoring the condition of natural resources in US National Parks. Environmental Monitoring and Assessment 151:161-174.

Fischlin, A., G. F. Midgley, J. T. Price, R. Leemans, B. Gopal, C. Turley, M. D. A. Rounsevell, O. P. Dube, J. Tarazona, and A. A.Velichko. 2007. Ecosystems, their properties, goods, and services. Pages 211-272 *in*: Parry, M. L., O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, eds. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Franklin, J. F., and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, OR.

Franklin, J. F., W. H. Moir, G. W. Douglas, and C. Wiberg. 1971: Invasion of subalpine meadows by trees in the Cascade Range, Washington and Oregon. Arctic and Alpine Research 3:215-224.

Franklin, J. F., H. H. Shugart, and M. E. Harmon. 1987. Tree death as an ecological process. BioScience 37:550-556.

Franklin, J. F., T. A. Spies, R. Van Pelt, A. B. Carey, D. A. Thornburgh, D. R. Berg, D. B. Lindenmayer, M. E. Harmon, W. S. Keeton, D. C. Shaw, K. Bible, and J. Chen. 2002. Disturbance and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management 155:399-423.

Germino, M. J., W. K. Smith, and A. C. Resor. 2002. Conifer seedling distribution and survival in an alpine-treeline ecotone. Plant Ecology 162:157-168.

Godínez-Alvarez, H. J., E. Herrick, M. Mattocks, D. Toledo, and J. Van Zee. 2009. Comparison of three vegetation monitoring methods: their relative utility for ecological assessment and monitoring. Ecological Indicators 9:2001-1008.

Gonzalez, P., R. P. Nielsen, J. M. Lenihan, and R. J. Drapek. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. Global Ecology and Biogeography 19:755-768.

Grabherr, G., M. Gottfried, and H. Pauli. 1994. Climate effects on mountain plants. Nature 369:448.

Grace, J., F. Berninger, and L. Nagy. 2002. Impacts of climate change on the tree line. Annals of Botany 90:537-544.

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2007. Interagency whitebark pine monitoring protocol for the Greater Yellowstone Ecosystem, Version 1.00. Greater Yellowstone Coordinating Committee, Bozeman, MT.

Hamann, M. J. 1972. Vegetation of alpine and subalpine meadows of Mount Rainier National Park, Washington. Thesis. Washington State University, Pullman, WA.

Hamlet, A. F., P. W. Mote, M. R. Clark, and D. P. Lettenmaier. 2005. Effects of temperature and precipitation variability on snowpack trends in the western United States. Journal of Climate 18:4545-4561.

Harsch, M. A., P. E. Hulme, M. S. McGlone, and R. P. Duncan. 2009. Are treelines advancing? A global meta-analysis of treeline response to climate warming. Ecology Letters 12:1040-1049.

Harte, J., and R. Shaw. 1995. Shifting dominance within a montane vegetation community – results of a climate-warming experiment. Science 267:876-880.

Haugo, R. D., and C. B. Halpern. 2010. Interactive effects of tree and herb cover on survivorship, physiology, and microclimate of conifer seedlings at the alpine tree-line ecotone. Botany 88:488-499.

Henderson, J. A. 1974. Composition, distribution and succession of subalpine meadows in Mount Rainier National Park. Dissertation. Oregon State University, Corvallis, OR.

Holtmeier, F. K., and G. Broll. 2005. Sensitivity and response of northern hemisphere altitudinal and polar treelines to environmental change at landscape and local scales. Global Ecology and Biogeography 14:395-410.

Johnson, D. R., K. P. Foster, and K. L. Kerr. 1991. Mount Rainier National Park 1990 visitor survey. Subagreement No. 4, Coop. Agreement No. CA 9000-8-0007. National Park Service, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Seattle, WA.

Jurasinski, G., and J. Kreyling. 2007. Upward shift of alpine plants increases floristic similarity of mountain summits. Journal of Vegetation Science 18:711-718.

Kangas, A. 2006. Mensurational aspects. Pages 53-63 *in* A. Kangas, and M. Maltamo, editors. Forest inventory: methodology and applications. Springer, Dordrecht, The Netherlands.

Kearney, M. S., and B. H. Luckman. 1983. Holocene timberline fluctuations in Jasper National Park, Alberta. Science 221:261-263.

Keeley, J. E., and C. J. Fotheringham. 2005. Plot shape effects on plant species diversity measurements. Journal of Vegetation Science 16:249-256.

Kendall, K. C., and R. E. Keane. 2001. Whitebark decline: infection, mortality, and population trends. Pages 221-243 *in* D. F. Tomback, S. F. Arno, and R. E. Keane, editors. Whitebark pine communities: ecology and restoration. Island Press, Washington, D.C.

Kincaid, T., and T. Olsen. 2009. spsurvey: Spatial Survey Design and Analysis. R package version 2.1. Available at http://CRAN.R-project.org/package=spsurvey (accessed 9 June 2011).

Kincaid, T., T. Olsen, D. Stevens, C. Platt, D. White, and R. Remington. 2009. spsurvey: Spatial survey design and analysis. R package version 2.1. Available at http://www.epa.gov/nheerl/arm/analysispages/software.htm (accessed 9 June 2011).

Klanderud, K. 2005. Climate change effects on species interactions in an alpine plant community. Journal of Ecology 93:127-137.

Klanderud, K. 2008. Species-specific responses of an alpine plant community under simulated environmental change. Journal of Vegetation Science 19:363-372.

Klanderud, K., and Ø. Totland. 2005. Simulated climate change altered dominance hierarchies and diversity of an alpine biodiversity hotspot. Ecology 86:2047-2054.

Klasner, F. L., and D. B. Fagre. 2002. A half century of change in alpine treeline patterns at Glacier National Park, Montana, U.S.A. Arctic, Antarctic, and Alpine Research 34:49-56.

Körner C., and W. Larcher. 1988. Plant life in cold climates. Pages 25–57 *in* S. F. Long and F. I. Woodward, eds. Plant and temperature. Symposium of the Society for Experimental Biology. Volume 42. The Company of Biologists, Cambridge, UK.

Kudo, G., M. Kimura, T. Kasagi, Y. Kawai, and A. S. Hirao. 2010. Habitat-specific responses of alpine plants to climatic amelioration: comparison of fellfield to snowbed communities. Arctic, Antarctic, and Alpine Research 42:438-448.

Kullman L. 2002. Rapid recent range-margin rise of tree and shrub species in the Swedish Scandes. Journal of Ecology 90:68-77.

Kuramoto, R. T., and L. C. Bliss. 1970. Ecology of subalpine meadows in the Olympic Mountains, Washington. Ecological Monographs 40:317-347.

LaMarche, V. C. 1973. Holocene climatic variations inferred from treeline fluctuations in the White Mountains, California. Quarternary Research 3:632-660.

Larson, E. R. 2011. Influences of the biophysical environment on blister rust and mountain pine beetle, and their interactions, in whitebark pine forests. Journal of Biogeography 38:453-470.

Lawler, J. J., T. H. Timothy, C. Pyke, M. R. Shaw, P. Gonzalez, P. Kareiva, L. Hansen, L. Hannah, K. Klausmeyer, A. Aldous, C. Bienz, and S. Pearsall. 2009. Resource management in a changing and uncertain climate. Frontiers in Ecology and the Environment 8:35-43.

Lenoir, J., J. C. Gegout, P. A. Marquet, P. de Ruffray, and H. Brisse. 2008. A significant upward shift in plant species optimum elevation during the 20th century. Science 320:1768-1771.

Lesica P., and B. M. Steele. 1996. A method for monitoring long-term population trends: an example using rare arctic-alpine plants. Ecological Applications 6:879-887.

Little, R. L., D. L. Peterson, and L. L. Conquest. 1994. Regeneration of subalpine fir (*Abies lasiocarpa*) following fire: effects of climate and other factors. Canadian Journal of Forest Research 24:934-944.

Loarie, S. R., P. B. Duffy, H. Hamilton, G. P. Asner, C. B. Field, and D. D. Ackerly. 2009. The velocity of climate change. Nature 462:24-31.

Logan, J. A., W. W. MacFarlane, and L. Willcox. 2010. Whitebark pine vulnerability to climate-driven mountain pine beetle disturbance in the Greater Yellowstone Ecosystem. Ecological Applications 20:895-902.

Lundquist, J. D., and F. Lott. 2008. Using inexpensive temperature sensors to monitor the duration and heterogeneity of snow-covered areas. Water Resources Research 44: W00D16, doi:10.1029/2008WR007035.

Maher, E. L., M. J. Germino, and N. J. Hasselquist. 2005. Interactive effects of tree and herb cover on survivorship, physiology, and microclimate of conifer seedlings at the alpine tree-line ecotone. Canadian Journal of Forest Research 35:567-574.

Malanson, G. P., D. R. Butler, D. B. Fagre, S. J. Walsh, D. F. Tomback, L. D. Daniels, L. M. Resler, W. K. Smith, D. J. Weiss, D. L. Peterson, and others. 2007. Alpine treeline of western North America: linking organism to landscape dynamics. Physical Geography 28:378-396.

Manly, B. F. J. 1997. Randomization, bootstrap and Monte Carlo methods in biology, 2nd ed. Chapman and Hall, London, England.

Markgraf, V., and L. Scott. 1981. Lower timberlines in central Colorado during the last 15,000 yr. Geology 9:231-234.

McCune, B. and J. B. Grace. 2002. Analysis of ecological communities. MJM Software Design. Gleneden Beach, OR.

Miller, M. E., D. L.Witwicki, R. K. Mann, and N. J. Tancreto. 2007. Field evaluations of sampling methods for long-term monitoring of upland ecosystems on the Colorado Plateau: U.S. Geological Survey Open-File Report 2007-1243. U.S. Department of Interior, U.S. Geological Survey, Reston, VA. Available at: http://pubs.usgs.gov/of/2007/1243/ (accessed 22 August 2011).

Mote, P. W, A. F. Hamlet, M. P. Clark, and D. P. Lettenmaier. 2005. Declining mountain snowpack in western North America. American Meteorological Society 86:39-49

Mote, P., A. Hamlet, and E. Salathé. 2008. Has spring snowpack declined in the Washington Cascades? Hydrology and Earth Systems Sciences 12:193-206.

Mote, P., and E. Salathé. 2010. Future climate in the Pacific Northwest. Climatic Change 102:29-50.

Murray, M. P., and M. C. Rasmussen. 2003. Non-native blister rust disease on whitebark pine at Crater Lake National Park. Northwest Science 77:87-90.

National Park Service. 1936. Vegetation cover survey for Mount Rainier National Park. National Park Service, Branch of Forestry, Civilian Conservation Corps. Published Report-132562.

National Park Service. 2001. Park vital signs monitoring – a commitment to resource protection. National Park Service, resource brief. National Resource Program Center, Fort Collins, CO.

National Park Service. 2006. Management Policies. Available at: http://www.nps.gov/policy/mp/policies.html (accessed 6 February 2007).

North Coast and Cascades Network (NCCN). 2007. NCCN Metadata Guidelines. U.S. Department of Interior, National Park Service. Available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm (accessed 9 June 2011).

North Coast and Cascades Network (NCCN). 2009. NCCN GPS Guidelines. U.S. Department of Interior, National Park Service. Available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm (accessed 9 June 2011).

Oakley, K. L, L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31:1000-1003.

Odland, A., T. Høitmomt, and S. L. Olsen. 2010. Increasing vascular plant richness on 13 high mountain summits in southern Norway since the early 1970s. Arctic, Antarctic, and Alpine Research 42:458-470.

Oliver, C. D., and B. C. Larson. 1990. Forest stand dynamics. McGraw-Hill, Inc., San Francisco, CA.

Pacific Meridian Resources (PMR). 1996. Vegetation and landform database development study final report. Unpublished report to the National Park Service. Pacific Meridian Resources, Portland, OR.

Pauli, H., M. Gottfried, K. Reiter, C. Klettner, and G. Grabherr. 2007. Signals of range expansions and contractions of vascular plants in the high Alps: observations (1944- 2004) at the Gloria* master site Schrankogel, Tyrol, Austria. Global Change Biology 13:147-156.

Piepho, H. P., and J. O. Ogutu. 2002. A simple mixed model for trend analysis in wildlife populations. Journal of Agricultural, Biological and Environmental Statistics 7:350-360.

Price, M. V., and N. M. Walker. 1998. Effects of experimental warming on plant reproductive phenology in a subalpine meadow. Ecology 79:1261-1271.

Price, M. V., and N. M. Walker. 2000. Responses of subalpine meadow vegetation to four years of experimental warming. Ecological Applications 10:811-823.

PRISM. 2009. Prism Climate Group, Oregon State University. Data available online at http://www.prism.oregonstate.edu/ (accessed 9 June 2011).

Resler, L. M., D. R. Butler, and G. P. Malanson. 2005. Topographic shelter and conifer establishment and mortality in an alpine environment, Glacier National Park, Montana. Physical Geography 26:112-125.

Resler, L. M., and D. F. Tomback. 2008. Blister rust prevalence in krummholz whitebark pine: implications for treeline dynamics, northern Rocky Mountains, Montana, U.S.A. Arctic, Antarctic, and Alpine Research 40:161-170.

Rochefort, R. M. 2008. The influence of white pine blister rust (*Cronartium rubicola*) on whitebark pine (*Pinus albicaulis*) in Mount Rainier National Park and North Cascades National Park Service Complex, Washington. Natural Areas Journal 28:290-298.

Rochefort, R. M., R. L. Little, A. Woodward, and D. L. Peterson. 1994. Changes in the distribution of subalpine conifers in western North America: A review of climate and other factors. Holocene 4:89-100.

Rochefort, R. M., and Peterson, D. L. 1996. Temporal and spatial distribution of trees in subalpine meadows of Mount Rainier National Park. Arctic and Alpine Research 28:52-59.

Schlesinger, M. E., and J. F. B. Mitchell. 1987. Climate model simulations of the equilibrium climatic response to increased carbon dioxide. Reviews of Geophysics 25:760-798.

Schneider, S. H. 1989. Global Warming. Sierra Club Books, San Francisco, CA.

Schreiner, E. G. 1994. Appendix A1: Vegetation sampling. Pages 234-241 *in* D. B. Houston, E. G. Schreiner, and B. B. Moorhead, editors. Mountain goats in Olympic National Park: biology and management of an introduced species. Scientific Monograph,

NPS/NROLYM/NRSM-94/25. National Park Service, Natural Resources Publication Office, Denver, CO.

Shoal, R., and C. Aubry. 2006. Assessment of whitebark pine health on eight National Forests in Oregon and Washington. USDA US Forest Service, Pacific Northwest Region (R6) Oregon and Washington, Olympia, WA. Available online at http://www.fs.fed.us/r6/genetics/publications/detail/pub007 (accessed 9 June 2011).

Scott, C. T. 1998. Sampling methods for estimating change in forest resources. Ecological Applications 82:228-233.

Smith, C. M., B. Wilson, S. Rasheed, R. C. Walker, T. Carolin, and B. Shepard. 2008. Whitebark pine and white pine blister rust in the Rocky Mountains of Canada and northern Montana. Canadian Journal of Forest Research 38:982-995.

Stevens, D. L., and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics 14:593-610.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Stueve, K. M., D. L. Cerney, R. M. Rochefort, and L. L. Kurth. 2009. Post-fire tree establishment patterns at the alpine treeline ecotone: Mount Rainier National Park, Washington, USA. Journal of Vegetation Science 20:107-120.

Theobald, D. M., D. L. Stevens, Jr., D. White, N. S. Urquhart, A. R. Olsen, and J. B. Norman. 2007. Using GIS to generate spatially balanced random survey designs for natural resource applications. Environmental Management 40:134-146.

Theurillat, J. P., and A. Guisan. 2001. Potential impact of climate change on vegetation in the European Alps: a review. Climatic Change 50:77-109.

Tomback, D. F., S. F. Arno, and R. E. Keane. 2001. The compelling case for management intervention. Pages 3-28 *in* Tomback, D. F, S. F. Arno, and R. E. Keane, eds., Whitebark Pine Communities: Ecology and Restoration. Island Press, Washington, D.C.

Tomback, D. F., R. E. Keane, W. W. McCaughey, and C. Smith. 2003. Methods for surveying and monitoring of whitebark pine for blister rust infection and damage. Whitebark Pine Foundation, Missoula, MT.

van Mantgem, P. J., and N. L. Stephenson. 2007. Apparent climatically induced increase of tree mortality rates in a temperate forest. Ecology Letters 10:909-916.

van Mantgem, P. J., N. L. Stephenson, J. C. Byrne, L. D. Daniels, J. F. Franklin, P. Z. Fulé, M. E. Harmon, A. J. Larson, J. M. Smith, A. H. Taylor, and T. T. Veblen. 2009. Widespread increase of tree mortality rates in the western United States. Science 323:521-524.

Vittoz, P., and A. Guisan. 2007. How reliable is the monitoring of permanent vegetation plots? A test with multiple observers. Journal of Vegetation Science 18:413-422.

Vittoz, P., N. Bayfield, R. Brooker, D. A. Elston, E. I. Duff, J-P. Theurillat, and A. Guisan. 2010. Reproducibility of species lists, visual cover estimates and frequency methods for recording high-mountain vegetation. Journal of Vegetation Science 21:1035-1047.

Walker, M. D., C. H. A.Wahren, R. D.Hollister, G. H. R. Henry, L. E. Ahlquist, J. M. Alatalo, M. S. Bret-Harte, M. P. Calef, T. V. Callaghan, A. B. Carroll, and others. 2006. Plant community responses to experimental warming across the tundra biome. Proceedings of the National Academy of Sciences of the United States of America 103:1342-1346.

Walther, G.-R., E. Post, P. Convey, A. Menzel, C. Parmesan, T. J. C. Beebee, J. M. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416:389-395.

Walther, G.-R., S. Beißner, and C. A. Burga. 2005. Trends in the upward shift of alpine plants. Journal of Vegetation Science 16:541-548.

Washington Department of Fish and Wildlife. 1999. Washington GAP Data Products available on line at http://wdfw.wa.gov/conservation/gap/ (accessed 9 June 2011).

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

Weisberg, P. J., and W. L. Baker. 1995. Spatial variation in tree seedling and krummholz growth in the forest-tundra ecotone of Rocky Mountain National Park, Colorado, U.S.A. Arctic and Alpine Research 27:116-129.

Wilson, J. B. 2011. Cover plus: ways of measuring plant canopies and terms used for them. Journal of Vegetation Science 22:197-206.

Woodward, A., E. G. Schreiner, and D. G. Silsbee. 1995. Climate, geography, and tree establishment in subalpine meadows of the Olympic Mountains, Washington. Arctic and Alpine Research 27:217-225.

Woodward, F. I., M. R. Lomas, C. K. Kelly. 2004. Global climate and the distribution of plant biomes. Philosophical Transactions of the Royal Society B: Biological Sciences 359:1465-1476.

Woodward, F. I., and B. G. Williams 1987. Climate and plant distribution at global and local scales. Plant Ecology 69:187-197.

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.

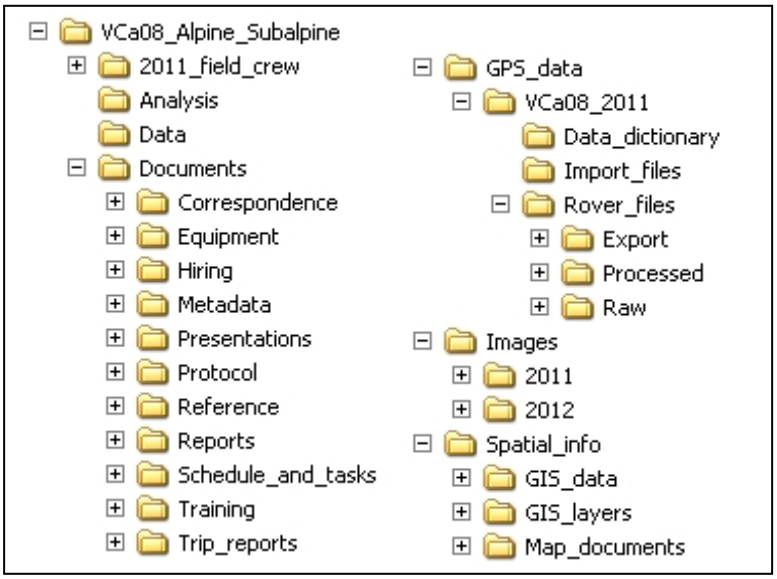


Figure 1.1. Recommended file structure for project workspace. Note: The workspace folder name includes 'VCa08', the NCCN project code.

Each major subfolder is described as follows:

- Analysis – Contains working files associated with data analysis.
- 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 14: Managing Photographic Images** for more details.
- Spatial info – Contains files related to visualizing and interacting with GIS data.
    - GIS data – 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.

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. See **SOP 14: Managing Photographic Images** for specific instructions for images.
3. Compare older files against the retention schedule in NPS Director's Order 19 (available at: http://home.nps.gov/applications/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 4J, Identifying and Handling Sensitive Information**). 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 18: Product Delivery, Posting and Distribution**.
7. Send analog (non-digital) materials to the park collections for archiving.

SOP 2: Preparing for the Field Season

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides instructions for preparations prior to the field season. This SOP encompasses season scheduling and travel planning, assessing and ordering equipment and supplies, and assembling packets of maps, directions, and data sheets for plot measurements. This work begins in late fall after certification of the previous year's data and continues through the start of the field season in late May or early June.

Scheduling and Coordinating with Personnel

1. Update the season schedule (located in the project workspace within the folder Documents\Schedule_and_tasks\), including a list of plots to be visited. When planning field tours keep in mind the time required for the components of field tours listed below. Once plots have been visited, the logistics information recorded on the Event Log will help refine time estimates. Consider the following:
   a. Transportation time to and from campsite or housing
   b. Hiking to the field site. In the case of backcountry travel, from the campsite to the plot location
   c. Approximate time to complete plots.
   d. A full office day or more at the end of each tour is essential to the acquisition of quality data. The crews need time to download photos, GPS points, maintain equipment, identify plants, and enter data while it is still fresh in their minds.
2. Create a map for each park with plot locations to be visited that year.
3. Send copies of the schedule and map to:
   a. Project Lead
   b. The park Plant Ecologist
   c. Crew hires
4. Make plans to pick up the vehicles that will be used by the crews during the field season.
5. When the vehicles arrive, make a duplicate set of keys to keep in a designated key drawer or key board should the original set be lost or misplaced.
6. Arrange and confirm scheduled orientation and field training dates with project leads and training personnel (e.g., Data Manager, GIS Specialist, botanists, and others).
7. Arrange for introduction of crew to key personnel for the first week the crew arrives. This sets the groundwork for cooperation among park personnel.

8. Contact radio personnel and coordinate radio use and protocol for that season for each park.
9. Speak with the WIC at each park to let them know that our crews will be contacting them for backcountry permits.
10. Speak with the dispatch office at each park. Let them know our plans for the season, crew member names, and the crew call number. Inquire about current dispatch protocol, and operating hours. Obtain current guidelines and tracking documents to be filled out by crew before each tour.
11. Reserve seasonal housing for crew members as well as housing for one week of training at one of the parks:
12. Reserve housing and/or campsites for the season's field tours (see folder Documents\Reference\Travel_Logistics\Housing\ in the project workspace).
13. Reserve the following for the week of orientation and training:
    a. Conference room
    b. Power point projector
    c. Laptop computer

Ordering Supplies

At the end of each field season, project equipment and supplies should be inventoried by the Field Lead. The Project Lead and the field crews can then discuss what needs to be ordered for the next field season as part of the season close-out. During the off-season, the Project Lead should use this information, the list of gear supplied by NPS (Table 2.1), and the list of supplies for plot establishment (see Table 5.2 in **SOP 5: Preparing for Fieldwork**) to determine which items to order. Restock the first-aid kits using the check list (Table 2.2), and consider what safety supplies may be needed in vehicles (see Table 4.2 in **SOP 4: Orientation and Training of Field Crews**). Contact information for companies and stores that have stocked equipment is located in the folder Documents\Reference\Travel_Logistics\Equipment_Lists\Purchasing in the project workspace.

Label all new supplies with and the 4-letter abbreviation for the park that purchased the supplies (MORA, NOCA, OLYM). Number the gear if there is more than one of a particular item (i.e., hand lenses, compasses, tents, etc.).

Table 2.1. Field gear supplied by NPS.

Gear	
Daypack (limited supply)	Bear canister
Pack cover	Compass
Trekking poles	Water filter
Tent w/ ground cloth and fly	Plant press
Camp stove	Hand lens
Fuel bottles and fuel	Bug net
Cooking pots	Collecting bags, pencils, clipboards etc.

Table 2.2. First aid kit item list.

Item	Qty	Item	Qty
Moleskin	2	Pain reliever	20
Second skin	1	Antihistamine	10
Ace bandage	2	Cold pack	1
Alcohol wipes	10	Gloves	1 pair
Antibiotic ointment	1	Duct tape	1 m
Iodine swabs	1	Tweezers	1
Sterile bandages (assorted)	10	Scissors	1
Sterile gauze pads(assorted)	10	Triangular bandage	1
Tape	1 roll	Emergency blanket	1
Ace bandage	1	CA-1 accident report form	3

Preparing Camping Supplies

1. Refer to the Field Lead's inventory report from the previous year. At the end of the previous season, the field and camping gear was checked and properly stored after noting and presenting any problem gear to the Project Lead. Make sure that non-functioning camping gear is fixed or replaced.
2. It is essential that the field crew take time to inventory and check the gear that they will use themselves (rain gear, stoves, filters, first aid kit, etc.). This should be done on the first day of orientation, or the first day of arrival at their home park, so that any problem gear can be addressed before field work begins. Consider having gear from the other park(s) organized into large plastic tubs and brought to orientation.
3. Each tent should be set up and fully checked over. Examine the tents to determine whether they require additional seam sealer on the rain fly and around the bottom of the tent.
4. Test the camp stoves to make sure they are in working order, and that each crew member knows how to safely use and maintain them. Replace the repair kits if necessary.
5. Be sure that enough white gas (or canisters for other stove types) is on hand to cover the crews for the field season. By law, the fuel is required to be stored in a "fire safe" location. Crews need to ask their supervisors where fuel is to be stored.
6. Fuel canisters are stored with the fuel. Two 22 oz. canisters are usually enough for a 3-4 person crew for an eight-day tour. For each stove set, make sure there are two working lighters and matches in a water tight container.
7. Test the water filters and make sure that the crew knows how to use and clean them properly.
8. Inspect and clean the bear-resistant food containers (BRFC) – one food container per person. The large, light-weight, composite bear canisters are 900 cubic inches (9" base x 14" length) and are recommended for eight-day tours. Some crew members prefer the smaller, hard plastic canisters.

Preparing Field Supplies

1. Determine needs for ordering (and constructing) plot marking gear, either for initial set up or replacement of missing parts for whitebark pine and for the alpine/subalpine sampling

a. Rebar – Whitebark pine plots – one rebar to mark the center of the plot. Alpine and subalpine plots - four 0.5” rebar to mark corners of plots and twenty 0.25” to mark corners of subsampling quadrats per new plot
b. Tree tags – about 100 per new whitebark pine plot
c. Aluminum nails – 100 per new plot, and hammer
d. Wire – to attach tags to samplings
e. Quadrat frames for subalpine/alpine plots
f. Data loggers – 2 to 5 per subalpine/alpine plot (Figure 2.1); landscape staples, nylon cord, and flagging to mark data loggers
g. Tape measures: two 10-meter tape measures for whitebark pine seedling plots; one tape measure at least 40 m for subalpine/alpine or whitebark pine plots

2. Check that there are enough field sets of dichotomous botanical keys and/or field guides that are up-to-date and appropriate for each park location. Additionally, inspect the field keys for condition and repair or replace as necessary. The NCCN Vegetation Association key can be useful.
3. Check that there is a working radio, battery, spare battery, and charger for each crew, and that the radio is programmed for the parks in which the crew will be working.
4. Charge all batteries that will be used in the field, including batteries for the GPS unit, digital camera, laser range finder, and radios.

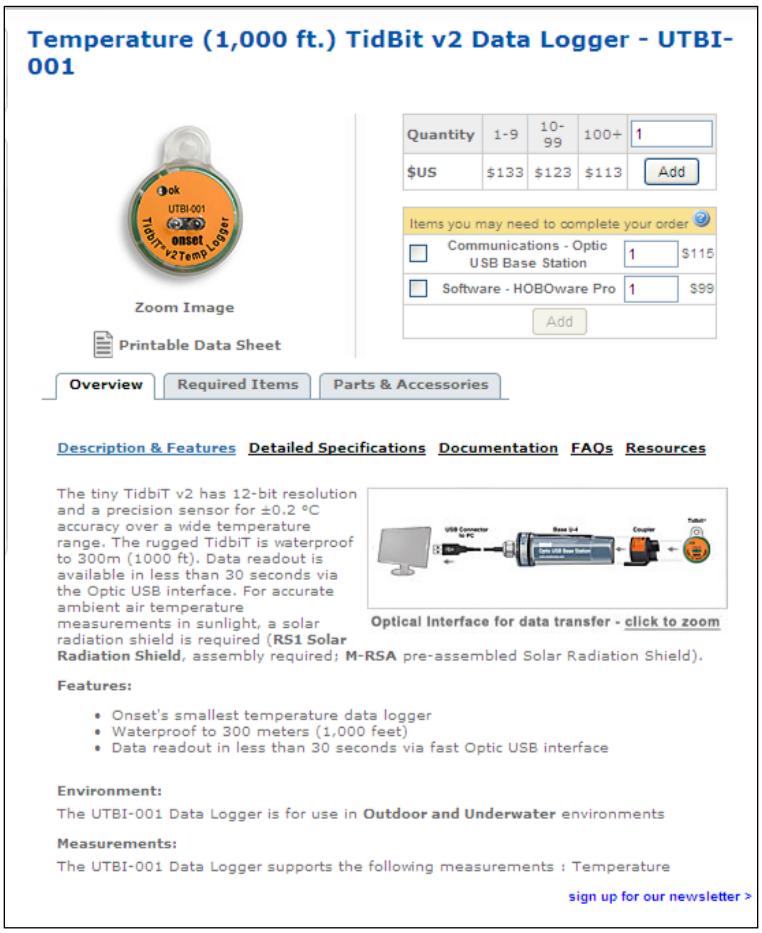


Figure 2.1. Data logger recommended for five year deployment in subalpine/alpine vegetation plots.

Preparation of Directions, Maps, and Data Sheets

For each plot being visited during the ensuing field season, print the following documents and place each set into a large envelope (approximately 11 x 12 inches; one per plot), labeled with the plot identification code (e.g., NOCA3-035) and a site name (e.g., Rainbow Ridge). Remove the sticky adhesive on the envelope flap to prevent accidental sticking in the field. Refer to the season schedule to identify plots being sampled that year.

1. Navigation Report: This report contains information about the plot, including navigational directions, UTM coordinates, tasks that must be completed, and extra equipment or supplies needed. The report is produced from the database using a utility that is part of the front-end. It should be generated each year prior to the field season. It should be reviewed before heading into the field and brought along into the field.
2. Plot Location: The location of the vegetation plots (GIS map).
3. Alpine/Subalpine or Whitebark Pine or Plot Diagram: The alpine/subalpine vegetation plot diagram illustrates the plot layout including subplot numbers and intra-plot distances. The whitebark pine diagram documents the location of trees within the plot (see **SOP 8: Establishing and Monitoring Alpine/Subalpine Vegetation Plots** and **SOP 9: Establishing and Monitoring Whitebark Pine Plots**). Both diagrams can provide useful references for navigating to and within the study plots.
4. Blank Datasheets: Assemble complete sets of datasheets for each plot being sampled in the coming season. The Reconnaissance Datasheet (**SOP 7: Screening and Reconnaissance for Selection of Alpine/Subalpine Vegetation and Whitebark Pine Plots**) is used only for initial reconnaissance, not for plot sampling. Photocopy all datasheets onto two-sided Rite-in-the-Rain paper and collate into sets. Place a set into each plot envelope.
5. Images sheet: Print in color previously taken plot and quadrat photos to ensure repeat photos capture the same view. Three to four images per page should provide enough detail to assist in relocating the photopoint as well as keeping the photo frame consistent from year to year.

GIS Maps and Orthoquads

The GIS Specialist is responsible for creating field maps and will save the ArcMap project (.mxd file) used to create them in the project workspace folder, Spatial_info\Map_documents. The GIS Specialist will create a 1:24,000 scale topographical map to show the plot in the larger context of travel and its relationship to important features such as roads, trails, and streams. Additional maps based on aerial photos at a 1:10,000 scale will show in detail the area in which the plot lies. Print one copy of the 1:24,000 map for each crew person, and one copy of the 1:10,000 map for the entire crew. Maps should be printed on waterproof paper if available. Permanent plot maps may be laminated in plastic for field use in inclement weather.

SOP 3: Hiring Guidelines and Procedures

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This Standard Operating Procedure describes procedures for hiring the seasonal field crew for the NCCN vegetation monitoring projects. The vegetation monitoring projects will employ three crews of two people each, a Field Lead and a Field Technician, to conduct the field work and data entry for both the Forest Vegetation and the Alpine and Subalpine Vegetation Monitoring projects in NCCN parks. Job announcements must be completed in early December and posted in early January. Certifications are to be completed in early February so that the applications can be viewed at this time, crews can be selected, and background check paperwork can be submitted by the end of February. Adherence to this time schedule will increase the ability to hire a quality field crew, and to complete the required paperwork before the field season begins in late May or early June.

1. **Interview Questionnaire for Seasonal Biotech Position** (The folder Documents\Hiring\Questions_Interview in the project workspace)**:** Documents interviews with potential crew hires and suggests interview questions.
2. **Questionnaire for Biotech References** (The folder Documents\Hiring\Questions_References in the project workspace)**:** Documents interviews with references and supervisors of crew members and suggests interview questions.
3. **Hiring Contact Record Form** (obtain from personnel)**:** Documents contact with biotech and their response to a job offer or availability request.
4. **Interview Guidelines from the US Dept of the Interior** (available on the web)**:**
   - Selection Interview: to provide a supervisor with job-related information upon which a selection can be made. http://www.doi.gov/hrm/pmanager/st13c1.html
   - Ranking Interview: to evaluate and reduce the number of qualified applicants. http://www.doi.gov/hrm/pmanager/st13c2.html
   - Inappropriate Interview questions: http://www.doi.gov/hrm/pmanager/st13c3
   - Interview Subjects: guidelines for interview topics http://www.doi.gov/hrm/pmanager/st13c4.html

Hiring the Field Crew

Once the lists of eligible candidates have been received, the Project Lead and Park Plant Ecologists will arrange a time to meet or speak on the phone, to review applications and plan

interviews with potential hires and references. The folder Documents\Hiring in the project workspace contains questionnaires which can be used or adapted for interviewing prospective crew members and references. The Department of the Interior maintains a website with useful information on selecting employees, including many aspects of interviewing (http://www.doi.gov/hrm/pmanager/staffing.html).

Field Crew Lead Qualities

- Proficiency at identifying vascular and non-vascular plants of the Pacific Northwest.
- Ecological survey experience, preferably conducting repeated vegetation sampling and tree stand measurements.
- Knowledge and experience in vegetation sampling in forested, grassland and alpine ecosystems.
- Experience with scientific field equipment.
- Substantial backcountry orienteering and backpacking experience.
- High level of physical fitness.
- Familiarity with one or more of the NCCN parks.
- Leadership experience.
- Strong and efficient organizational skills.
- Experience using database software to manipulate and store data and ensuring data quality
- Ability to lead and be compatible with diverse individuals in a field crew setting.
- Knowledge of (or preferably, certification in) wilderness first aid.
- Ability to drive a vehicle.

The first three of the above qualities should be considered mandatory; the others are desirable but not strictly required, as long as there is a balance of required skills within the crew. Priority consideration should be given to a returning Field Lead, and if funding allows, a term position should be created for the Field Lead to maximize year-to-year consistency in field operations and methods. Once selected, the Field Lead, especially if new, should review all relevant sections of the protocol and discuss any questions with the Project Lead.

Field Technician Qualities

The Field Technicians do not need to have the same level of experience nor all of the required skills as the Field Lead, however similar general qualities should be sought:

- Proficiency at identifying vascular plants of the Pacific Northwest. Successful candidates should at least be able to identify common plant species, and be able to demonstrate enthusiasm and ability to learn to identify new species.
- High level of physical fitness.
- Ability to get along well with others in a field crew setting.
- Ecological survey experience, preferably conducting repetitive vegetation sampling.
- Backpacking experience and proficiency at backcountry orienteering. Because orienteering will be emphasized during training, the orienteering requirement may be waived keeping a balance of required skills within the crew.

- Familiarity with one or more of the NCCN parks (desirable but not required).
- Knowledge of (or preferably, certification in) wilderness first aid (desirable but not required).

- Ability to enter data into a database and to use software to manage digital media (e.g., images, GPS files)

The first three of the above qualities should be considered mandatory; the others are desirable but not strictly required, as long as there is a balance of required skills within the crew. As with selection of the Field Lead, priority consideration should be given to returning crew members, to maximize year-to-year consistency in field operations and methods.

Informing New Hires

Soon after being hired, Field Technicians should be sent the following:

1. A written description of job expectations, duties, and responsibilities.
2. Supervisor contact information
3. Start date, time, and location
4. Proposed season schedule
5. Maps of headquarters, each park, and local towns, plus local info
6. List of all plant species likely to be encountered during the field season (see **SOP 4: Orientation and Training of Field Crews**)
7. List of camping and hiking gear recommended and/or supplied by the parks

SOP 4: Orientation and Training for Field Crews

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP contains instructions for orienting and training field crews. Some paperwork will be sent ahead of time so that crew members know what to expect and feel prepared from day one. The goal is a safe and successful field season with a satisfied crew that is well informed, able to work cooperatively with other park personnel, and prepared to follow the guidelines expected of park employees. Most of the orientation will occur during the first week of the field season. Training for the field work will occur in mid-July, prior to the field work. The Project Lead is responsible for orientation and training of the field crews.

Training needs will be determined by the Project Lead each year once hiring has been completed. Training will conducted at a one park each year for all the crews, rotating between OLYM, NOCA and MORA each year. The Project lead will conduct specialized training at each park following the generalize training to address special aspects and unique flora for each park if needed. NCCN park plant ecologists are encouraged to attend as much of the training as possible, so that they may become familiar with the crews and refreshed in the measurement methods.

In addition to the orientation and training described here, each crew member may attend the seasonal orientation at their park. These sessions usually cover park issues, current research, and safety. Crew members may attend a CPR/first aid course if it is offered at their park.

Information for Seasonal Employees

Soon after being hired, Field Technicians should be sent the following:

1. A written description of job expectations, duties, and responsibilities.
2. Supervisor contact information.
3. Start date, time, and location.
4. Proposed season schedule.
5. Maps of each park where they are likely to perform fieldwork, and information on local towns and amenities.
6. List of camping and hiking gear recommended and/or supplied by NCCN.

Orientation Supplies

Upon arrival the crew hires will be supplied with:

1. An orientation schedule
2. A 3-ring binder for organizing handouts (access to a 3-hole punch)
3. A copy of the NCCN Alpine and Subalpine protocol and a set of data forms. Crews will **not** need copies of the appendices. A copy of the protocol, including all appendices, is available for reference in the folder \Documents\Protocol\Active_docs in the project workspace (read-only for crews).

Paperwork and Personnel Logistics

The Project Lead will ensure that the following items are addressed with employees in the first few days of the season.

1. Completion of hiring paperwork including: W-4 form, emergency contacts, bank deposit information, etc. with administrative personnel.
2. Details of seasonal appointment including the work schedule, holidays, Sunday pay, and annual and sick leave.
3. Unemployment, and rehire status.
4. How time sheets should be handled, who will fill them out, and where they are turned in.
5. Travel per diem, travel forms, to whom and where travel forms are turned in.
6. Performance evaluation procedures. The crew will be given a written document of expectations and evaluation criteria to read, ask questions about, and sign. Work performance will be evaluated by the Project Lead half way through the season and at the season's end.
7. IT Security Awareness Training and other required training such as defensive driving and first aid (when available).
8. Accident forms and procedures: Paperwork, timeframe, and procedure for notification.

Office Training

The Project Lead and/or Park Plant Ecologist/Botanist will give new crew members a tour of the office and relevant surrounding facilities. The Project Lead will ensure that crew members become familiar with local computer usage, e-mail, resource information, the local park servers, location of project files, and that the crew knows which computers are available for their use. Crew members are responsible for completing the IT Security Awareness Training in the first week of employment and verifying that their e-mail accounts are working properly. They are also responsible for reading their NPS e-mail before and after each tour. Because of closely shared office space, it is *critical* that personnel know which space is designated for their crew's use, and contain all work and gear to within the designated area. Personnel should be considerate with respect to noise and placement of belongings.

Crew Gear and Packing

The Project Lead will distribute items of individual gear provided to crew members for the season. Crew members will check out the equipment as outlined below. A packing demonstration is highly recommended so that the crew (especially new members) will be

prepared for up to eight days in the backcountry in the potentially extreme weather conditions that can occur in the Pacific Northwest, even in summer.

Sign-Out and Sign-In Procedure

Individual Gear: includes compasses, hand lenses, and packs, (if available). Each crewperson should record any individual gear taken on the "Individual equipment checkout form" in the project workspace folder \Documents\Equipment\Gear_individual_checkout. This form must be filled out before crew members take project gear into the field. Crew members may use personal gear in place of equipment provided by the NPS, but personal gear will not be replaced or repaired by the NPS if it is lost, stolen, or broken. At the end of the field season, the crew and the supervisor will ensure that the equipment is returned and that any damaged or lost items are noted for repair or replacement.

Group Gear: is distributed to the crews at the beginning of the field season. Crews are responsible for maintaining group gear and making sure that items are cleaned and dried at the end of each sampling tour. Specific equipment is maintained as follows:

- Water filters - disassembled, flushed with clean water, cleaned as necessary, air dried
- Tents - cleaned and dried
- First aid kits - restocked and dried if necessary
- Batteries - recharged or replaced
- Stoves - cleaned and tested for satisfactory burning
- Cook kits - washed and dried
- Fuel bottles - filled and returned to an approved storage location

Information regarding broken or lost gear, or other problems, should be included in the reports prepared by the Field Crew Lead at the end of each tour and brought to the attention of the Project Lead.

Miscellaneous Equipment

Batteries: Batteries are required for the camera, GPS unit, and laser range finder. Radios have internal, rechargeable batteries; inquire about their ability to hold a charge before leaving them on the charger for several days. Check for the best batteries to use for your camera, laser range finder, and GPS unit. Rechargeable AA batteries are an option but sometimes not the best for field instruments. Always carry a spare set in the equipment case for each piece of equipment. Upon return from the field, recharge all rechargeable batteries and replace spent batteries. Consult with the Project Lead as to the proper disposal of dead batteries. Notify the Project Lead before you get close to running out of disposable batteries.

Safety

During the training week, the Project Lead will facilitate a discussion of the “Job Safety Analysis” form to explore all aspects of working safely. This form is also referred to as a “Job Hazard Analysis.” Versions of the form from previous years are located in the folder \Documents\Reference\Safety\Prevention in the project workspace. Each year the crew, the Project Lead, and the Park Plant Ecologist/Botanist will share their experiences about items

included on the form and revise text or add new items as necessary. Two areas of emphasis in the Job Safety Analysis are vehicle use and working in the field. See **Appendix F: Job Hazard Analysis** for example form.

Safe Use of Vehicles

The Project Lead will go over vehicle use and safety with crew members as follows:

1. Vehicle use
   - Key drawer or board: where keys (and spares) will be kept at all times when not in use
   - How to use government credit card for purchasing gas
   - Other items covered by government credit card (car wash, tire repair, unexpected needs such as motor oil and windshield wipers) – NOTE: Save receipts
   - Ferry travel: how to obtain reimbursement
   - How to schedule if using shared vehicle
2. Vehicle Safety
   - Safety checklist (Table 4.1)
   - Location and use of vehicle safety equipment (tire gauge, jumper cables, camera, etc)
   - Items to keep in vehicle (Table 4.2)
   - Emergency procedures
   - Procedure and equipment for changing a flat tire

Table 4.1. Vehicle safety checklist.

Check the following on your vehicle at the beginning of the field season and before each tour
Tires: pressure (do tires look low?) and tread condition
Fluids: Coolant, motor oil, transmission, and other under-the-hood fluid levels
Gas: Check that the tank is full. When traveling across park, fill the tank before leaving the last available gas station.
Lights: brake, turn signals, tail lights, headlights
Horn
Windshield (GSA pays for repairable chips)
Windshield wipers: condition
Body damage: dents or scratches
All items secure: secure items so that they are not able to fly at passengers in the event of an accident

Table 4.2. Items to keep in the vehicle.

Required gear	
Washington atlas and gazetteer	Spare tire
First aid kit	Space blanket
Fire extinguisher	Camera (disposable, in case of accident)
Flashlight, warning markers or reflectors	CA-1 Form
Car jack and lug nut wrench	Motor Vehicle Accident Report Form
Jumper cables	
Extra field gear that might come in handy	
50 m tape	Binoculars
Pin flags	Spare camp stove
Extra data forms	

3. Safety on the Road
   - **Seat belt.** Use is required in all government-owned or leased vehicles and is required by law in the State of Washington for driver and all passengers. Do not ride in the back of pickups.
   - **Drive defensively.** Expect the other person, whether a vehicle operator or a pedestrian, to do the worst thing, and be prepared. Observe all speed regulations and traffic signs.
   - **Alert and in control.** Do not drive when sleepy, taking medication, or when other personal conditions make it unsafe to drive a vehicle. Get someone else to drive or, if alone, stop driving and nap (out of public view).
   - **Hands on the wheel.** Keep both hands available for driving at all times. Safely pull off to the side of the road before using a cell phone.
   - **Headlights.** Always drive with headlights on to increase the visibility of the vehicle. It is particularly important when driving in fog, on dusty roads, traveling in and out of shadows, and any other low light/visibility situations. Turn lights off when parking the vehicle.
   - **Conditions.** Do not operate a vehicle in an unsafe condition. Check the vehicle frequently to keep it in good mechanical condition. Lights, horn, steering, and brakes should be kept in proper adjustment at all times. Make necessary repairs as soon as unsafe condition develops. Report any unsafe conditions to your supervisor.
   - **Keep the vehicle clean.** Windows, mirrors, and lights should be kept clean and free of obstructions to increase visibility. Keep the cab and driver area clean so that material is not rolling under pedals or distracting the driver.
   - **Downhill.** Shift to a lower gear at the beginning of a downhill grade, if the grade is a long, steep descent. This is possible in vehicles with manual or automatic transmissions, and will help extend the life of the brakes.
   - **Speed.** Adjust vehicle speed to the driving conditions. Wet, icy or snowy roads and decreased visibility require decreased speed. Be aware of speed when changing from one type of road to another, i.e., freeway to secondary highway to gravel and adjust speed accordingly.
   - **Tail-gating.** Allow at least three seconds of travel distance between yourself and the vehicle ahead. Under slippery road conditions and poor visibility, allow more distance.
   - **Be aware of your vehicle's idiosyncrasies.** Adjust your driving accordingly.
   - **Back up safely.** Walk around your vehicle to check for hazards before backing, and use a spotter to guide you.
   - **Navigation.** Do not drive and navigate at the same time. If the driver needs to look at maps and photos, he or she should stop at a safe place, then look at them.
   - **Watch for animals on the road.** Most hoofed animals travel in groups, so where there is one, assume there are more, all just itching to jump out in front of your vehicle. Stop and let the animal move off the road, look for others to follow, and then proceed. If you cannot stop in time to avoid hitting an animal, it is generally better to hit it than to swerve, drive off the road, or hit another vehicle.
   - **Oncoming vehicles.** Be especially alert for on-coming vehicles when driving on single-lane roads. Vehicles may be moving at high speeds in a shared lane and not paying attention when coming around corners.

- **Blind curves.** Keep as far right as is safely possible on blind curves and on single-lane roads. If the curve is blind and less than two lanes wide, slow way down and be ready to take evasive action. You may also honk as you approach a blind curve on a single lane road.
- **Yield.** Yield to *uphill* vehicles on roads wide enough for only one vehicle.
- **Parking.** Park the vehicle so that it is not a hazard to other drivers. Park facing the direction you will use to exit the site. Do not park where dry grass or other potential fuels can come in contact with your vehicle's hot exhaust system.

Safety in the alpine and subalpine environment

- **Clothes**. Wear protective clothing: Long-sleeved shirts, long pants, and gloves may protect you from contact with brush, rocks, and stinging insects. Trouser legs should be loose enough to avoid binding or cramping, and should not have cuffs. Hats, sunglasses, and sunblock (skin and lips) will help provide protection from sun exposure. Head nets may also be helpful during the season when insects are bad.
- **Boots.** Wear good quality boots that provide good support and traction and can be water-proofed.
- **Cross country travel**. Take your time and plan your route. Routes across brushy, irregular and steep terrain with loose rocks and down logs can be hazardous; be aware of footing at all times. Trekking poles can also be useful when travelling off trail, and can offer additional stability and balance when the ground and vegetation are wet and slippery. Walking while reading instruments is hazardous.
- **Eyes.** Be watchful of twigs and branches, which may cause eye injury. A pair of standard sunglasses can be used for eye protection when travelling off trail. Safety glasses will be provided if necessary. Be especially alert when stepping up to trees that retain their small dead twigs. Keep a sufficient distance behind the person ahead of you.
- **Travel on steep slopes**. Use caution while traveling on steep slopes of scree, talus and wet vegetation. Take your time and be aware of foot placement. Use trekking poles if necessary.
- **Travel on snow**. Snow travel, not glacier travel, may occur while accessing a site. If snow travel is expected, each crew member should be trained is snow travel and be proficient at ice axe self-arrests. Each crew member should carry an ice axe.
- **Buddy system.** Always work in crews of at least two people.

Backcountry Basic First Aid

Methods to treat common backcountry injuries with first aid kit and available backcountry equipment:

- **Ankle sprain:** Use Ace bandage wrap or triangular bandage.
- **Fractures:** There are two types of fractures, open and closed. Open fractures are a much more serious condition than closed fractures. Open fractures will have some bleeding. Control serious bleeding, treat for shock, and check for pulse of injured extremity. Remove or cut clothing from injury site, if possible gently move fractured limb to splinting position, and then splint extremity, immobilizing joints above and below the

fracture site. Leave fingers and toes exposed to monitor circulation and nerve function. Keep the injury clean.
    - **Leg fracture:** Splint in place. If open fracture, bandage to stop bleeding. A splint can be made from hiking or tent poles wrapped with triangular bandage and/or rope to keep splint in place.
    - **Arm fracture**: Bandage open fracture wounds. Splint with arm to body using triangular bandage. Splint with section of trekking pole or tent pole.
    - **Hand fracture**: Check for circulation and nerve impairment; splint with ruler, pencil, or stick.
- **Joint dislocation**: Common dislocations are of the shoulder but may also happen with elbows or knees. Check for pulse in injured extremity; splint with triangular bandage. DO NOT attempt to straighten any dislocated joint (serious nerve and blood vessel damage may occur).
- **External Bleeding** - Methods to control: direct pressure, elevation
    - DO NOT elevate extremity if there is a possible fracture, dislocation, impaled object, or spinal cord injury. Pressure points (use only if direct pressure and elevation fail): Brachial and femoral, are the most important to know.
    - NEVER remove a dressing that is in place, apply more dressing on top if needed.
- **Laceration**: Use butterfly bandages to close the wound, then dress with 4x4 sterile pads, bandage with gauze, and triangular bandage.
- **Puncture**: DO NOT remove an impaled object; dress and bandage around it, stabilizing the object. Treat for shock.
- **Hypothermia:** Keep person dry and warm, remove wet clothing, place person in sleeping bag. NEVER allow a person to remain in, or return to, a cold environment.
- **Heat exhaustion or stroke**: Cool the person, move the person to shade, treat for shock, and check vital signs.
- **Shock: Two forms to be aware of are** Metabolic (loss of body fluids) and Anaphylactic (allergic reaction). To treat, remember ABC (Check for Airway, Breathing, Circulation), control bleeding, splint fractures, elevate legs, be alert for vomiting, keep victim warm, and check vital signs often.
- **Animal attacks**: Cougar and bear, what to do: Stand up, DO NOT RUN, look as tall as you can.
- **Choking**: Perform an abdominal thrust, details will be discussed in seasonal training or first aid training.
- **Field Equipment that can be used in First-aid procedures:**
    - Trekking Pole: The c**ollapsible trekking pole can be used to splint leg fractur**es and can be pulled apart to serve as a splint for an arm fracture.
    - Bandana: Can be used as a bandage or dressing material.
    - Other: Tent poles used as splints; sleeping pad can also be used as a splint.

What to Do if Injured

- Keep a CA-1 form, a vehicle accident report form, and a disposable camera for photographing vehicle accidents in the glove box of your vehicle at all times.
- If injured, treat promptly. If you are in the front country and if immediate medical attention is required, go directly to a hospital emergency room. Try to make contact with

your supervisor or the office to get instructions and assistance. Make sure the doctor fills out his/her part on the CA-1 form.

- If you are in the backcountry, contact dispatch and relay the information to the ranger division or search and rescue staff and make sure they contact your supervisor. Be prepared to describe the nature of the injuries, when the injuries happened, and your location (be as exact as possible). If the injuries are serious enough to require helicopter rescue, try to find a suitable landing location. Use your GPS unit to get the Lat/Long coordinates for the helicopter pilot and the search and rescue personnel.
- Inform your supervisor of all injuries and ask which, if any, forms need to be filled out. Supervisors must complete the accident reporting forms within 24 hours or as promptly as possible.
- Fill out federal accident forms completely with signatures. ALWAYS make a copy for your personal records. Give the completed forms to your supervisor. Have the supervisor check your entries for mistakes, fill out his/her section, and forward the completed forms to the appropriate person.
- Gather information. If you are in a multi-vehicle accident, provide the other parties with enough written information so that they can easily get in touch with you, your crew supervisor, and the office. In turn, you must get the following information from all involved parties and witnesses: names, addresses, phone numbers, vehicle license numbers, driver's license numbers, insurance company names, policy numbers, and police report numbers. If possible, do not admit responsibility without first contacting your supervisor.

Radio Use

The Project Lead and/or Park Plant Ecologist/Botanist will go over radio protocol for the assigned park. The most recent radio information should be obtained from each park's communication center. Crew members will be shown:

- How to use the type of radio assigned to them (with handout)
- How to maintain radios and batteries (if replaceable) with specifics about battery life on the shelf and in the backcountry
- How to contact dispatch
- Which repeater to use in each region of the park. A map will be provided illustrating the locations of repeaters for each park.
- Appropriate topics and terminology for radio communication
- Who to contact if radio malfunctions

Wilderness, Backcountry, and Front-country Camping Etiquette

The Project Lead will go over "Leave no trace" camping practices, wilderness ethics, and park regulations applicable to front-country and backcountry camping. Crews are expected to read and follow posted NPS camping regulations and cooperate with NPS rangers.

Temporary Park Housing

Occasionally crews will be able to stay in temporary park housing or ranger stations during a tour. It is essential that the crews be considerate of the space and belongings of other employees and volunteers using these quarters. Recognize that some ranger stations are people's homes for the summer and that you are a guest. Upon arriving, introduce yourself to others in the building as part of the NCCN Alpine and Subalpine Monitoring project. Bring your own gear for cooking, eating, sleeping, and bathing as this will usually not be supplied at the housing unit. Pick up after yourself, always leave the space cleaner than when you arrived, and make sure that lights are turned off, heat is returned to the original setting, and the doors are locked. Return the keys as per your arrangement with your supervisor and/or the park staff.

Overview of Training

1. Presentations. Training will begin with a PowerPoint presentation given by the Project Lead, Park Lead, Data Manager, and GIS Specialist. The Project Lead will provide an overview of the project outlining the objectives of long-term ecological monitoring in NCCN, and the design of the Alpine and Subalpine monitoring project. The presentation will cover the history of the NPS I&M Program, the formation of NCCN, and the study plan for vegetation monitoring, including the plot selection process and the crew's role for the current field season and beyond.

   Additional PowerPoint presentations are available and may be used by the Project Lead to introduce:
   - Identification of vascular plant species occurring in plots
   - Estimation of cover in monitoring quadrats: cover classes for herbaceous plots and whitebark pine plots, canopy estimation, mapping of tree and krummholz canopies
   - Identification of symptoms of white pine blister rust: cankers, needle spots, and flagging
   - Identification of first year whitebark pine cones
   - Use of clinometer and range finder for measuring tree heights

   These topics will be further addressed with hands-on training; note that crew members consistently prefer and benefit more from hands-on training than from indoor lectures.

   The Park Lead will orient the crews to the park, travel within the park, office space, and safety procedures. The Data Manager and GIS Specialist will instruct the crews on data management and GPS use.

2. Reading the Protocol. Each member of the field crew should read and become thoroughly familiar with the protocol at the start of the season. This may be accomplished in increments, facilitated by hands-on training. The Project Lead may choose to assign each person on the crew "lead" status for a subset of the SOPs (note that individual skills and interests will become more evident as training progresses). The crew member should become thoroughly familiar with the methods and materials required for his or her assigned procedures. Crew members may rotate through different tasks, but the Field Crew Lead is responsible to see that their assigned tasks are being carried out correctly.

Time will be provided for leads of the different SOPs to undertake specialized training, if necessary. Crew members are also expected to indicate where they may need additional training.

3. Training Plot. During the training, the Project Lead, and experienced crew members will lead the crew in a mock reconnaissance, establishment, and sampling of a plot. Even with an experienced crew, review of correct methods is critical. Data forms for each sampling activity can be introduced just prior to the activity. Experienced employees then guide the new crew members through the sampling techniques, first allowing new members to record data and then to take measurements. Upon return from the field, the data can be entered into the database as would occur at the end of each field tour. Doing a complete trial plot allows crew members to become thoroughly familiar with the data forms, the individual SOPs, and the order in which the procedures are carried out. If the crew is new, it will also be necessary for the Project Lead or Park Plant Ecologist/Botanist to accompany the crew on their first tour.

4. Assessment. Throughout training, the Project Lead must assess the accuracy and precision of the measurements being taken by the crew, discuss discrepancies, and correct mistakes. One key component of the training will be calibration of canopy cover estimates among crew members. Crew members will practice cover estimates on several sample plots, compare estimates, and review estimates among members. It is essential that crew members' estimates are within the same cover class before field work begins. Fieldwork must not commence until the Project Lead is satisfied that measurements are being done in an accurate, consistent and precise manner by all crew members. During the field season, crew members will periodically compare cover class estimates to ensure consistency in ocular estimation.

5. Returning Crew. A key element for training will be to maximize the duration of each crew member's tenure with the project. Reducing turnover of staff is an important way to increase the efficacy of training. Experienced crew members will require less general training than new crew members, they will be able to help train new staff, and they will increase the consistency of data from year to year. Consider who may be interested in remaining on the project for multiple years and provide them with additional training, direction, and incentive. Consider also cooperating with nearby universities that may be conducting similar sampling methods as part of their coursework.

Compass and Orienteering

Crew members will receive hands-on training with the Silva Ranger, or similar compass. Crew members will be instructed in the following:

1. Safety. When heading into the field, always bring maps with you, and always have your own compass. Never assume this has been taken care of for you. Know where you are going, and notify another person of your plans.
2. Tools. Maps, orthophotos, satellite availability chart (**SOP 5: Preparing for Fieldwork**), compass, altimeter, GPS, calculator, field notebook.

3. Maps. Use 7 ½ minute quads and orthophotos (if available) at the same scale (1:24,000). Additional maps of the plots will be provided at the 1:10,000 scale. Maps and photos should be printed on rite-in-the-rain paper.
4. Declination. You will need to set the declination on your compass specifically for each park and the current year. Do not use the declination indicated on a topographic map; this will not be accurate for the current year. Websites are available for determining declination by entering a zip code or latitude and longitude and the date, such as http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp. The Silva Ranger-type compasses can be set by inserting the attached metal screwdriver into the small brass screw on the front or the back of the compass and rotating until the north arrow points to the appropriate degrees. To do this most accurately, check that the south tail points to the correct degrees on the clinometer part of the compass. A loupe can be helpful in reading the small print used for the declination scale.
5. Azimuth**.** Keep compass level, and away from metal. Hold the compass at eye-level and adjust the mirrored lid so that the face of the compass is visible in the reflection. Use the sighting notch to position the compass. Turn the dial until the magnetic needle is within the box ("put red in the shed"); align other lines and center points to increase accuracy; read the degrees. It is important to practice proper positioning and alignment of the compass for accurate azimuth measurements. For less accurate readings the compass can be held out in front with the lid flat. Practice and familiarize yourself with your field compass.
6. Bearing**.** To take a bearing from a map, lay the map down on a flat stable surface and use the compass to orient the map N-S. Align the edge of the compass with the imaginary or penciled line that adjoins your present location to your target location. Your bearing can be read directly from the compass.
7. Following a bearing. Because we rely on the GPS for giving intermittent locations, it is usually enough to sight on an object (e.g., a large tree or snag) and walk to that object before sighting again. For a more accurate bearing, two people are needed (check that the compasses are in sync): one person takes a sighting and walks to the target, then sights back to the stationary person. The stationary person then walks to the first person and the first person continues the process until the site is located. This method is time-consuming.
8. Distance. You may want to record the distance traveled, for example, down a trail before turning into the woods, or you may want to know how far you need to walk to reach a point on a map. Horizontal or slope distance can be measured with a laser range finder. Distance can also be estimated with pacing. To determine paces (a pace = two steps) lay out a 50-meter tape and count paces. Record in field book for future reference. Two people can average their paces for greater confidence in the field. Keep in mind the great difference between horizontal and slope distance on steep slopes. You will need to adjust your estimates if you are reading from a horizontal map view and pacing on a steep slope. Make note of the travel time - although everyone travels at different speeds, this will give an inexperience person and idea of the travel time so that they can plan accordingly.
9. Map distance. Use the scale displayed at the bottom of each map. Some maps are gridded with a set distance (i.e., every 500 m). As a general reference, section lines (when present) are 1 mile apart, and UTM lines are 1 km apart.

10. Contouring. It is sometimes easier to reach a point by contouring across the slope. Hike along a maintained trail until you are at the same elevation as the target point and then, staying at the same elevation, contour the hillside to the target point. Again, we often use the GPS to read and record our point of entry, but if you have a precise altimeter, this can be used to indicate when to begin contouring. Remember that an altimeter needs to be adjusted several times a day at trailheads or other known elevation points to maintain accuracy as barometric pressure changes.
11. Triangulation. You can determine your position on a topographic map using a compass to triangulate between three points (note that this works best from a vantage point and does little good in dense forest). Pick three topographic features that you can see and identify on your map. Determine the bearing between you and each feature. Using a protractor, draw a pencil line through the topographic feature at the measured angle. The three lines should intersect at your current location. Some measuring error may result in an imperfect intersection. If the location does not make sense, or the three lines do not intersect, check your assumptions.
12. Location/direction indicators. To double check your location, you can check the azimuth of lines on a map (e.g., roads, trails, streams, gullies, ridges). If you are heading directly north up a trail, but thought you were in a spot on the map where the trail heads east, check your assumptions. Other indicators of location or direction include slope angle, aspect, and sun position. Orthophotos can also help by showing, for example, open patches in forest or tree clumps in the subalpine parkland. Always keep other location possibilities in the back of your mind as you are determining your location. If there is any doubt in your mind, or in the mind of another crew member, refer again to the map and direction indicators. It takes less time to stop and take another look at the map and compass than to back-track several miles.
13. Map error. There will be map errors in trail lines and topographic contour lines. Also rivers may have changed course. Use other topographic features to verify location: elevation, gullies, peaks, and ridges.
14. Notes. It is a good idea to take notes while navigating. Write down GPS waypoints, target points and distances. It may help you get back to the trail, remember the decisions you made, give you a backup of data collected on the GPS, and/or make it easier to write the description for a plot location.

Equipment Training

The Project Lead, Park Lead, and GIS Specialist will provide the crew with hands-on training with the GPS, laser range finder, clinometer, digital camera, and dbh tape. Training for measuring dbh can take place during the mock plot exercise.

1. GPS. The GIS Specialist will lead the crew through the procedures required to locate plots and to record and download data for center points and navigation points. He/she will provide them with a map and UTMs and have them locate nearby points and practice data collection and download. Crew members who have not used a GPS will need additional exercises to feel comfortable using the unit in the field. Those with previous GPS experience may not be familiar with the particular model of GPS unit, data dictionary or settings, or methods used in this protocol. Review at the beginning of the field season is important for crew safety, confidence, and the collection of quality data.

See **SOP 6: GPS Use: Navigation, Data Collection, and Downloading**. Crew members will be given a copy of the GPS operating instructions for their model of GPS unit. During training the crew should understand and practice the following:

a. Power on the unit
b. Use stylus and/or control buttons to move through each menu and display screen
c. Observe configuration settings and adjust if necessary
d. Interpret PDOP, and learn to adjust (if possible)
e. Check battery power
f. Navigate to a selected target
g. Name and log a navigation feature (NavPt)
h. Name and log a plot center location (PlotCtr)
i. Measure and record an offset
j. Delete files
k. Record GPS data on the data form
l. Download GPS files for post-processing
m. Maintain the GPS unit and recharge battery (or replace batteries if applicable)

2. Laser Range Finder. The laser range finder will be used for measuring horizontal distance and tree heights. For accurate height measurements, the pivot must be set to match the manner in which the observer tilts the device when measuring angles to tree top and base. The pivot can be changed, but crew members should be aware of the pivot point and pivot method for which the device is set, and aim to be consistent. Accuracy can be tested by measuring a tower or building of known height. The laser range finder can also be used to measure slope angle and slope distance.

3. Clinometer. The clinometer is a simple device for measuring slope. It can also be used, along with a tape or other distance-measuring device, to calculate tree heights or horizontal slope distance, but the laser range finder is much simpler to use. The clinometer and measuring tape can serve as a backup. If you only plan to measure slope, the clinometer is much lighter to carry. Look through the small glass window to read slope in degrees on the left, and in percent on the right. If you forget this you can tilt the device up or down to see the percent symbol on the right (if you do not see any numbers you are probably holding it upside down). When measuring slope hold the clinometer to your eye, focus one eye on the degree or %, and the other eye down or up slope to eye height of a second person. Make sure to record the units of measurement as either degrees or %.

4. Digital Camera. Refer to **SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log** and **SOP 14: Managing Photographic Images**.

5. DBH Tape. Demonstrate the correct measurement of tree diameter at breast height per instructions in **SOP 9: Establishing and Monitoring Whitebark Pine Plots**.

Data forms

Before beginning each sampling activity in the field, the Project Lead and Data Manager will go over the field data form. Each of the data form fields will be explained giving the crew the opportunity to take notes and ask questions.

1. Reconnaissance form
2. Plot layout
3. Site map
4. Plot locations
5. Plot establishment form
6. Event log

Vegetation Training

1. Skilled and Enthusiastic Crew. Training the crews to recognize the alpine and subalpine plant species is the most critical aspect of this protocol. Crews will be asked to recognize many vascular species including sedges and grasses. These technicians need not be experts in the Pacific Northwest alpine and subalpine flora, but it is crucial that they have the ability to differentiate species in the field and be experienced in doing so either as a result of academic training or professional experience. For learning the flora, there is no substitute for 1) a strong interest and desire to learn on the part of the trainee and 2) the opportunity to learn by performing ecological fieldwork.

2. Plant Lists. Crew members will be given plant species lists for each park with space for writing notes. Two types of lists will be provided: 1) a list of vascular plant species previously recorded from Alpine Subalpine monitoring project work and 2) an up-to-date list of plants that occur in each park.

3. Field Recognition. A minimum of a full day should be spent on plant species identification and tree pests and pathogens. Sedges and grasses are important components of subalpine and alpine plant communities and field crew will practice field recognition and keying out collected specimens in the office. Field and office training will also focus on identification of blister rust signs (cankers, wounds, and flagging) and mountain pine beetles. This may be coordinated with other training activities. Identification training will begin with local guided walks. If there is time, the Project Lead will take the crew to visit sites with the appropriate vegetation types. Crew members are encouraged to keep notes on their species lists during the field instruction.

4. PowerPoint Presentations. PowerPoint presentations will be used to review the common subalpine and alpine vascular plant species including trees and recognizing white pine blister rust and mountain pine beetle damage. This is a good time to go over species which are difficult to identify, allowing the crew to take notes on key differentiating characteristics.

Taking Field Notes

All members of the crew should keep a field notebook with hours worked, tasks completed, observations, and topics that need addressing. The main responsibility for this task, however, falls to the Field Crew Lead. The Field Crew Lead must be ready with pencil and notebook in

hand at all times to take notes: 1) for every day of work summarizing who did what, where, when, why and how; 2) in the office when communicating with supervisors and others about field plans, data issues, etc.; and 3) any time there is an issue that needs to be addressed relating to data collection, hiking routes, campsites, field gear, an injury, or other concerns. Include dates, times, locations, names and other pertinent information. Figure 4.1 shows how to organize a page in a field notebook.

Develop a system so that information is always in a similar format and is easy to find. Keeping dates, locations, tasks, and other repeated information in the same place will help you relocate that information later. The supervisors will rely on the Field Crew Lead's ability to quickly access information in these notes as questions arise regarding logistics or data that needs clarification. These notes will also help the Field Crew Lead to write a trip report at the end of each tour and to write the end-of-season report. Photocopy the notes after each tour and place in the specified folder in the filing cabinet. This is important for two reasons: 1) If the notebook is lost in the field, not everything is lost, and 2) If someone needs to access that information, it will be on file. Create a contact list on a back page of the notebook with all phone numbers (and e-mail) for supervisors and crew.

General location & task

MORA
PLOT: A1-057

Total Hours worked: 11 hrs. *(keep track on back page: comp time = 1 hr)*

Day of Week: Tues.
Date: 6/4/11
Day 2 of 8 day tour

7:00am - 6:30pm

Weather: overcast, cool in morning; downpour from 4pm on; freezing at night

- Maps used
- What each person did.
- Observations about plot or interesting sightings.
- Circle every plot number done that day and write simple determination in bold capital letters, for example:

33 DONE

- Important GPS file #s (good to have them in more than one place)
- What was completed each day and how long it took for each part: hiking to the site, completing a form…
- Trails, water sources, campsites, including those noted for future reference
- Asterisk by any notes that need to be communicated to supervisor.
- Notes to yourself for next tour or for future surveyors
- Plot or trail conditions.
- Any concerns.
- Any mistakes.
- Anything that needs clarification.
- Any issues.
- Any suggestions.
- Have a thought? WRITE IT DOWN

Create a contact list on a back page of your notebook (phone numbers etc. of sup. and crew)

Figure 4.1. Field notes example.

Crew Assignments

Each crew member will be solely responsible for a specific set of tasks. These will be assigned according to skill and interest. Divide the tasks so that each person has something to do before and after a field tour. It is the responsibility of each specific task leader to read the applicable SOPs at the onset and then again as the season progresses. Any needed corrections, additions, or improvements should be written down and presented to the Project Lead for review. We expect methods to continue to improve, but these should be tracked during the field season and written down while they are fresh in mind. Task responsibilities for the Project Lead and a two-person crew are outlined in Table 4.3. Rearrange as seems fit for each individual crew.

Table 4.3. Task responsibilities.

Crew member	Pre-tour and tour	Post-tour
Project Lead	Prepare site maps and orthophotos. Planning logistics: housing, road closures, ferry permits, etc. Coordinate with other Project Leads, rangers. Coordinate with GIS Specialist and Data Manager to insure that GPS units are available and set-up and access to databases has been established for field crew. Be available to answer questions from field crew on methodology and species identification.	Review and discuss recent tour with crew. Update crew about next tour.
Field Crew Lead	Note-taking; crew logistics; contacting supervisors; oversee data collection and data input.	Contact, oversee; pick up the slack.
Additional tasks to divide between the Field Crew Lead and the other crew members	Wilderness permits, current backcountry information; Maintain and track technical gear (GPS, radios, laser range finder); Vehicle; Gear organization and distribution; Data forms: pack and track; Maps: pack and track; Digital camera and photography (see **SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log**).	Maintain batteries and technical gear; Download GPS data; Gear organization; Clean vehicle Travel voucher forms; Data forms: photocopy and track; Download and label photos (**SOP 14: Managing Photographic Images**).

SOP 5: Preparing for Fieldwork

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP describes preparations for field tours for NCCN's Alpine and Subalpine Vegetation monitoring project. These procedures are carried out prior to departure to the field.

One week in advance

The following tasks are to be conducted approximately one week (or earlier) before crews depart for a field tour. Tasks may be conducted at the end of the previous tour by the Field Lead and crew or by the Park Plant Ecologist during the week prior to departure.

1. Check road access and trail access. Park roads and trails are often damaged by winter flooding events, blocked by downed logs, or subject to scheduled repairs. Access roads that are owned or maintained by other agencies are subject to the same hazards. Check the park road report on the web:

   - North Cascades: http://www.nps.gov/noca/planyourvisit/trail-conditions.htm, http://www.nps.gov/noca/planyourvisit/road-conditions.htm
   - Olympic: http://www.nps.gov/olym/planyourvisit/wilderness-trail-conditions.htm, http://www.nps.gov/olym/planyourvisit/current-road-conditions.htm
   - Mount Rainier: http://www.nps.gov/mora/planyourvisit/trails-and-backcountry-camp-conditions.htm, http://www.nps.gov/mora/planyourvisit/road-status.htm

   If you need access on "official use only roads," contact the park liaison prior to planning your trip. The Park Plant Ecologist will serve as the park liaison or will provide the Field Crew Lead with the needed contact information.

2. Determine campsite or housing. Review past plot Event Logs for campsite suggestions. Park housing accommodations should be reserved at the beginning of the season if possible, but housing may still be available at mid-season. Ranger station cabins may be available to the crew if approved by the ranger for that area. Designated campsites may be within hiking distance from the plot; some require reservations through the park's Wilderness Information Center (WIC). Consider camping near the plot if 1) it is within park guidelines, 2) there is a water source, and 3) it will not impact the plot.

3. Going to another park? Contact the Park Plant Ecologist to let them know of your plans, inquire about roads and trails, gain permission to restricted areas if necessary, and arrange to pick up keys to housing or to gated roads. If going into the backcountry contact the WIC well in advance for camping reservations. Make sure that the crew has access to a road atlas, park-wide map, park plant lists and other references.

Pre-tour crew tasks

The following tasks are to be conducted by crews on the day they depart for the field.

1. Arrive on time, ready and packed for the field. It is imperative that all crew members arrive on time and ready for the tour. When prepared, crew members are able to help with crew tasks, they can be relaxed, and positively influence the attitude of the crew.

2. Check e-mail. Read work related e-mail only, for messages from supervisor.

3. Check weather. If it has not been done already, check on the weather so that you know what you are in for, and consider alternative plans. There are several weather websites available – simply search on "weather" to find them. The NOAA weather site can be accessed at: http://www.wrh.noaa.gov/sew/. The University of Washington Atmospheric Sciences department maintains observational data and forecasts at http://www.atmos.washington.edu/data/.

4. Obtain wilderness permit. Wilderness permits can be obtained from the park's WIC (located behind the Visitor Center at Olympic National Park, at the Marblemount Ranger Station at North Cascades National Park, or at the closest ranger station for Mount Rainier National Park) and are required for overnights in the backcountry. Contact the WIC office as early as possible once you know your trip plans; they will be better able to accommodate your needs, especially in areas of high use where reservations need to be made well in advance. The WIC is also a good place to check on current back country conditions, recent trail or road washouts, common concerns for the area, weather forecasts, and alternative camping options. Be sure to ask for information. Note that the campsite should be reserved early, at the end of the previous tour if possible.

5. Send itinerary. Send a tour itinerary to Dispatch or the Communication Center if required. Include crew names, radio numbers, dates of travel, anticipated route, backcountry campsites, and trailhead locations that you will use to enter and exit the backcountry. This is outlined in the Wilderness_Tracking_Itinerary_Form.doc (in the folder \Documents\Reference\Travel_Logistics\Forms in the project workspace). Each park has different protocols for check in. Be familiar with the parks protocol prior to entering the backcountry.

6. Look over data sheets. Data sheets are pre-printed on waterproof paper as outlined in **SOP 2: Preparing for the Field Season** and stored in an envelope labeled with the plot name. Check that all required data sheets and reference documents are present.

7. Gather visit reports, maps and orthoquads. These should be pre-printed on waterproof paper (or laminated) before crew arrival as outlined in **SOP 2: Preparing for the Field Season** and are stored in the plot folder.

8. Satellite availability charts. Satellite availability charts can be obtained by contacting the GIS Specialist well in advance of the field tour.

9. Check new gear. If taking gear that is new to you, check to see that it is in working order and that you know how to use it. Ask for help if you need it. Make sure that any battery-operated gear has fresh batteries plus one spare set, or if batteries are rechargeable, that they are fully charged.

10. Pack gear. All personal gear should be packed and ready to go prior to the morning of departure (Table 5.1). Group and plot gear should be organized so that packing can be accomplished quickly that morning. See below for packing tips. If some crew members bring their own camping gear, make sure it is clear what is being shared and that everyone has a water filter, stove, tent, etc. for their use. The Field Lead is ultimately responsible for assuring that the crew has essential gear, but the entire crew is responsible for communicating on these matters. Use a scale to check that you are not carrying more than your capacity (recommended: <1/3 your body weight).

11. Check the visit report. Check the visit report for each plot you plan to visit that tour, and determine if there are any logistics, additional items, concerns, or tasks to prepare for. If establishing and setting up a plot, determine whether or not the corrected UTMs indicate that the plot center needs to be adjusted.

12. Fold envelopes. Voucher envelopes are to be pre-printed as outlined in **SOP 2: Preparing for the Field Season** and kept in the filing cabinet in the crew's work area. Crew members that have completed field preparation can take a stack of voucher paper and begin folding envelopes. This task can also be done in the car on the way to the site.

13. Check the vehicle. Give the vehicle a safety check. Walk around the vehicle looking for low tires or other problems, check the oil level, fuel gauge, and test the head lights and blinkers.

14. Double check the equipment list. Make sure that you have everything on the equipment list by checking it twice.

15. Going to another park? Check the following:
    - Road atlas in vehicle
    - Park-wide map
    - Radio protocol
    - Radio repeater for your location
    - GPS is set for Datum: NAD83 Zone: 10N (if borrowing a GPS)
    - Change in declination: Check http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp to calculate the declination for a new location

- Plant lists
- Additional field references
- Keys to pick up
- Personnel to meet?

Packing gear

Each person is in charge of maintaining, packing, and carrying their own personal gear as listed below. Some of this gear will be available on loan from the NPS. All other gear (including group gear and required field equipment) is the responsibility of the assigned Field Lead to set out and distribute evenly amongst the crew before each tour. If you choose to take your own equipment in place of "group gear," you are responsible to work this out with the rest of the crew. Tour preparation and packing should be done quickly so that the crew is able to depart from the office approximately one hour from the meeting time.

Tips for packing gear:

- Consider whether you will be packing for one or *possibly more* than one activity (e.g., plot reconnaissance *and* plot establishment and measurement; or activities at Alpine and Subalpine plots *and* whitebark pine plots).
- Consider whether the crew will be splitting into more than one crew, requiring additional GPS units, maps, radios, first aid kits, tents, etc.
- If you will be car camping, or staying in park housing, you may want to pack some extra amenities.
- Always assume that the nice warm sunshine is going to be gone tomorrow, replaced by torrential down pours or a sudden dive in temperature. Always bring rain gear and be prepared for very cold temperatures.
- Consider whether you need maps of an alternate return route, for example, in cases of unexpected weather events that cause river crossings to become to be dangerous. For back country hiking you should carry about one-third of your body weight, or less.
- Make sure you cover all safety precautions and keep all crew members' abilities and needs in mind.

Gear lists:
Print and keep a copy of the camping list (Table 5.1) and equipment for plot setup and sampling (Table 5.2) posted in the office so that they can be checked when packing before a tour.

Table 5.1. Gear recommended for camping and hiking in NCCN parks.

Personal Gear*	
Large capacity backpack	Raingear - always
Compass*	Waterproof boots
Map of route*	Hat and gloves
Whistle*	Long underwear
Headlamp or flashlight (spare batteries)	Fleece jacket
Notebook, 3 pencils, 2 sharpies*	Quick dry clothes: nylon zip-off pants, polyester shirt
Hand lens* (at least one 10x for each crew)	Spare: socks, dry clothes
Bear barrel* (full of food)	Toothbrush, etc.
Water bottle: 1 bottle and perhaps an extra	Iodine capsules (in case water filter breaks)
Eating utensils (bowl, cup, fork, spoon, chopsticks, etc.)	Optional: your own tent, water filter, or stove if preferable to NPS-supplied gear
Pack cover*	Other suggestions: Bug repellant, bug net*, chapstick, sunscreen, sunglasses, hat/visor, spare shoes/sandals, hiking poles*, gators, camp clothes, daypack or field vest, lightweight long-sleeved shirt or windbreaker, parachute cord for bear wire etc., towel, bandana, personal first aid kit w/ moleskin, ace bandage, etc., hot chocolate, cards, book, chocolate chip cookies
2-3 Garbage bags* for inside pack - always	
Sleeping bag (pack in garbage bag – no holes!)	
Sleeping mat	
Group Gear (supplied by NPS)	
Scale (at office) for weighing backpack	Lighter/ matches
Water filter (recommend 1 per two people)	Cooking pot w/ handle
Stove	Tent w/ ground cloth and fly either shared or single person.
Fuel (2 x 22oz for 2 people for 8 days)	Trowel

*Supplied by the NPS

Table 5.2. Equipment for plot setup and sampling.

Plot Setup Equipment	
Field vest or daypack	Flagging
Compass	Pin flags
GPS w/ spare batteries	Rebar
Radio w/ spare batteries	7.5 minute quad or similar map
Laser rangefinder w/ spare batteries	ArcGIS map of plot locality
Range pole w/ reflector (optional)	Template/ map of plot layout
50 m measuring tape	Satellite availability chart
10 m tape strips (pre-cut)	Data loggers
Clinometer	Quadrat sampling frame

SOP 6: GPS Use: Navigation, Data Collection and Downloading

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides general information on preparation for and best practices in using a GPS receiver to navigate to plot target locations and to collect geographic coordinates at reconnaissance and permanent plots. Plots that have met the criteria for safe access, slope, vegetation cover, and distance from roads, trails and boundaries, are visited during reconnaissance to assess suitability for permanent plot establishment. Those that pass this field reconnaissance and that are selected for permanent plot establishment will have the plot coordinates updated through the collection of a GPS point at the plot during plot installation.

The material in this SOP should be used in conjunction with the step-by-step instructions for collecting and exporting GPS data in the NCCN Global Positioning System Data Acquisition and Processing guidance document available on the NCCN internet site at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm. The guidance document contains appendices on the use of various software programs for GPS data collection (Trimble TerraSync, Thales MobileMapper) and for GPS project workspace set-up, GPS data download, post-processing, and export to GIS (Trimble Pathfinder Office, Thales MobileMapper Office). The appendices also detail the methods of GPS unit operation, data collection, data transfer, data import/export as well as list the NCCN-recommended settings/configurations for a variety GPS receiver makes and models.

General Practices for GPS Data Collection

Training

Field crews are required to receive GPS training for the particular make and model of GPS unit they will be using prior to conducting field work (see **SOP 4: Orientation and Training of Field Crews**). Contact park GIS staff to schedule training in the use of the GPS units and the related software programs for GPS data collection and download in advance of the field season start (see **Appendix C: Yearly Project Task List**, in the protocol).

Important Considerations in GPS Data Collection

Regardless of GPS receiver type, certain data collection standards apply. Most of the quality control measures below can be specified by the user and should be followed whenever possible to produce the most accurate data.

- Satellite availability and satellite geometry (Positional Dilution of Precision, or PDOP): Acquiring at least four satellites will enable determining a 3-D position. Satellites that are spread out in the sky (better geometry) will produce a more accurate position than when they are clustered together. Mapping accuracy can be increased by using mission planning charts (from GPS software) and targeting data collection to the times of day when satellite availability and geometry are best. PDOP should be 6 or less if possible.
- Length of time GPS data file is open:
  Positional accuracy will be better the longer a GPS file is open and the more GPS positions are logged and averaged for a given point location. For Trimble GPS units, it is recommended that at least 60 positions be logged for each point feature mapped. For MobileMapper units, 3 minutes of data collection is recommended for each point feature mapped.
- Multipath error, or signal interference:
  While mostly beyond a user's control, some adjustments can be made to minimize multipath error. These include positioning the GPS in the most unobstructed view of the sky as possible, using offsets from areas of better satellite reception to the target location if that location is under canopy or other obstruction, or using an external antenna.
- Signal to noise ratio (SNR):
  Trimble units allow a minimum ratio value to be set in the configuration such that positions with SNR below that value are not logged. A SNR value of 39 is recommended for Trimble units. For Thales MobileMappers, this is not controlled by the user.
- Real-time differential correction:
  Real-time correction improves the accuracy of GPS data collected in the field, even if it will be post-processed later in the office. Until recently, real-time corrections were difficult to obtain in some NCCN parks due to variable topography and extensive canopy cover. With the launch of a new WAAS satellite that orbits at a higher elevation above the horizon, it is now easier to obtain real-time signal in NCCN parks.

Coordinate System and Datum

The NCCN uses the Universal Transverse Mercator (UTM) coordinate system, zone 10 North (10N), and North American Datum of 1983 (NAD83 (Conus) CORS96) for all spatial data sets. Satellites broadcast positional information using the World Geodetic System 1984 (WGS84) datum, but most GPS units can be configured to display the position coordinates in UTM, NAD83. Be sure to set the GPS unit display to this coordinate system and datum (refer to the NCCN GPS Data Acquisition and Processing guidance document).

GPS field coordinates (coordinates displayed on a GPS receiver's screen while the GPS is receiving satellite signals) and the datum should be recorded on the field data forms. These coordinates will become the best measure of spatial location in the event a GPS data file is lost or

corrupted. Be aware that these coordinates read from the GPS unit display in the field cannot be post-processed and are in the coordinate system and datum that were selected for the unit's display (which should be set as UTM 10N, NAD83 (Conus) CORS96). These coordinates consist of an easting (six digits) and a northing (seven digits).

Navigation

While the GPS is an excellent tool for navigation, it should not be exclusively relied upon for this purpose. It displays a straight-line azimuth and distance to targets and will not necessarily indicate the safest navigation route (for example, following ridge lines, safely crossing rivers or circumnavigating cliffs). At times the GPS unit may not function due to location (i.e., in a canyon), low satellite coverage, or battery power loss. Always use a map and compass (and altimeter if available) in addition to the GPS for navigation. Refer to the Appendices in the NCCN Global Positioning System Data Acquisition and Processing guidance document for detailed instructions on navigating with the GPS unit.

Office Preparations Prior to Field Data Collection

The Project Lead should contact the GIS Specialist to schedule GPS unit use for the season, and to have the units prepared for field use (configuring unit settings; loading background imagery or layers, sample site target coordinates, and data dictionaries, etc). The Project Lead should also arrange a schedule with the GIS Specialist for the regular delivery of GPS transect data from the field crew. At the end of each field tour, the field crew will download the GPS data files and save in the \Rover_files\Raw folder of the project workspace. The GIS Specialist will be responsible for post-processing these GPS data files.

Project Workspace Set-up

Contact NCCN GIS staff to have appropriate GPS download/processing software installed on the office computer, and if needed, assistance with creating the appropriate GPS data folders within the Alpine and Subalpine Vegetation Monitoring project directory structure (Figure 6.1). The GPS-related folders are organized by year and include: 'Data_dictionary' for any GPS data dictionary files, 'Import' for background layers or maps to display on the GPS unit, and 'Rover_data' for the data collected with the GPS unit. The Rover_data subfolders include: 'Base' for base station files used in differential correction, 'Export' for GPS data exported to GIS or database formats, 'Processed' for GPS files that have been post-processed, and 'Raw' for the original, un-processed GPS rover files.

```
VCa08_Subalpine\GPS_data\
                    VCa082009\
                    VCa082010\
                    VCa082011\
                              Data_dictionary\
                              Import_files\
                              Rover_files\
                                         Base\
                                         Export\
                                         Processed\
                                         Raw\
```

Figure 6.1. Example of folder organization for GPS data within project directory structure.

Data Dictionary

GPS units will be loaded with a project-specific data dictionary (called "Feature Library" in Thales GPS units) named VCa08_YYYY.xxx (where VCa08 is the project code, YYYY denotes the year, and xxx denotes the software-specific file extension) which will be used when mapping permanent plot locations as well as other features of interest. The data dictionary has six point feature types that may be collected: 'PlotCtr,' 'RarePlant,' 'ExoticPlant,' 'NavPt,' 'PhotoPt,' and 'Other.'

The PlotCtr feature is used for mapping the center of permanent plot locations. Enter the park code, the panel number, and the three digit plot number (please use leading zeroes, e.g., NOCA1-006).

The RarePlant feature can be used at any time to map the location of rare plant species. It has a drop-down list of expected rare species and a field to enter the number of plants observed. It also has a 50-character 'Comment' field to be used for ancillary information, or for plant species not on the drop-down list.

The ExoticPlant feature is available for high-priority, invasive, exotic plants. GPS each exotic plant and record as many of the listed attributes as possible. Check with the Project Lead for a list of high-priority, invasive, exotic plant species for each park.

The feature NavPt can be used to mark a location to help with future navigation. Enter a sequential navigation point number (unique per day), the park code, and an optional description. Record the NavPt number and a location description in your field notebook.

The PhotoPt feature is used to map the location where the Alpine/Subalpine plot photopoints (two views encompassing the entire plot area) are taken.

The ‘Other’ feature type is reserved for incidental observations or mapping needs for which there is no feature type already in the data dictionary.

For Trimble GPS units, the generic point feature type, ‘Point_generic’ can be selected if some other feature of interest needs to be mapped but for which there is no feature type in the data dictionary. The ‘Point_generic’ feature type is available in all Trimble data dictionaries, whether default or custom, and while it has no attribute fields, it does have a 32-character ‘Comment’ field into which notes can be entered about what the feature is.

Note: The point at which you select the data dictionary during GPS data collection varies by GPS model.

GPS File Naming Convention

File names should begin with the letter that has been assigned to and that uniquely identifies the GPS unit being used. GPS data file names should be recorded on the field data forms.

Please name each file using the following format: GPS unit letter, two digit year, two digit month, two digit day, underscore, and 6 character ID for the plot. The 6 character ID starts with the plot type (W = whitebark pine, A = alpine, and S= subalpine), followed by the panel number, a dash, and the plot number (GRTS firing order). For example, I090708_W1-220 indicates GPS unit I on July 8, 2009 at panel 1, and whitebark pine plot number 220.

Field Data Collection

The GIS Specialist will be responsible for loading background layers (or imagery) as well as the target coordinates of permanent plot locations onto the GPS at the start of each field season, if the GPS model supports these options. Field crews will then be able to display the background layers on the GPS to aid in navigation to the plot locations. They can then select the coordinates of target plot locations and navigate to each target site for plot establishment and sampling. Refer to the Appendices in the NCCN GPS Data Acquisition and Processing guidance document for detailed instructions on navigating with the GPS unit.

NOTE: When using the background map display screen to navigate, be aware of the display scale. Different makes of GPS units will default to different scales. Zoom in or out as needed to achieve the appropriate scale for navigation. Also, the coordinates displayed on GPS unit display screens will often rapidly change or jump around. Use the coordinate averaging capability of the GPS unit, if available, to better calculate a current location.

Before collecting any GPS data in the field, field crews should turn on the GPS and verify that all the settings are correctly set as specified in the NCCN Global Positioning System Data Acquisition and Processing guidance document. It is also extremely important to verify that the correct date and time are displayed on the GPS unit screen before beginning any data collection. If GPS data is logged to a data file with the wrong date/time stamp, post-processing back in the office will not be possible. The field crew should also wait a few minutes with the GPS turned on to allow the unit to communicate with the satellites. In particular, if the GPS unit is capable of real-time differential correction, make sure this option is activated on the unit and wait until the

WAAS satellite is being tracked as this will increase spatial accuracy (the GPS data may still be post-processed in the office).

Navigating to a Location

Selected plot location coordinates may be incorporated into the GPS background map or may be loaded as a separate data file on the GPS, depending on the GPS model. In the absence of a background map or data file on the GPS, hardcopies of target coordinates can be compared to coordinates shown on the GPS unit display screen while navigating.

Strategy for Locating Plot Center

1. First look at a hardcopy map marked with the plot location and determine your route.
2. When leaving camp and/or the trail turn on the GPS receiver to verify your location and the target location.
3. Navigate to within the vicinity of the target point or plot center using map and compass.
4. Turn on the GPS if you need to check your location. Established plots may have rebar, flagging, and/or tagged trees as additional clues.
5. If you are establishing the center point for a new plot, turn on the GPS as you near the plot. Continue to move toward plot center, getting as close as you can.
6. Within a few meters of the point you will find that the UTM coordinates, as displayed by the GPS unit, are continually changing. This is because satellite signals are often blocked or bounced around by terrain and trees. It is best to stop and log a point at this time. This will give you more accurate UTM coordinates for your location and you can determine whether you need to move closer to a plot center.
7. Open a GPS file to record your current location as outlined in Data Collection: Using the data dictionary prompt you will name each location “PlotCtr” and give it a number (1, 2, 3…) to identify each subsequent attempt to locate plot center. The highest number recorded will later be interpreted as plot center. Alternatively, use the GPS position averaging (if available in the GPS receiver) to average coordinates for approximately two to three minutes and compare the averaged coordinates to the target coordinates to determine how close the current location is to the target location and adjust your location if needed.
8. If the current UTM coordinates are within 10 meters of target UTM coordinates you may consider this the “plot center.”
9. Record the GPS file name on the hardcopy datasheet.
10. Record coordinates from the GPS display screen as “field UTM coordinates” on the datasheet.
11. If you are more than 10 meters off, you may calculate the distance and direction to plot center, move to this location, and collect another GPS file (go to step (8).

Other Data Collection Considerations

Once a file is open, do not move from your location (moving will alter the average position calculation). Try to collect at least three minutes worth of data (MobileMapper units) or a minimum of 60 positions (Trimble units) for each point, preferably with at least four satellites and a PDOP of 8 or less.

On the hardcopy datasheet, record the UTM coordinates displayed on the unit.

Downloading and Processing GPS Files

Transferring GPS files requires a computer, a data-transfer cable, and having GPS software installed on the computer. GPS receivers typically come with manufacturer-specific software and data-transfer cables. Refer to the NCCN Global Positioning System Data Acquisition and Processing guidance document or the GPS user manual for instructions on transferring files from the GPS unit to a computer.

It is extremely important that after each field tour, field crews transfer all GPS data files from the GPS receivers to the computer. Files should be saved in the 'Rover_files\Raw' folder in the temporary workspace created for them in the project workspace. Communicate with the GIS Specialist to determine where and how GPS files should be stored and if other procedures are necessary for delivery of files for processing.

The GIS Specialist will be responsible for all GPS file processing including differential correction. The GIS Specialist can export GPS data into GIS or database formats upon request throughout the field season. Any GIS shapefiles will be saved in the 'Export' folder of the project directory structure. At the end of each field season, the GIS Specialist will transfer all the GPS files from the Field Crew's temporary workspace to the appropriate subfolders of the GPS_data\ folder in the project workspace. The GIS Specialist will also be responsible for conducting GPS coordinate data quality assurance and for loading and processing GPS data in the project database.

SOP 7: Screening and Reconnaissance for Selection of Alpine/Subalpine Vegetation and Whitebark Pine Plots

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides instructions for the screening and field reconnaissance of the Generalized Random Tessellation Stratified (GRTS) generated points for selection of permanent plots. Much of the reconnaissance for MORA, NOCA, and OLYM was carried out during the 2010 and 2011 field seasons. Additional reconnaissance at all parks (beyond the number of plots specified in the sampling frame) will be performed as funding permits to identify a reserve of acceptable plot locations in case established plots experience catastrophic disturbance or become inaccessible.

Screening and reconnaissance consists of two parts, an initial screening in the office using GIS followed by field reconnaissance of those points that pass the office screening. The criteria for identifying the potential alpine and subalpine habitat in the three parks and the subsequent spatial analysis to create a GIS layer for GRTS point distribution are described in **Chapter 2: Sampling Design** and **Appendix E: Alpine and Subalpine Habitat Delineation Methods**.

Equipment needed for conducting GRTS point field reconnaissance is listed in Table 7.1. The GRTS Point Field Evaluation Form is presented in Figures 7.1 and 7.2.

Office Screening

ArcMap is used to view the GRTS-generated points.

Layers in ArcMap include:

- National Agriculture Imagery Program (NAIP) imagery, or other orthophotos
- Trails (includes maintained trails and some trails well-established by use such as climbers routes)
- Roads
- Major streams and rivers
- Park boundaries
- Slope 35° to 45° (displayed in yellow), slope >45° (displayed in red)
- USGS quads can also be useful for identifying named geographic features

The point is accepted for field reconnaissance if:

- It is accessible (no physical barrier): There is an access route that does not cross major rivers, cliffs, or glaciers.
- The access route is ≤2 km from a trail. While the sampling 'universe' of alpine and subalpine zones was restricted to within 1.5 km of trails, the safest route to a point may not be the direct line, but the point may still be within a reasonable distance to travel off trail if the terrain is gentle. Thus we chose 2 km as the distance threshold for the office screening, to be at the discretion of the office reviewer.
- Access to the plot is not too steep; there is a safe route to access the plot without having to traverse slopes >45°. While areas >35° were eliminated from the sampling 'universe' of alpine and subalpine zones, such slopes may be encountered in the access route to a GRTS point. Slopes >45° are deemed impassable, but slopes between 35° and 45° may be short enough to be safely traversed. We decided this can be determined by the crew in the field.
- The plot area does not contain private land or a development (for example: camps, constructed trails, parking areas, clearings, gravel pits).
- The plot is not dominated (i.e., >25%) by open water such as a major stream, river, lake or pond. A major stream or river should not pass within the plot, regardless of % area. This criterion may be difficult to assess during the office review; it will be assessed again in the field.
- If tree cover is >25% within the plot area, the plot will not be acceptable for the alpine/subalpine vegetation plots, but it should be reviewed in the field to determine if whitebark pine trees are present and it is acceptable as a whitebark pine plot.

Field Reconnaissance

Points that meet the above criteria are further evaluated in the field. The field reconnaissance evaluation is conducted within the 10 x 10 m area. The sides of the plot run directly N-S and E-W. The plots are evaluated according to the above criteria with changes and additions including:

- Slopes must not exceed 35° for more than 10% of the 10 x 10 m plot.
- Cover of trees must be <25% within the 10 x 10 m plot for it to be an Alpine and Subalpine Vegetation Monitoring plot.
- Whitebark pine sampling points are evaluated using a circular plot (radius of 17.84 m, 0.1 ha) at the GRTS point. Due to the generally sparse distribution of whitebark trees in the NCCN alpine-treeline ecotone, we will review 5 plot locations for whitebark pine at each GRTS point. After evaluating the 0.1 ha plot area around the GRTS point, 4 additional plots area evaluated by moving 35.68 m in each of the four cardinal directions and evaluating the 0.1 ha (17.84 m radius) area around each of the 4 additional points.
- Inclusions of non-target vegetation types must not exceed 25% of the 10 x 10 m plot. Non-target habitat types are defined as streams, talus, snowfields, or standing water.

A GRTS Point Field Evaluation Form is completed for each point visited in the field and a photograph is taken of each point. One person should stand at the GRTS point or place an object such as a backpack to identify the plot center. The second person should take a photo of the person and plot so that the general landscape is visible (i.e., do not take a photo of the ground).

Because of the time and effort to reach a reconnaissance site, crews should take the time to thoroughly investigate potential plots and record any data and observations that will assist with the final determination of whether to accept the site for permanent plot establishment. Crews should walk through the entire 10 x 10m area.

Table 7.1. Equipment for conducting reconnaissance.

Pencils	Calculator
Field notebook	Radio, spare batteries
GPS, spare batteries	Flagging and permanent marker
GPS satellite availability chart	Meter tape
Compass	GRTS Point Field Evaluation Forms (one for each recon. point)
Clinometer	Plant field guide
Maps and orthophotos	Plant descriptions
Print-out of target UTMs	Digital camera, spare batteries

GRTS Point Field Evaluation Form

Data Field Descriptions

The following describe each field on the GRTS Point Field Evaluation Form. Ensure that data are entered in all fields.

Header:

Park: Enter the four-letter code for the park where the plot is located (MORA, NOCA, or OLYM).

GRTS Point ID: Enter the 5-character point code _ - _ _ _ _, where the first character is the letter denoting the park (e.g. “M” indicates MORA) and the four following characters are numeric and are the GRTS point number.

Date: Enter the date in the format month, day and year (MM/DD/YYYY).

Observers: Enter the field crew names (first initial and last name).

Field UTM N, Field UTM E: Enter the UTM northing and easting.

Coordinate source: Circle “GPS” or “Map” to indicate whether the coordinates were obtained from the GPS unit or determined from a map.

GPS Model, GPS File name: Enter the make and model of the GPS unit and the name of the file in which the coordinates were stored (see **SOP 6: GPS Use: Navigation, Data Collection and Downloading** for file naming convention).

Datum: Enter the datum from the GPS or map (depending on which was used to obtain the coordinates). NCCN uses NAD83.

Photo number: Enter the file number created by the digital camera (see **SOP 14: Managing Photographic Images**). The photo number will only be used to retrieve photos for filing and labeling with the permanent number. Photo numbers can change when photos are downloaded to the computer or when photos are deleted so, the number order may be more important than the actual number.

Photo Perspective: Check one of either Downslope or North, depending on whether plot is on a slope. The photo is taken from 10 m upslope of plot center facing downslope. If plot has no slope, the photo is taken facing north from 10 m south of plot center. Be sure to take the photograph in landscape orientation so that the entire plot area is in view.

Photo File Name: This field is grayed-out, indicating that this is for office use only. The file name is assigned in the office when photos are downloaded to the project workspace. Format as: YYYYMMDD_XXXX_xxxx_, where YYYYMMDD is the date, XXXX is park code, and xxxx is the four-digit GRTS number. Example: 20100802_MORA_0306.jpg for photo taken August 2, 2010 at MORA GRTS point 0306.

Plot safely accessible? (unsafe = too steep, cliffs, major river or glacier crossing): Enter your assessment of whether the plot can be safely reached (circle Y or N), and if not, indicate what the barrier is.

Is the plot in an avalanche track? Circle yes (Y) or no (N) and enter observations under Explanation.

Is this plot within a forest opening? Is the site an opening within a forest of upright trees? Circle yes (Y) or no (N) and enter what type of inclusion and any other observations under Explanation.

Tree cover ≥25%? Trees are >2.54cm dbh. Circle yes (Y) or no (N) and enter any observations in the Explanation field.

Estimate cover of permanent snow/ice (0, 5, 15, 25…85, 95%, 100%). Enter a value of either zero if none or a percentage to the nearest 5% if permanent snow/ice is present in the plot.

Estimate cover of any open water (0, 5, 15, 25…85, 95, 100%). Enter a value of either zero if none or a percentage to the nearest 5% if open water (pond, river, lake) exists in the plot.

Estimate cover of talus (0, 5, 15, 25…85, 95%, 100%). Enter a value of either zero if none or a percentage to the nearest 5% if talus is present in the plot.

Estimate cover of tall shrubs (0, 5, 15, 25…85, 95%, 100%). Enter a value of either zero if none or a percentage to the nearest 5% if tall shrubs are present in the plot. Tall shrubs do *not* include heather and subshrub varieties. Refer to Table 1 on the data form for subshrub species found in the three parks.

Tall shrub species present: Enter the 6- or 9-character species code for each tall shrub species present. Refer to the species list for each park for species codes. These will be available in the project workspace or from the Project Lead.

Count the number of whitebark pine trees in each plot (C, N, E, S, W). Count and enter the number of live and dead trees in each of the five circular 17.84 m plots. Note: only count stems ≥2.54 cm dbh.

Vegetation association (keyed in 10 x 10 m plot around GRTS point): Enter the vegetation association observed. The vegetation association key will be available in the project workspace or from the Project Lead.

An important attribute to distinguish between alpine and subalpine habitats is tree form. Upright trees (>2 m tall) are found in subalpine habitats; alpine habitats are characterized by lack of trees or krummholz (shrubby or dwarf) trees. Answer the following two questions based on the area around you (up to about 1 km radius) to classify the plot site as alpine or subalpine.

Are krummholz trees found at the same elevation as, or below, plot center? Circle yes (Y) or no (N).

Are upright trees at found at the same elevation as, or above, plot center? Circle yes (Y) or no (N).

Is this a subalpine or alpine plot, why? Describe the rationale for the determination. This field will help refine the criteria that distinguish between alpine and subalpine plots.

Are there obvious signs of human impact? Circle one of the following: *No*, *Campsite*, or *Trail*.

If none of these, enter a value for *Other*: Indicate what the impact is.

Is there sign of wildlife use in the plot? Circle yes (Y) or no (N).

Describe animal sign (*e.g., goat hair, elk trampling, scat)*: If yes (Y) was circled, detail what was observed.

Is the plot within 5 m of a summit (of a knoll or peak)? Circle yes (Y) or no (N). This will provides us with an idea of the location of the site on the landscape.

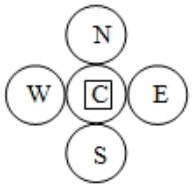
If not, do you see one from the center? If no (N) was circled, but one is seen beyond 5 m of the plot, enter values for *Azimuth*, *Distance (m)*, and *Name*.

Description of route, special considerations for efficient and safe access: Note any pertinent information about safely accessing the plot, e.g., if a detour was taken around a cliff or description of distinctive landmarks for route-finding.

Office use only: Final determination – is plot suitable? Why or why not? The grayed-out area of the data form includes fields only to be completed upon return to the office. These include the final determination of whether the point is accepted for an Alpine, Subalpine or Whitebark pine plot as well as who made the determination and when. There are also fields for who entered and verified the data and when.

GRTS Point Field Evaluation Form

Park: _____ GRTS Point ID: __-__ ____ __ Date: ____/____/_____ Observers: _____
Field UTM N: _____ Field UTM E: _____ Coordinate source: GPS Map
GPS Model: _____ GPS File Name: _____ Datum: _____ (should be NAD83)
Photo Number: _____ Photo Perspective* (check one): Downslope: ___ North: ___
Photo File Name**: _____



Reconnaissance plot sizes: 10 x 10 m for alpine/subalpine plot with the GRTS point at the center.

Whitebark Pine Reconnaissance includes 5 plots (diagram at right): C is the center (or GRTS Point) and 4 circular plots at North, East, South, and West. Each plot has a radius of 17.84 m. The box around the center point C indicates the placement of the 10 x 10 m alpine/subalpine plot.

	Circle		Explanation:	
Plot safely accessible? *(unsafe = too steep, cliffs, major river or glacier crossing)*	Y	N		*[Reject and abandon if unsafe]*
Is the plot in an avalanche track?	Y	N		*[Reject if yes]*
Is the plot within a forest opening?	Y	N		*[Reject if yes]*
Tree cover >25%? *(trees are >2.54 cm dbh)*	Y	N		*[Reject for alpine / subalpine if ≥25% tree cover]*
Estimate cover of open water (0, 5, 15, 25…85, 95, 100%):				*[Reject if ≥25%]*
Type of open water present: pond ____ persistent stream ____ intermittent stream ____ other (describe) _____				
Estimate cover of permanent snow/ice (0, 5, 15, 25…85, 95, 100%):				*[Reject if ≥25%]*
Estimate cover of talus (0, 5, 15, 25…85, 95, 100%):				*[Reject if ≥25%]*
Estimate cover of tall shrubs* ** (0, 5, 15, 25…85, 95, 100%):				*[Reject if ≥25%]*
Tall shrub species present:				

Count the number of whitebark pine trees in each plot (C, N, E, S, W) *Note: only count stems ≥2.54 cm dbh*

Plot	Live trees	Dead trees	
C			*[Reject for whitebark pine if no trees are in any of the five plots]*
N			
E			
S			
W			

Vegetation association (keyed in 10 x 10 m plot around GRTS point):

Are krummholz trees found at the same elevation as or below the plot center	Y	N	**Are upright (>2 m tall) trees found at the same elevation as or above the plot center?**	Y	N
Is this a subalpine or alpine plot and why?					
Are there obvious signs of human impact?	Y	N	Impact (check): social trail ____ campsite ____ Other (describe):_____ Distance to center (m):_____		
Is there sign of wildlife use in the plot?	Y	N	Describe animal sign (*e.g., goat hair, elk trampling, scat*):		
Is the plot within 5 m of a summit (of a knoll or peak)?	Y	N	If not, do you see one from the center? Azimuth:_____ Distance (m):_____ Name:_____		
Description of route, special considerations for efficient and safe access:					

Office use only: Final determination – is plot suitable? Why or why not?	Alpine plot?		Subalpine plot?		Whitebark pine plot?	
	Y	N	Y	N	Y	N
Determination made by:		Date (mm/dd/yy):				
Entered by:	Date (mm/dd/yy):	Verified by:		Date (mm/dd/yy):		

Page 1 of 2

Figure 7.1. GRTS Point Field Evaluation Form, page 1.

GRTS Point Field Evaluation Form (continued)

Table 1. Sub-shrub species found in alpine and subalpine habitats of MORA, NOCA, and OLYM.

Scientific Name	Common Name	MORA	NOCA	OLYM
Arctostaphylos nevadensis	pinemat manzanita	X	X	X
Arctostaphylos uva-ursi	kinnikinnick	X	X	X
Cassiope mertensiana	western moss heather	X	X	X
Cassiope tetragona var. saximontana	white mountain heather		X	
Empetrum nigrum	black crowberry	X	X	X
Gaultheria humifusa	western wintergreen	X	X	X
Gaultheria ovatifolia	western teaberry	X	X	X
Harrimanella stelleriana	Alaska bellheather	X	X	
Juniperus communis	common juniper	X	X	X
Kalmia microphylla	alpine bog laurel	X	X	X
Phyllodoce empetriformis	pink mountain heather	X	X	X
Phyllodoce glanduliflora	yellow mountain heather	X	X	X
Phyllodoce X intermedia	hybrid mountain heather		X	X
Salix cascadensis	Cascade willow	X	X	
Salix nivalis	snow willow	X	X	
Salix petrophila	alpine willow		X	
Vaccinium deliciosum	Cascade bilberry	X	X	X
Vaccinium myrtillus	whortleberry	X		X
Vaccinium scoparium	grouseberry	X	X	X

* Take the photo from 10 m upslope of plot center facing downslope. If plot has no slope, take the photo facing north from 10 m south of plot center. Be sure to take the photograph in landscape orientation so that the entire plot area is in view.

** File name is assigned in the office when photos are downloaded to the project workspace. Format as: YYYYMMDD_XXXX_xxxx.jpg, where YYYYMMDD is the date, XXXX is park code, and xxxx is the 4-digit GRTS number. Example: 20100802_MORA_0306.jpg for photo taken August 2, 2010 at MORA GRTS point 0306.

*** Tall shrubs are >0.5 m in height and do not include species categorized as sub-shrubs (see Table 1).

Figure 7.2. GRTS Point Field Evaluation Form, page 2.

SOP 8: Establishing and Monitoring Alpine/Subalpine Vegetation Plots

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP contains instructions for establishing and monitoring permanent alpine/subalpine monitoring plots in MORA, NOCA, and OLYM. Plot locations were distributed in the alpine treeline ecotone and selected using a Generalized Random Tessellation Stratified (GRTS) sample, for each park, to produce a spatially balanced, random sample. Potential plots locations were screened both in the office and in the field to insure that they met predefined criteria (**SOP 7: Screening and Reconnaissance for Selection of Alpine/ Subalpine Vegetation and Whitebark Pine Plots**). Generally, plots will be established and monitored in the same trip. The NCCN Alpine/Subalpine Vegetation and Whitebark Pine Establishment Form is used to record environmental characteristics and navigation instructions for each plot and will be completed during the initial monitoring visit. The Alpine/Subalpine Vegetation Monitoring Form will be completed each time the plot is visited.

Equipment and Supplies

Supplies and equipment are listed in Table 8.1.

Table 8.1. Equipment for establishing and monitoring a permanent plot.

2- 50 m measuring tape	Hammer (2 lb. or claw)*
10 m measuring tapes (2)	GPS unit
Pre-cut tape or rope (11-m lengths)	Compass
4 - ¼" diameter rebar, 1-m lengths (used in plot establishment)*	Clinometer
40 Pin flags	Flagging
4 blue metal numbered tags and wires to attach tags to rebars*	Clipboard
Establishment Form*	Collection bags
Monitoring Form	Plant keys
Data loggers (2-5, dependent on funding), landscape staples, and nylon cord	Digital camera
Quadrat frame	Dry erase board and marker to label photos
dbh tape	

* Indicates supplies only needed during establishment

Plot Establishment

Alpine/subalpine plots are 10 m x 10 m and are oriented along cardinal directions. The GRTS point will be the SW corner of the plot. Tread as lightly as possible during plot establishment and monitoring since herbaceous vegetation is the primary component of this protocol. Prior to plot set-up, review the potential site and insure that the plot will not contain a social trail, permanent trail or that ≥25% of the plot is not covered by trees or water. Although the site should have been screened during the GRTS field review for tree, water, and trail coverage, conditions could have changed since that time so, a quick site review should be completed. If any of these conditions have changed, you can relocate the SW corner to one of five alternate positions: 10 m north, east, south, or west (Figure 8.1).

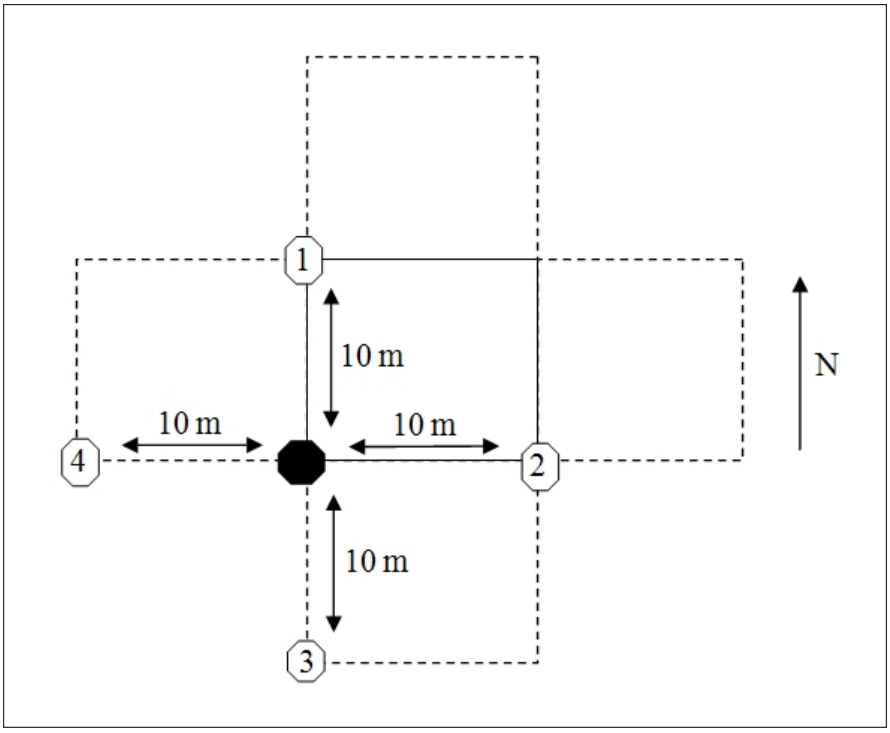


Figure 8.1. Diagram illustrating the GRTS point location for the permanent 100 m^2 alpine/subalpine monitoring plot. The solid hexagon indicates the GRTS point in the southwest corner of the plot. Alternate locations for the SW corner, and the order for review, are indicated by numbered hexagons.

Once you locate the SW corner, set the rebar in that corner and measure to the three other corners and temporarily insert the corner rebar. To locate the corners of the plot, use your compass and measure 10 m north of the SW corner, 10 m east of the SW corner. Finally, measure 10 east from the NW and 10m north from the SE corner and the intersection should mark the NE corner. Before permanently inserting the corner rebars, measure all four sides to insure they are 10m in length and check that they are north, south, east or west from adjacent corners. The last step is to measure diagonally across the plot (i.e., NW to SE and NE to SW), to ensure that the distance is 14.14 m across the plot. Once you are certain the rebars are in the correct locations, pound the rebar into the ground so that the top only protrudes 2 cm above the ground surface. Attach a blue numbered metal tag to each rebar; the tag should indicate the plot number and corner location (i.e., NW, NE, SE, SW). GPS the location of the SW corner and be

sure to write the coordinates read from the GPS on the data form (this is a back-up in case the GPS file becomes corrupted).

Quadrat Establishment

Twenty quadrats (50 cm x 50 cm) are established in each 10 x 10 m permanent plot. The 10 x 10 m plot is subdivided into five 2 x 2 m sections to locate the quadrats. Use the 50-m tapes and 10-m tapes to lay out a 2 x 2 m grid in the plot. At the NW corner of each intersection put in a pin flag according to the diagram in Figure 8.2. When you have marked all 20 quadrat locations, check to see if the spacing looks symmetrical. Use the pin flags to facilitate mapping of the plot. Map locations of all rebar in the plot diagram described in monitoring the plot.

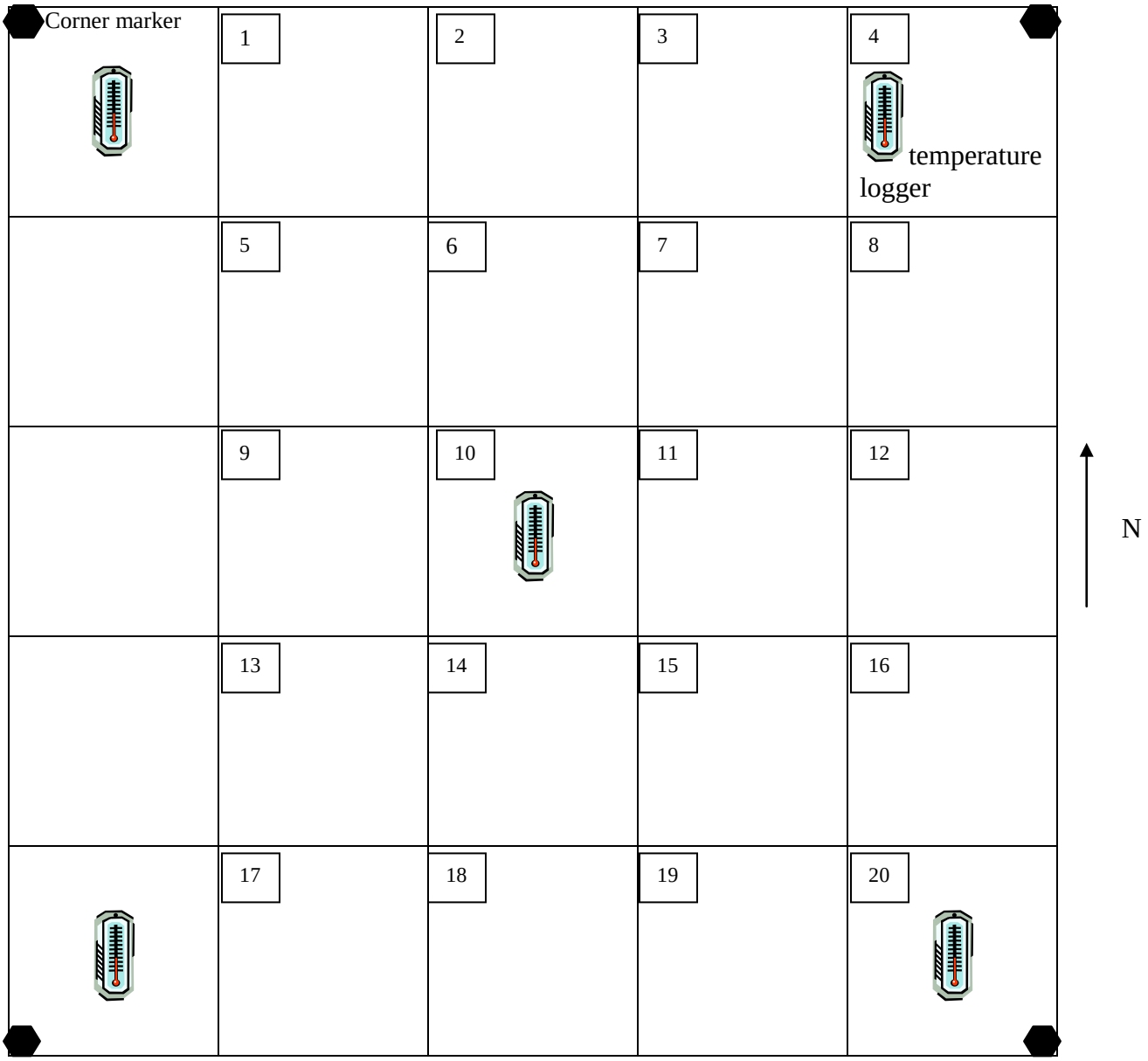


Figure 8.2. Locations of quadrats.

Completing the Vegetation Plot Establishment Form

The plot establishment form should be completed by the crew at the time of plot establishment (Figures 8.3, 8.4). The Field Crew Lead is responsible for ensuring that the form is completely filled out in the field and filed upon returning to the office. Fields labeled "office use only" are to be completed in the office and not in the field. Fill out the form as follows:

Identification and Location

Park: The four-letter code for the park where the plot is located (MORA, NOCA, or OLYM).

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc.

Plot type: Circle whether the plot is an Alpine, Subalpine or Whitebark Pine plot.

Plot No: Enter a five character plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. "M" for MORA).
- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0156 indicates this is a plot at MORA and it is the 156th point in the GRTS firing order.

Date: The month, day, and year that the plot was set up and established.

Crew: The last names and first initials of crew members that participated in plot establishment.

GPS file name: As indicated on the GPS unit when a location file is recorded. It is critical that the file name be recorded in addition to the UTMs, because it is the reference used for entering the corrected UTMs later.

GPS model: Record the make and model of the GPS device used to acquire coordinates for the plot, for example Trimble GeoExplorer 3, Thales MobileMapper, or Garmin eTrex.

Coord. source: Indicate if the coordinate data are from a GPS (default), or are estimated from a map.

Target UTM X: The latitude of the southwest corner, also known as easting, as determined from the GRTS-generated points.

Target UTM Y: The longitude of the southwest corner, also known as northing, as determined from the GRTS-generated points.

Field UTM X: The latitude of the southwest corner, also known as easting, as recorded in the field with the GPS (estimated from a map only if GPS is unavailable).

Field UTM Y: The longitude of the southwest corner, also known as northing, as recorded in the field with the GPS (estimated from a map only if GPS is unavailable).

GPS error: Record the horizontal error estimate from the GPS (m), if available.

Datum: The North American Datum for 1983 (NAD83) is the standard for NCCN data acquisition. Some older topographic maps are still in NAD27, but we rarely use these to obtain UTM coordinates. Recent project maps (i.e., from ArcMap) and target UTMs will be in NAD83. The GPS unit should be set for NAD83, and this should be verified at the beginning of each field tour and when borrowing or sharing a GPS unit. New crew members, or those temporarily filling in for others, must be instructed to use NAD83.

Elevation: The elevation at plot center measured in meters. If possible read the elevation from a calibrated altimeter or topographic map. The elevation can also be read from the GPS, but this may be less accurate. Verify the elevation units from the source you are using (meters or feet); if in feet, cross out and change the units to feet on the data sheet. Note: Elevations recorded in feet must be converted to meters (by multiplying the value in feet by 0.3048) prior to entering data into the database.

Source: Indicate whether the elevation value is derived from a map, the GPS, or an altimeter.

Directions to plot: Starting from a road, trail head, or other mapped landmark, give detailed directions to aid an entirely new crew returning to the plot. Include distances in meters or to the nearest 0.1 miles and use compass directions. For extremely difficult routes, consider including GPS locations on a marked map in a separate trip report. Include key information such as river crossings, other challenges, and advice.

Describe safety considerations when accessing or working in the plot: Document and special considerations that will benefit future field crews working at the site.

Task list: Plot needs, special instructions, or adjustments to consider before the next visit to the plot. This may include rebar or tags that need to be replaced, the advisability of bug nets, etc.

Environmental Features (of 10 x 10)

All data recorded in this section pertains to the 10 x 10 m area unless otherwise specified.

Vegetation Association (keyed in 10 x 10 m plot around GRTS point): Enter the vegetation association observed. The vegetation association key will be available in the project workspace or from the Project Lead.

Slope: The steepness of the slope at plot center in degrees. Standing at plot center measure the steepness of the slope (both up slope and down slope) with a clinometer. Record these two values as [up]/[down] in the margin and then record the average of these two measurements in the space provided. Slope degrees are read on the left side of the clinometer (tilt to see degrees sign).

Aspect: The compass direction of the downward slope of land at plot center; this azimuth is perpendicular to and facing away from the slope plane (think of the direction water would flow, also called the fall line). ‘True’ simply indicates that the declination adjustment has been made.

Declination: The magnetic declination or angle (degrees) that must be added or subtracted from an azimuth to convert between the needle direction on a compass (magnetic north) and longitude (true north). See **SOP 4**: **Orientation and Training of Field Crews**, for more information.

Microconfiguration: The general shape of the 10 x 10 m plot: convex, concave, straight, or undulating.

Microtopographic position: Also called microposition; the position on the landscape of the 10 x 10 m plot. Is the plot located on a ridgetop? At the toe of a slope? River bottom? If it is on a slope, where is it – upper, middle or bottom 1/3 of the slope?

Topographic position: Also called Macroposition; the landscape containing the plot relative to the features at the mountain scale.

Comments to clarify above choices: This is not a required field. If you have trouble choosing from the options in the boxed fields, or feel there isn't a perfect fit, you may offer an explanation here.

Photopoint Establishment for Alpine and Subalpine plots

Two photo points are established to document changes in broad physiognomic vegetation conditions at each monitoring interval. The first photopoint should be established south of the plot, looking north, so that the entire plot is visible. Walk south of the plot until you can see the entire plot in the frame of your digital camera. This photo will be most valuable if you can see the plot and the horizon and/or an easily recognizable landscape feature (e.g., large rock, hill profile) that can be used in the future to calibrate all photos. It may be useful to have a person stand on one corner of the plot. After taking the photo, record a detailed location of the photographer on the monitoring form.

The second photopoint is taken, using the same methods as photopoint 1, to provide additional documentation on vegetation physiognomic structure. The location for the second photopoint is selected from the N, E, or W side of the plot, whichever provides the best view.

Photopoint 1 (2): Record the field UTMs for each photopoint.

Distance (m): Record the distance, in meters, to the two closest plot corners. For photopoint 1, this will *always* be the SW and SE corners.

Azimuth: Record the azimuth, in degrees, to the two closest plot corners. For photopoint 1, this will always be the SW and SE corners.

Map: Draw the location of the two photopoints on the plot diagram on page two of the plot establishment data form.

Office use only *(use initials and mm/dd/yy)*
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

NCCN Alpine/Subalpine Vegetation and Whitebark Pine Plot Establishment Form **Page 1**

Identification and Location

Park: _____ Site name: _____ Plot type (circle): Alpine Subalpine Whitebark Pine

Plot No. ___ - _____ *(Park name first letter, GRTS Firing order #)*

Date: M ___ D ___ Y _____ Crew: _____ *(last name, first initial)*

GPS file name: _____ GPS model: _____ Coord. source: GPS Map

Target UTM **X** _____ m E Target UTM **Y** _____ m N

Field UTM **X** _____ m E Field UTM **Y** _____ m N GPS error: ____ Datum: NAD83 Zone: 10N
(check these on GPS unit)

Elevation: _____ m Source: __Altimeter __ Map ___GPS

Directions to plot: _____

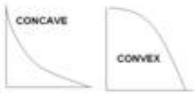
Describe safety considerations when accessing or working in the plot: _____

Task list - Plot needs, special instructions, or adjustments to consider before plot revisit: _____

Environmental Features – evaluated from plot center

Vegetation association: _____

Slope: ____ (°) Aspect: ____ (°) Declination: ___ (°)

Microtopographic Position	**Microconfiguration**
__Ridgetop __Toe of slope __Upper 1/3 __River bottom __Middle 1/3 __Hydric __Lower 1/3 __Bench, flat __Draw, intermittent stream bottom	__Convex __Concave __Straight __Undulating 
Topographic Position	
__Ridge or peak >130' wide __Narrow ridge or peak <130' __Side hill – upper 1/3 __Side hill – middle 1/3 __Side hill – lower 1/3	__Canyon bottom <660' wide __Bench, terrace, or dry flat __Alluvial flat >660' wide __Swamp or wet flat

Comments to clarify above choices: _____

Figure 8.3. Plot Establishment Form, page 1.

NCCN Alpine/Subalpine Vegetation and Whitebark Pine Plot Establishment Form **Page 2**

Photopoint Establishment for Alpine and Subalpine plots

Entire plot photopoints (two) – take one view of plot from south side (photopoint 1) and a second view from north, east or west, whichever best characterizes plot structure (photopoint 2). Draw location of each photopoint on map below. Record distance and azimuth from each photopoint to the two nearest plot corners for each view.

Photopoint 1: UTM N: _____
UTM E: _____
Distance (m) to SW corner: _____
Distance (m) to SE corner: _____
Azimuth to SW corner: _____
Azimuth to SE corner: _____

Photopoint 2: UTM N: _____
UTM E: _____
Distance (m) to ____ corner: _____
Distance (m) to ____ corner: _____
Azimuth to _____ corner: _____
Azimuth to _____ corner: _____

Photopoint location descriptions:
- View from south: _____
- View from N, E, W (circle): _____

Figure 8.4. Plot Establishment Form, page 2.

Monitoring the Vegetation Plot and Recording Data

When you arrive at the plot, assemble all supplies, locate the four corner markers and complete the data entries on the top of each data form:

Park: The four-letter code for the park where the plot is located (MORA, NOCA, or OLYM).

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc.

Plot No: Enter a five character plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. "M" for MORA).
- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0156 indicates this is a plot at MORA and it is the 156th point in the GRTS firing order.

Date: The month, day, and year that the plot was set up and established.

Sheet #: Write the number of each page and the total number of pages on each data sheet

Observers: Write the first initial and last name of all crew members working on the plot.

Recorder: Write the first initial and last name of person who recorded the data.

Mapping the Vegetation Plot

The next step in monitoring the plot is to document the condition of the 10 x 10 m plot (Figures 8.5, 8.6):

- Find the 4 corner rebars and outline the plot with measuring tapes
- Place pin flags at two meter intersections throughout the plot grid (Figure 8.5) to help with mapping and location of monitoring quadrats
- Record the locations of rebars and replace missing rebars and tags
- Map cover of trees, krummholz, and tall shrubs by species
- Measure and record the species and dbh of all trees
- Count and record the upright stems on all krummholz patches by species
- Take the two plot photos
- Retrieve the current data logger(s) and install new data logger(s)

There should be 4 rebars installed in each plot – at the corners of the 10 m x 10 m plot. Check for all rebars and tags and mark their location on the map of the vegetation plot. If rebars or tags are missing, replace them and record this on the Event Log. If you did not bring extra rebars, note the location of the missing rebar on the map, as well as in the event notes section of the Event Log and record the number of rebars or tags that will need to be replaced during the next site visit in the Event Log task list.

Next, map the cover and species of trees, tall shrubs (≥0.5 m in height), and krummholz patches on the map. Map the cover as precisely as possible because the diagrams will be used to estimate

percent cover by growth form and species. If you have just established the plot, you will still have the pin flags marking the intersections of the 2 x 2 m grid. If you are monitoring the plot and the rebar are not easily visible, place pin flags next to each rebar. Each 2 x 2 meter square represents 4% of the entire 10 x 10 m plot. If you ensure that the cover is correct to ± 1 m (1/4 of each 2 x 2 m square), you will have mapped to a resolution of 1 m which is our goal. Label each tree (≥2.54 cm dbh), tall shrub, or krummholz patch with the species name or the six letter alphacode. All species identification must be to species, do not assume that by recording the genus that anyone else will know the species. In addition, measure the dbh of all trees and record them on page two of the data sheet, it is not necessary to indicate the location of each tree (i.e., we do not need to match dbh with location on your map). Label each krummholz patch that you map with a number and then record the number of live upright stems, per patch, on the data sheet (Figure 8.7). Map and label (by species) cover of tall shrubs on the map.

Finally, map environmental features or evidence of disturbance that may either assist with plot relocation or may help explain changes in vegetation patterns that are recorded by future visits. Boulders or small streams may assist with both plot relocation or vegetation patterns. Signs of animal browse, trampling, or burrowing may assist in explanation of vegetation condition or composition (Figures 8.5, 8.8).

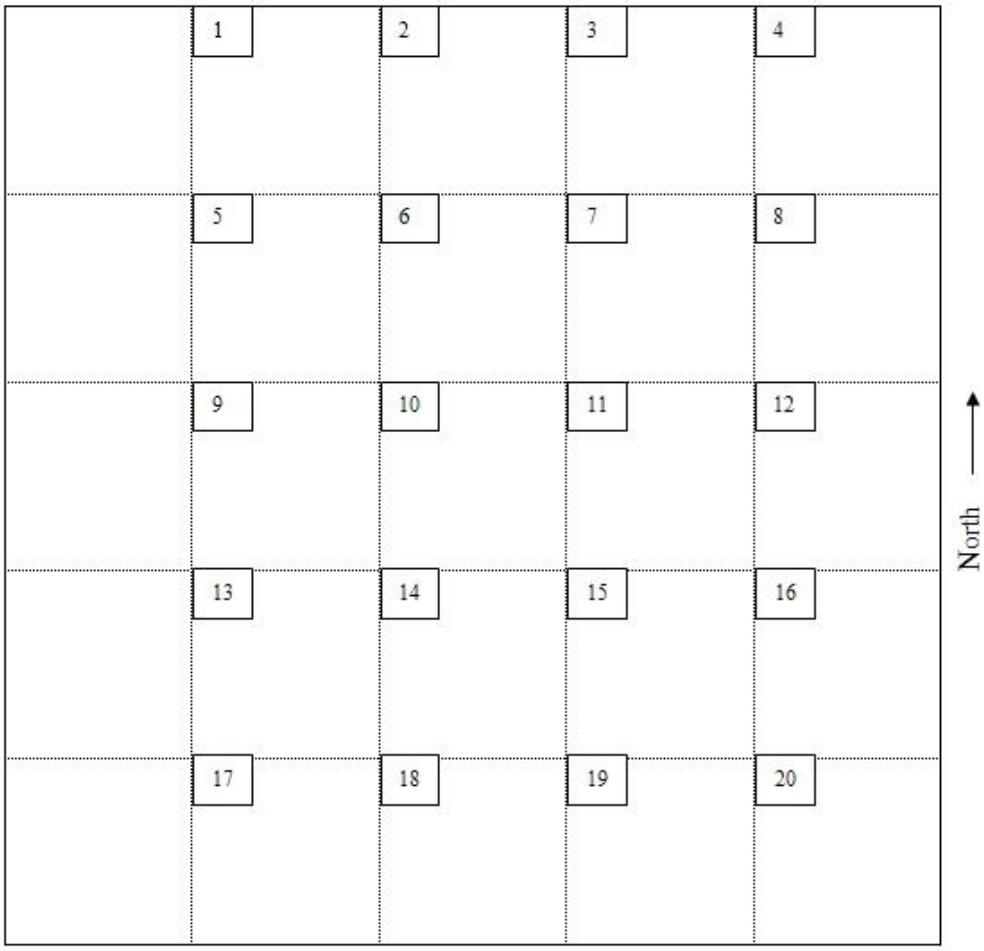
Once back in the office, the plot diagram should be scanned, labeled, and the scanned image file name should be entered in the Task List section of the Event Log form (see **SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log**). Save the scanned plot diagram in the appropriate folder of the project workspace as specified by the Project Lead.

Office use only (use initials and mm/dd/yy)
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

Alpine and Subalpine Vegetation Monitoring Field Form:

Plot Diagram

Park: _____ Site Name: _____ Plot No.: ___ - ___ ___ ___ ___
Date (mm/dd/yy): _____ Sheet #: ____of_____
Observers: _____ Recorder: _____



Be sure to draw and label:

- trees
- tall shrubs
- data loggers
- krummholz
- animal sign
- rebar (plot corners)
- distinguishing site features (large rocks, streams, small ponds, etc.)

Trees, krummholz, and shrubs should be labeled with species, and canopies should be drawn so that cover can be calculated to 1% of the plot (i.e. within 1 meter).

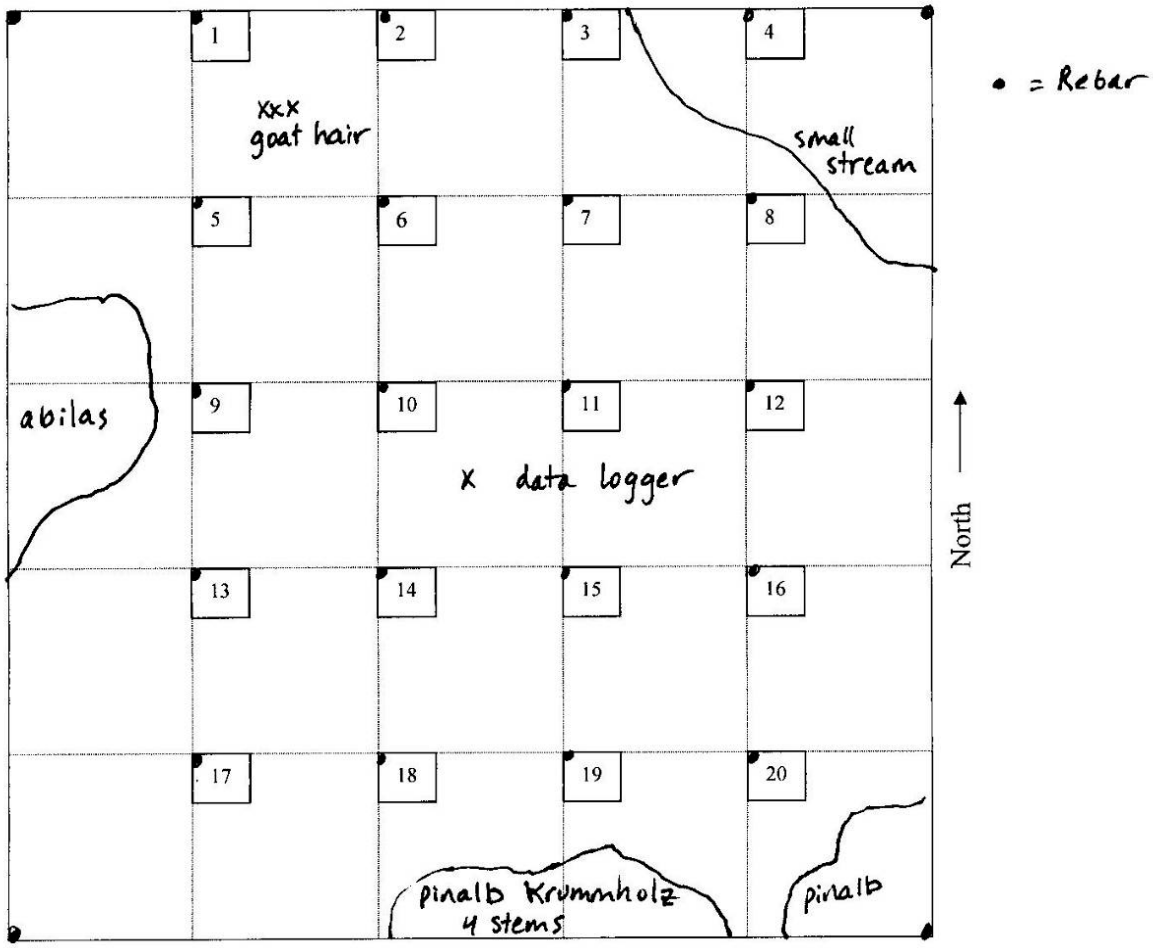
Figure 8.5. Alpine and Subalpine Vegetation Monitoring Field Form: Plot Diagram.

Office use only *(use initials and mm/dd/yy)*
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

Alpine and Subalpine Vegetation Monitoring Field Form:

Plot Diagram

Park: MORA Site Name: Wild Woman Rock Plot No.: M - 0 3 8 0
Date (mm/dd/yy): 08/08/2014 Sheet #: 1 of 4
Observers: M. Heather Recorder: H. Sedge



Be sure to draw and label:

- trees
- tall shrubs
- data loggers
- krummholz
- animal sign
- rebar (plot corners)
- distinguishing site features (large rocks, streams, small ponds, etc.)

Trees, krummholz, and shrubs should be labeled with species, and canopies should be drawn so that cover can be calculated to 1% of the plot (i.e. within 1 meter).

Figure 8.6. Example of completed Plot Diagram.

Figure 8.7. Example of upright stems on krummholz patches. The krummholz in this photo would be mapped as two patches. The patch on the left (white circle) is *Pinus albicaulis* (pinalb) and has 4 live, upright stems. The remainder of the krummholz is *Abies lasiocarpa* (abilas) and live, upright stems can be counted in the two yellow circles – 3 on the left and 4 on the right for a total of 7 for the abilas patch.

Figure 8.8. Examples of animal sign to record on map: on the left photo the white patch is goat hair and in the middle of the right photo there are soil piles and a tunnel.

Photographing the Vegetation Plot

Two photopoints are taken of the entire plot as mentioned in the plot establishment. The locations of the two points will be provided in the Navigation Report. Take the photos from the photopoints and record the photo numbers and description in the Event Log (see **SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log**).

Filling out the tree and krummholz data

Park: Fill in the four-letter code for the park where the plot is located (MORA, NOCA, or OLYM)

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc.

Plot No: Enter a five character plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. "M" for MORA).
- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0156 indicates this is a plot at MORA and it is the 156th point in the GRTS firing order.

Date: The month, day, and year that the plot was set up and established.

Sheet #: Write the number of each page and the total number of pages on each data sheet

Observers: Write the first initial and last name of all crew members working on the plot.

Recorder: Write the first initial and last name of person who recorded the data.

Tree species, dbh: record the dbh (cm) and species for each tree in the plot (Figure 8.9).

Krummholz, patch number and number of upright tree stems: On the map, each krummholz patch should have a number and species code. Record the number of upright, live stems for each patch. Upright stems are tree leaders that ascend at least 50 cm above the estimated mean height of the patch you are surveying. Number discrete krummholz patches on the plot map beginning in the northwest. If all krummholz is in one area and appears continuous, do not be concerned with splitting it into more than one patch (Figures 8.5, 8.9).

Alpine and Subalpine Vegetation Monitoring Field Form:

Tree and Krummholz Data Sheet

Park: _____ Site Name: _____ Plot No.: ___ - ___ ___ ___ ___
Date (mm/dd/yy):_____ Sheet #: ____of_____
Observers: _____ Recorder: _____

Record species and dbh for all trees, number krummholz patches, and record number of upright stems below:

Trees		Krummholz		
Species	**dbh (cm)**	**Species**	**Patch number**	**Number of upright tree stems**

Figure 8.9. Alpine and Subalpine Vegetation Monitoring Field Form: Tree and Krummholz Data.

Retrieving and replacing the data logger

There are five potential locations for the soil temperature data loggers (Figure 8.10): the center 2 x 2 m square and the four corners (Figure 14). The number of data loggers will be dependent on

funding, but a minimum of one data logger will always be installed in the center square of the 10 x 10 m plot. Data loggers should be programmed prior to traveling to the field site to collect temperatures every hour, following directions that accompany the data logger. The data logger should be buried 7-10 cm below the soil surface. If possible, bury the data logger in an opening between clumps of vegetation. If openings are not visible, bury it near a deciduous species rather than under a heather plant since our objective is to detect the duration of snow cover and soil temperature. Tie a nylon string around the data logger to a landscape staple. Once you bury the data logger, insert the landscape staple so that it is at the ground surface and can be used to relocate the data logger. Record the data logger location on the plot diagram and collect the GPS location for it. Data loggers will be deployed for five years so it is important to carefully note its location and that burial results in the smallest amount of site disruption. Data logger deployment times, locations, retrieval times, and notes will be entered into the Event Log as describe in **SOP12: Recording Plot Visit Details and Taking Digital Photos: Event Log**.

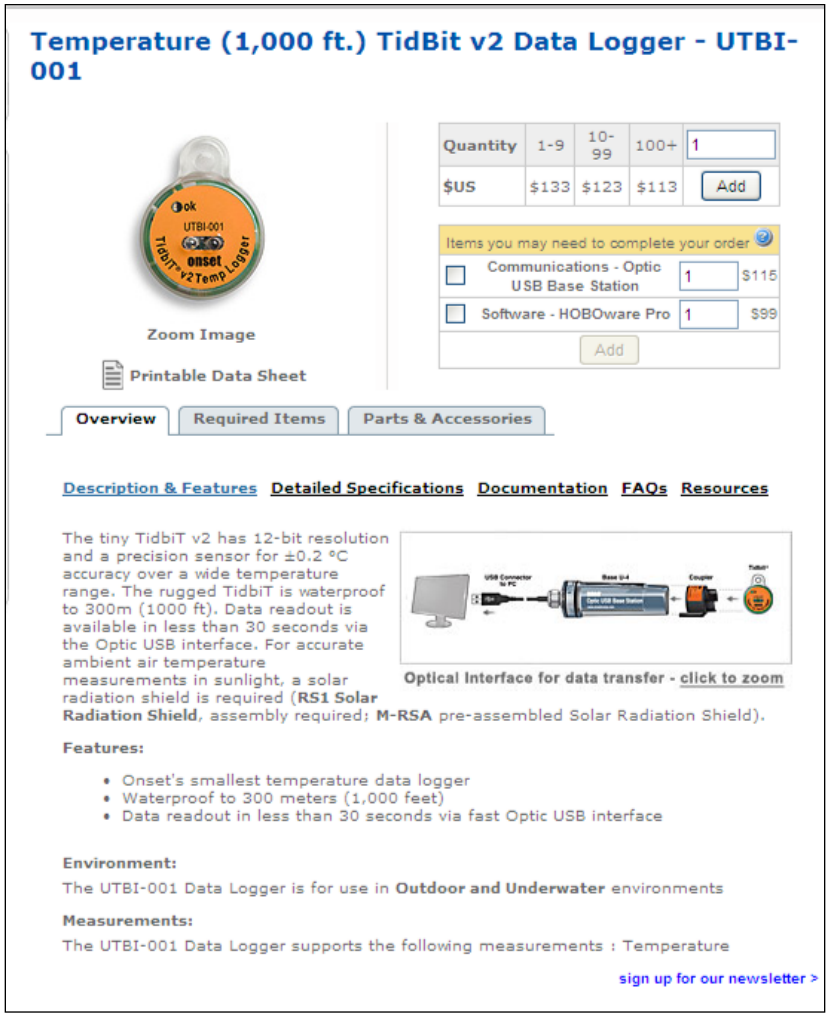


Figure 8.10. Illustration of the onset data logger recommended for use in the plots.

Vegetation Quadrat Monitoring

Vegetation cover is recorded in twenty 0.5 x 0.5 m quadrats. Species cover and frequency is estimated using a plot frame that is subdivided into 100 smaller squares (Figures 8.11, 8.13). The quadrat frame should be set down with the NW corner of the quadrat aligned with the NW corner of the 2x2m section of the plot and acorner marker (pin flag) in the NW corner of the plot frame. Generally the pin flag will mark the NW corner of the quadrat, but you should check the plot diagram – sometimes the substrate is impermeable so you (or your predecessor) may have to install the pin flag in a different corner. Each quadrat is photographed as describe in **SOP12: Recording Plot Visit Details and Taking Digital Photos: Event Log**.

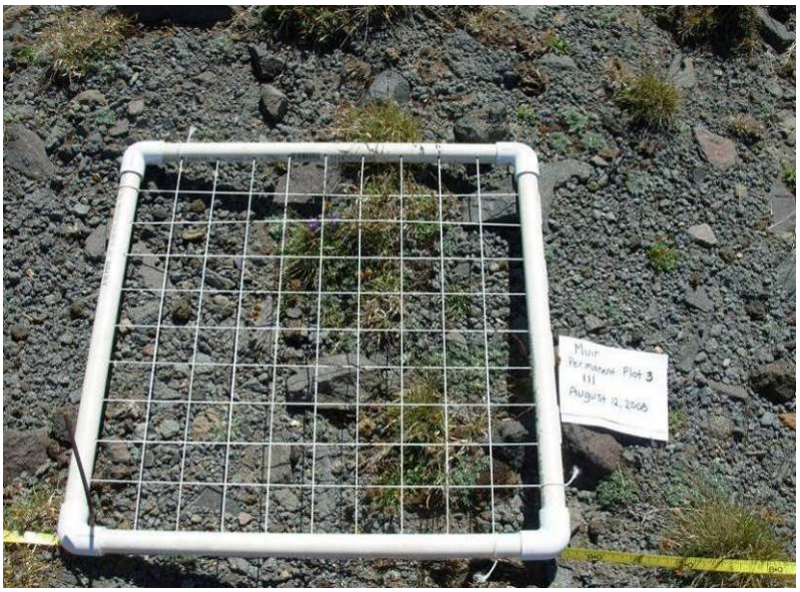


Figure 8.11. Photograph of one of the MORA alpine legacy plots. Note that the frame is subdivided into 100 squares, each delineating 1% of the plot. The rebar is in the lower left corner within the plot frame. The photo also illustrates that photos of each quad are take looking down from a standing position and a dry erase board (or file card in this case) labeling the plot, quadrat, and date is placed in the photo frame.

Cover values are best determined in mid-summer (July-August) when all species have attained maximum canopy coverage. The condition of the quadrat is described at two scales or resolutions. The first "scale" provides a general description of the quadrat by estimating the top cover (or surface cover) of six broad cover types: rock (large enough so as not to be moved by meltwater), gravel, bare soil, litter and dead plants, moss and lichen, and vascular plants. In this step you are describing your view of the quadrat in one plane, as if you photographed the quadrat and then outlined the six cover types as visible from directly above – basically a simplified diagram of the quadrat. Each cover type is estimate to the closest 1% and since you are visualizing the quadrat in one plane, the total of the six broad cover types must add up to 100%. When a plant canopy overlaps rock, gravel, or bare soil, record the cover type as the upper most surface (e.g., plant) and do not estimate the cover type below it (e.g., rock or bare soil).

The next step is to search the quadrat for seedlings and identify them by species if possible. The number of seedlings is tallied by species within the entire quadrat. If you cannot identify the species of seedling, record it as unknown seedling. If you are certain there is more than one

unknown seedling species, record them as unknown # 1, #2, etc. Take close-up photo of the unknown species for potential office identification. Unknown species will need to be resolved to a standard set of unknown taxa prior to data entry (e.g., “Unknown conifer”, “Unknown Ericaceae”, etc.).

The next scale is a detailed description of all plant and lichen species in the plot and in this step all canopy layers are searched to record frequency and cover of each species. The first step is to record frequency in each of four sub-quadrats. The 4 subquadrats are as follows: #1 is a 5cm x 5cm square in the northwest corner of the quadrat, #2 is a 25cm x 25 cm square, # 3 is 25cm x 50m (half the 50cm x 50cm quadrat), and # 4 encompasses the entire quadrat. For each species, record the smallest sub-quadrat in which the plant occurs (Figure 8.12). Starting with the smallest subquadrat (#1), record all species names, record a # 1 in the frequency column (NF on data sheet), and then proceed to subquadrat 2. Search subquadrat 2 and record any new species and place a 2 in the NF column; continue searching and recording species in subquadrats 3 and 4 until you have searched the entire quadrat. When searching the subquadrats, record the names of all plant species that occur in the quadrat on the data sheet (i.e., each species whose shoot occurs in the quadrat, the species does not have to be rooted in the quadrat). When you have finished recording frequency, you will have a complete species list for the quadrat and can the estimate cover for each species.

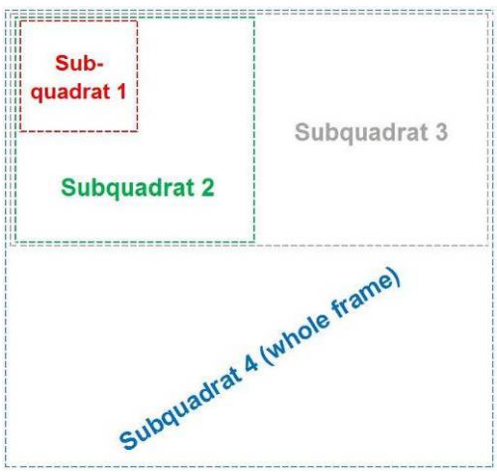


Figure 8.12. Diagram of numbered nested frequency sub-quadrats.

It is important to search the entire quadrat before you assign a cover class so you have a complete mental image of the species distribution and abundance. Species cover will be estimated using eleven cover classes: 1 (>0-5), 2 (>5-10), 3 (>10-20), 4 (>20-30), 5 (>30-40), 6 (>40-50), 7 (>50-60), 8 (>60- 70), 9 (>70-80), 10 (>80-90), 11 (>90-100). To estimate cover, begin by drawing a polygon around the canopy of each plant and then subtract all spaces that are not occupied by the plant (e.g., the area in-between grass blades). Remember that when estimating cover by individual species, you may be looking at multiple layers so the absolute cover of vascular plant species may exceed the total vascular cover recorded in the broad-scale approach.

There are two quick checks that should be performed in the field for quality assurance. First compare the vascular plant cover the broad scale review with cover classes you obtained in the

species estimates. If in the first part you estimated total vascular plant cover was 85% and there are only two species recorded with cover class values of 2 (>5-10) and 5 (>30-40), then probably the 85% is an overestimate or the cover classes are underestimated. If on the other hand you record a 1 (>0-5) for one species and a 10 (>80-90) for the second, this seems realistic or even if you record a 10 (>80-90) for both species, this could be true because their canopies overlap. The second quick check is to trade species with another crew member to make sure that you both would assign the same cover class. If you discover discrepancies in your estimations, take time to work through a few species of different life forms and work through the entire quadrat so that you can calibrate yourselves with each other.

Finally, all taxa must be identified to species. If you cannot identify a plant, walk outside the plot and collect a specimen that can be keyed out in the office and used as to prepare a voucher specimen (see **SOP 11: Collecting Plant Voucher Specimens**). If the plant is not in flower or fruit and you cannot find one outside the plot that is, carefully map its location, take a photo, and add this as a task that should be undertaken in the Event Log.

The data sheet should be filled out as follows:

Park: Fill in the four-letter code for the park where the plot is located (MORA, NOCA, or OLYM).

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc.

Plot No: Enter a five character plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. “M” for MORA).
- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0156 indicates this is a plot at MORA and it is the 156th point in the GRTS firing order.

Date: The month, day, and year that the plot was set up and established.

Sheet #: Write the number of each page and the total number of pages on each data sheet

Observers: Write the first initial and last name of all crew members working on the plot.

Recorder: Write the first initial and last name of person who recorded the data.

Quadrat No.: Write the quadrat number at the top of the column.

Cover (%): Fill in the % cover for stone, gravel, bare soil, litter and dead, moss and lichen, and vascular plants for the quadrat. Cover should be estimated by 1% and the sum of the six categories should add to 100%.

Seedlings by species: Write the number of seedling for each species observed. If you cannot identify the seedlings to species, write ‘unknown sp.’ and the number of seedlings.

Vascular Plant Cover by Species: Write the nested frequency (1-4) and cover class (1-11) for each vascular plants species in the quadrat.

Moss and Lichen Cover by Species: Record the nested frequency (1-4) and cover calss (1-11) for each moss and lichen species in the quadrat. If you do not know the species, write 'unknown moss sp.' or 'unknown lichen sp.,' take a sample for identification back in the office, and replace the species name on the filed form after you have identified the species.

Species in plot but not in quadrat: Write the species of vascular and nonvascular plants you notice in the immediate vicinity of the plot but not within any quadrats.

Alpine and Subalpine Vegetation Monitoring Field Form:

Species Cover and Frequency

Park: _____ Site Name: _____ Plot No.: ___ - ___ ___ ___ ___
Date (mm/dd/yy):_____ Sheet #: ____of_____
Observers: _____ Recorder: _____

Quadrat No.										
Cover (%)										
stone										
gravel										
bare soil										
litter and dead										
moss and lichen										
vascular plants										
Seedlings by species	No.		No.		No.		No.		No.	
Vascular Plant Cover by Species (in cover classes and nested frequency*)										
Species	NF*	CC	NF*	CC	NF*	CC	NF*	CC	NF*	CC
Moss and Lichen Cover by Species (in cover classes and nested frequency*)										

*Nested Frequency (NF): ranges from 1 to 4 based on the smallest sub-quadrat the species occurs in (1 is the smallest and 4 is the largest or entire quadrat); Cover Classes (CC): 1 (>0-5), 2 (>5-10), 3 (>10-20), 4 (>20-30), 5 (>30-40), 6 (>40-50), 7 (>50-60), 8 (>60- 70), 9 (>70-80), 10 (>80-90), 11 (>90-100).

Species in plot but not in quadrats: _____

_____

_____

Comments: _____

_____

Figure 8.13. Alpine and Subalpine Vegetation Monitoring Field Form: Species Cover and Nested Frequency.

SOP 9: Establishing and Monitoring Whitebark Pine Plots

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP contains instructions for establishing and monitoring GRTS-based whitebark pine plots and monitoring legacy whitebark pine plots. Legacy plots were established in MORA and NOCA in 2004. The legacy plots are located within polygons that were delineated to encompass stands where whitebark pine is known to be present. Each of these legacy whitebark pine polygons covers an area of up to 3 km^2. In MORA, there were 8 polygons each with a maximum of five plots; 5 polygons were sampled in NOCA, each with 7 plots. In the 2004 monitoring design, the polygon was the sample unit while in the GRTS based sample frame, the plot is the sample unit. Newer GRTS-based plots will be established beginning with implementation of this protocol in 2011. Although the attributes measured in plots remains the same, the difference between the two sampling designs is the size of plots to measure trees, saplings, and seedlings. Newer GRTS-based whitebark pine plots will be established during the first monitoring visit.

GRTS-based plots are 0.1 ha in size (17.84 m radius) and all trees (≥2.54 cm dbh) are measured within this plot. In the legacy plots, all trees were measured in a 0.04 ha plot (11.3 m radius), but if there were fewer than 30 whitebark pine trees within this radius, observers continued to spiral out counterclockwise until 30 trees (live and dead) were surveyed or a maximum radius of 50 m. In the old plots, a slope correction factor was applied for the 11.3 m radius plot; no slope correction factor will be used on the GRTS-based plots. In the legacy plots, seedlings, saplings and understory vegetation were counted within the entire plot. In the new GRTS plots, understory is still estimated in this inner circle, but seedlings and saplings are counted within five 2.52 m radius subplots located in the center and on the four cardinal points on the 11.3 m radius circle.

Plots are marked with rebar at plot center and the coordinates of the plot have been recorded. Plots will generally be monitored every 5 years, but may be monitored earlier if there have been disturbance events of interest (i.e., fire or indication of forest pests by the USFS Forest Pest overflights).

Equipment Needed

- Clipboard
- Data forms printed on waterproof paper
- **SOP 9: Establishing and Monitoring Whitebark Pine Plots**

- Pencil
- GPS unit loaded with plot center locations
- List of plot center locations (UTM coordinates)
- Maps illustrating area and plot locations
- dbh tape
- 30-m tape
- Survey flags (to temporarily mark plot boundary while surveying)
- Tree tags, nails and wire
- Hammer
- Rebar (1) to mark plot center
- Timepiece
- Digital camera
- Safety related equipment: 10 essentials
- Vegetation field guide (recommended)

Plot Establishment

All plot locations have been reviewed during field screening and should have passed the selection criteria: minimum of 10 live whitebark pine trees, absence of trails or social trails, and <25% cover by water. Check the area around the GRTS point (i.e., 17.84-m radius) to be certain the site does meet these criteria. If the 0.1-ha area (17.84-m radius) does meet the criteria, insert a rebar into the center of the plot, fill out the Establishment Form, and monitor the plot. If the area does not meet the criteria, you can review four additional points for the plot center: 35 m North, East, South, or West – all four of these areas should have been checked during field review. Review these alternate center points in the order listed (N, E, S, W). The first point that meets the criteria is the new plot center. Insert the rebar and fill out the Establishment Form. There is one other instance when the plot center can be offset – if a subalpine monitoring plot has already been established in this site. We do not want the two plots located on top of one another because measuring of whitebark pine trees may cause trampling to understory vegetation monitored in the subalpine plot. In this case, follow the same review of N, E. S, and W points and establish the center point at that location.

Completing the NCCN Plot Establishment Form

The plot establishment form should be completed by the crew at the time of plot establishment (Figure 9.1). The Field Crew Lead is responsible for ensuring that the form is completely filled out and filed. Fields labeled “office use only” are to be completed in the office and not in the field. Fill out the form as follows:

<u>Identification and Location</u>

Park: The four-letter code for the park where the plot is located (MORA, NOCA, or OLYM).

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc.

Plot No: Enter a five character plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. “M” for MORA).

- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0106 indicates this is a plot selected at MORA, and it is the 106th point in the GRTS firing order.

Crew: The last names and first initials of crew members that participated in plot establishment.

Date: The month, day, and year that the plot was set up and established.

GPS file name: As indicated on the GPS unit when a location file is recorded. It is critical that the file name be recorded in addition to the UTMs, because it is the reference used for entering the corrected UTMs later.

GPS model: Record the make and model of the GPS device used to acquire coordinates for the plot, for example Trimble GeoExplorer 3, Thales MobileMapper, or Garmin eTrex.

Coord. source: Indicate if the coordinate data are from a GPS (default), or are estimated from a map.

Target UTM X: The latitude of plot center, also known as easting, as determined from the GRTS-generated points.

Target UTM Y: The longitude of plot center, also known as northing, as determined from the GRTS-generated points.

Field UTM X: The latitude of plot center, also known as easting, as recorded in the field with the GPS (estimated from a map only if GPS is unavailable).

Field UTM Y: The longitude of plot center, also known as northing, as recorded in the field with the GPS (estimated from a map only if GPS is unavailable).

GPS error: Record the horizontal error estimate from the GPS (m), if available.

Datum: The North American Datum for 1983 (NAD83) is the standard for NCCN data acquisition. Some older topographic maps are still in NAD27, but we rarely use these to obtain UTM coordinates. Recent project maps (i.e., from ArcMap) and target UTMs will be in NAD83. The GPS unit should be set for NAD83, and this should be verified at the beginning of each field tour and when borrowing or sharing a GPS unit. New crew members, or those temporarily filling in for others, must be instructed to use NAD83.

Elevation: The elevation at plot center measured in meters. If possible read the elevation from a topographic map or calibrated altimeter. The elevation can also be read from the GPS, but this may be less accurate. Verify the units for elevation from the source you are using (meters or feet); if in feet, cross out and change the units to feet on the data sheet. Note: Elevations recorded in feet must be converted to meters (by multiplying the value in feet by 0.3048) prior to entering data into the database.

Source: Indicate whether the elevation value is derived from a map, the GPS, an altimeter, or from a GIS theme.

Directions to plot: Starting from a road, trail head, or other mapped landmark, give detailed directions to aid an entirely new crew returning to the plot. Include distances in meters or 0.1 miles and use compass directions. For extremely difficult routes consider including GPS locations on a marked map in a separate trip report. Include key information such as river crossings, other difficulties, and advice.

Describe safety considerations when accessing or working in the plot: Document and special considerations that will benefit future field crews working at the site.

Task list: Plot needs, special instructions, or adjustments to consider before the next visit to the plot. This may include rebar or tags that need to be replaced, the advisability of bug nets, etc.

Environmental Features (of 0.1 ha)

All data recorded in this section pertain to the 0.1 ha area, around the plot center, unless otherwise specified.

Slope: The steepness of the slope at plot center in degrees. Standing at plot center measure the steepness of the slope (both up slope and down slope) with a clinometer. Record these two values as [up]/[down] in the margin and then record the average of these two measurements in the space provided. Slope degrees are read on the left side of the clinometer (tilt to see degrees sign).

Aspect: The compass direction of the downward slope of land at plot center; this azimuth is perpendicular to and facing away from the slope plane (think of the direction water would flow). Record the aspect in degrees and record the declination adjustment, also in degrees, of the compass.

Declination: The magnetic declination or angle (degrees) that must be added or subtracted from an azimuth to convert between the needle direction on a compass (magnetic north) and longitude (true north). See **SOP 4**: **Orientation and Training of Field Crews**, for more information.

Microconfiguration: The general shape of the 0.1-ha plot: convex, concave, straight, or undulating.

Microtopographic position: Also called microposition; the position on the landscape of the 0.1 ha plot. Is the plot located on a ridgetop? At the toe of a slope? River bottom? If it is on a slope, where is it – upper, middle or bottom 1/3 of the slope?

Topographic position: Also called Macroposition; the landscape containing the plot relative to the features at the mountain scale.

Office use only *(use initials and mm/dd/yy)*
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

NCCN Alpine/Subalpine Vegetation and Whitebark Pine Plot Establishment Form **Page 1**

Identification and Location

Park: _ _ _ _ _ Site name: _____ Plot type (circle): Alpine Subalpine Whitebark Pine

Plot No. ___ - _ _ _ _ _ _ _ *(Park name first letter, GRTS Firing order #)*

Date: M _ _ D _ _ Y _ _ _ _ _ Crew: _____ *(last name, first initial)*

GPS file name: _____ GPS model: _____ Coord. source: GPS Map

Target UTM **X** _ _ _ _ _ _ _ _ m E Target UTM **Y** _ _ _ _ _ _ _ _ m N

Field UTM **X** _ _ _ _ _ _ _ _ m E Field UTM **Y** _ _ _ _ _ _ _ _ m N GPS error: ____ Datum: NAD83 Zone: 10N
(check these on GPS unit)

Elevation: _ _ _ _ _ m Source: __Altimeter __ Map ___GPS

Directions to plot: _____

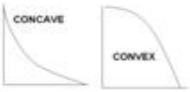
Describe safety considerations when accessing or working in the plot: _____

Task list - Plot needs, special instructions, or adjustments to consider before plot revisit: _____

Environmental Features – evaluated from plot center

Vegetation association: _____

Slope: _ _ _ (°) Aspect: _ _ _ (°) Declination: ___ (°)

Microtopographic Position	**Microconfiguration**
__Ridgetop __Toe of slope __Upper 1/3 __River bottom __Middle 1/3 __Hydric __Lower 1/3 __Bench, flat __Draw, intermittent stream bottom	__Convex __Concave __Straight __Undulating 
Topographic Position	
__Ridge or peak >130' wide __Narrow ridge or peak <130' __Side hill – upper 1/3 __Side hill – middle 1/3 __Side hill – lower 1/3	__Canyon bottom<660' wide __Bench, terrace, or dry flat __Alluvial flat >660' wide __Swamp or wet flat

Comments to clarify above choices: _____

Figure 9.1. Plot Establishment Form, page 1. Note: page 2 not shown because it applies to alpine and subalpine plots only.

Monitoring the plot - order of activities
Upon arrival at a marked plot, or following the initial installation of a new plot:

1. The center seedling plot should be located and seedlings counted as this area will be most disturbed by further work in the plot.
2. Mark the north, south, east and west tree plot boundary locations (17.84 m radius), as well as any other plot boundary locations necessary to clearly define the plot. Mark these points using survey flags or flagging tape (a minimum of 8 boundary markers is recommended).
3. Locate the seedling subplots and count the seedlings within the subplots surrounding the north, south, east and west tree plot boundary points.
4. Fill in all the fields in the remaining data forms and take reference photos. Tree data collection should begin at the plot boundary at 0 degrees and proceed clockwise.
5. Remove the temporary plot boundary markers and proceed to the next plot.

Plot design
The whitebark pine monitoring project uses one large plot for tree monitoring, and six smaller subplots for vegetation and seedling and sapling monitoring (Figure 9.2). Data on trees ≥2.54 cm dbh are collected in the 17.84-m radius plot. Understory vegetation cover data are collected in the 11.30 m radius vegetation subplot. Data on trees ≤2.54 cm dbh are collected in five 2.52-m radius seedling/sapling subplots. One of these subplots is located at plot center. The other four are centered 11.3 m from plot center in each cardinal direction. The areas of each of the plots are:

- Tree plot – 1000 m^2
- Vegetation subplot – 400 m^2
- Seedling/sapling subplots – 20 m^2 each

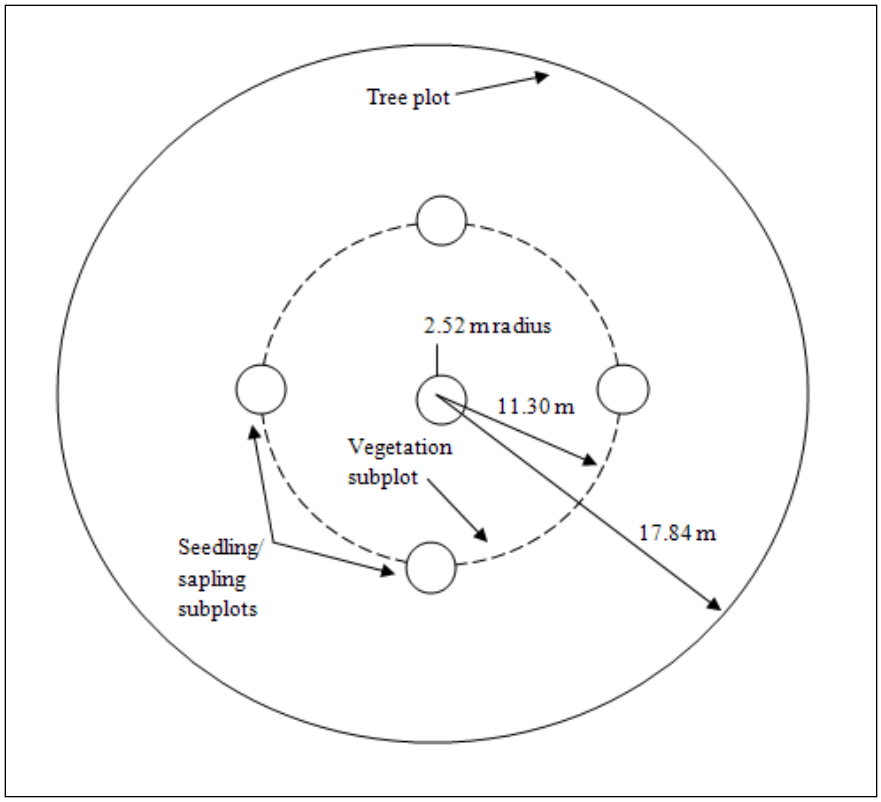


Figure 9.2. Diagram of sample plot and subplot arrangement.

Data collection

Data collection is scheduled to occur every 5 years. Additional data collection visits may be made in cases where a disturbance (e.g., fire, mountain pine beetle outbreak, avalanche, or landslide) occurs in the area of whitebark pine monitoring plots. On these additional trips, data will only be collected on whitebark pine and regeneration and the Event Log will be filled out (**SOP 12**).

Filling out the Whitebark Pine Monitoring Form

The following sections describe each field on the whitebark pine data form. Ensure that data are filled in all fields and that each page is given a page number.

Whitebark Pine Plot Monitoring Field Form, page 1 (Figure 9.3)

Park: Check the park in which the plot is located (MORA, NOCA, or OLYM).

Date: The month, day, and year that the plot was set up and established.

Page __of__: Write the number of each page and the total number of pages on each data form.

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc. For legacy plots, the site names refer to the original polygons delineating whitebark pine areas (Table 9.1).

Office use only *(use initials and mm/dd/yy)*
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

Whitebark Pine Plot Monitoring Field Form

Location and survey crew Page ___ of ___
Park: __ MORA __ NOCA __ OLYM Plot No.: __-__ __ __ __
Date (mm/dd/yy): ___-___-___ Site Name: _____
Observers (first initial, last name): _____ Recorder: _____

Animal observations

Clark's Nutcracker:	Not seen: ____	Seen near plot (within 50 m): ____	Time of observation: _____
Red squirrel:	Not seen: ____	Seen in plot: _____	Time of observation: _____
Douglas squirrel:	Not seen: ____	Seen in plot: _____	Time of observation: _____

Overstory description: estimate percent cover (by cover class) for each tree species and for canopy (all trees combined)

Tree species	Cover class (C.C)	Comments
Canopy (i.e. all species)		

Understory cover (shrubs, forbs, and grasses):

Species	C.C.	Species	C.C.	Species	C.C.

Substrate:

Substrate category	C.C.	Comment
Boulder (≥30 cm)		
Rock (3-30 cm)		
Gravel (<6 cm)		
Bare ground		
Litter		
Lichen/Moss		
Down Woody Debris(Not Rooted)		

Describe weather conditions: _____
_____
_____

Cover classes (%): 1 (0-5), 2 (6-10), 3 (11-20), 4 (21-40), 5 (41-60), 6 (61-80), 7(81-100) Version 7/26/2012

Figure 9.3. Whitebark Pine Monitoring Form, page 1.

Table 9.1. Two letter code for each legacy polygon/site in MORA and NOCA.

Polygon/site	Code
MORA	
Antler Peak	AP
Crystal Ridge	CR
Fryingpan	FP
Glacier Basin	GL
Mystic Lake	ML
Skyscraper	SS
Sunrise Campground	SG
The Palisades	PA
NOCA	
Dee Dee Lake	DD
Juanita Lake	JL
Rainbow Lakes	RL
Rainbow Ridge	RR
Stiletto	ST

Plot No: Enter a five character plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. "M" for MORA).
- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0156 indicates this is a plot selected at MORA, and it is the 156th point in the GRTS firing order.

Observers: Write the first initial and last name of all crew members working on the plot.

Recorder: Write the first initial and last name of person who recorded the data.

Animal Observations

Clark's nutcracker: Indicate if a Clark's nutcracker (Figure 9.4) was seen within 50m of the plot center. If seen, indicate the time of observation.

Red squirrel: Indicate if a red squirrel (Figure 9.5) was seen within the plot. If seen, indicate the time of observation.

Douglas squirrel: Indicate if a Douglas squirrel (Figure 9.6) was seen within the plot. If seen, indicate the time of observation.

Figure 9.4. Photograph of an adult Clark's Nutcracker (Photo credit: Dave Menke, USFWS).

Figure 9.5. Photograph of an adult red squirrel (Photo credit: Donna Dewhurst, USFWS).

Figure 9.6. Photograph of an adult Douglas squirrel (Photo credit: Walter Siegmund, GNU Free Documentation License).

Overstory description: This section contains fields on the canopy cover of trees greater ≥2.54 cm dbh in the 17.84-m radius plot. Tree skirts are not counted in is section. [If you are monitoring a legacy plot the overstory description is based on the 11.3-m radius circle around the center rather than the 17.84 m radius.]

Tree species: Identify each tree species present in the plot. 'Canopy' is included in this column. Estimate cover for all the tree species together in the cover class column next to this entry.

Cover class: Estimate cover class for each identified species using the cover classes specified at the bottom of the data sheet and in Table 9.2.

Table 9.2. Tree, understory and substrate cover classes.

Percent range	Cover class
>0 – 5%	1
6 – 10%	2
11 – 20%	3
21 – 40%	4
41 – 60%	5
61 – 80%	6
81 – 100%	7

Comments: Write down any notes about each tree species present (optional).

Understory vegetation: This section contains fields on the canopy cover of understory vegetation in the 11.3 m radius subplot. Trees <2.54 cm dbh are counted in this section. [Understory is estimated in the same manner and in the same area for legacy plots.]

Understory cover (shrubs, forbs, grasses): This section contains fields for data on the canopy cover of understory species. Tree skirts are included in this section

Species: Identify each species of tree <2.54 cm dbh, shrub, forb, or grass that covers more than 1% of the plot. Each species is recorded using a 6 letter identifier comprised of the three first letters of the genus name and the three first letters of the species name.

Cover class: Estimate cover class for each identified species using the cover classes specified at the bottom of the data sheet and in Table 9.2.

Substrate: This section contains fields for data on the ground surface cover types in the 11.3 m radius subplot. [Substrate is estimated in the same area and manner for legacy plots.]

Cover class: Substrate cover classes are estimated by substrate category. Estimate cover class for each substrate using the cover classes specified at the bottom of the data sheet and in Table 9.2 above. Definitions of the substrate categories are:

- Boulder – Loose stones or bedrock outcrop larger ≥30 cm in diameter
- Rock – Loose stones or bedrock outcrop ≥3 cm to <30 cm in diameter
- Gravel – Loose stones <3 cm in diameter
- Bare ground – Exposed soil, not included soil visible under vegetation.
- Litter – Vegetative debris
- Lichen/Moss – Soil covered by lichen or moss but not including lichen or moss on woody debris, rocks, or boulders
- Down woody debris (not rooted) – Dead woody material

Comments: Write down any notes about each substrate type (optional).

Describe weather conditions: Briefly describe the weather conditions during the sampling event (clear skies, overcast, rain, snow, freezing, high winds, foggy). Weather can affect the plot environment, as well as the performance and endurance of the crew. Knowing the weather conditions may help to explain why certain decisions or observations were made.

<u>Filling Out the Whitebark Pine Seedling Form</u>

Seedlings are defined as trees less than 50 cm tall. Seedlings of all species are tallied in five 20 m^2 subplots (radius = 2.5 m) located at the plot center and on the four cardinal directions (Figures 9.2, 9.7). [Seedlings in legacy plots are monitored in the same manner.]

Species: Write the six letter species code for each species. The six letter code is made up of the first three letters of each the genus and species name (Table 9.3).

Table 9.3. Species codes used in data collection. If other species found use the same naming convention.

Species	Code
Pacific silver fir (*Abies amabilis*)	ABIAMA
Subalpine fir (*Abies lasiocarpa*)	ABILAS
Yellow-cedar (*Callitropsis nootkatensis*) (formerly *Chamaecyparis nootkatensis*)	CALNOO
Subalpine larch (*Larix lyallii*)	LARLYA
Engelmann spruce (*Picea engelmannii*)	PICENG
Whitebark pine (*Pinus albicaulis*)	PINALB
Lodgepole pine (*Pinus contorta*)	PINCON
Western white pine (*Pinus monticola*)	PINMON
Ponderosa pine (*Pinus ponderosa*)	PINPON
Douglas-fir (*Pseudotsuga menziesii*)	PSEMEN
Mountain hemlock (*Tsuga mertensiana*)	TSUMER

Tally: Tally seedlings by subplot; if no seedlings are present for a species in the subplots, enter zero. You can tally seedlings using lines or dots, but when you finish counting, sum the lines and write and circle the total number of seedlings/species/subplot.

Seedling Form

Park: __ MORA __ NOCA __ OLYM Plot No.: __-__ __ __ __ Date (mm/dd/yy): ___-___-___ Page ___ of ___

Seedlings: trees < 50 cm in height. List species and tally number within each subplot 20 m^2 (2.53 m radius)

Species	Seedling Tally by Subplot				
	Center	North	East	South	West

Figure 9.7. Whitebark Pine Monitoring Seedling Form.

Filling Out the Whitebark Pine Sapling Form

Saplings are trees ≥50 cm in height and <2.54 cm dbh. Saplings are recorded using the same subplots as used for seedlings (Figures 9.8, 9.9). [Legacy plots use the same methodology.]

Whitebark pine saplings: Whitebark pine saplings are counted and classified by health status.

Tally: Use this area to tally saplings by heath category when counting. The health categories are:

- Healthy (no blister rust): No evidence of blister rust cankers or more than 15% of crown dead or chlorotic from other causes.
- Cankers present: Active cankers or inactive canker scars present. Saplings with browse wounds or chlorotic needles should be labeled in this category.
- Browse wound: Evidence of needle browse apparent, and no cankers found.
- Chlorotic or dead needles >15% of crown: Mark trees in this category only if no cankers present. Chlorotic needles are needles which are discolored and appear yellow.
- Dead, from blister rust: Sapling is dead and canker wound is visible and appears to the cause of death.
- Dead, other cause: Sapling is dead from a cause other than white pine blister rust. Evidence of a canker may be present but if cause of death appears to something other than blister rust (e.g., crushed by another tree) the sapling should be counted in this category.

Number: After counting in the subplot is complete, write the number of seedlings of each species here.

Other species saplings: Saplings of all other species present should be identified and counted by species.

Species: Identify each species of seedling using six letter species code Table 9.3.

Tally: Use this space to tally seedlings.

Number: When counting is complete enter total number of seedling for each species.

Sapling Form – Part 1

Park: __ MORA __ NOCA __ OLYM Plot No.: __-__ __ __ __ Date (mm/dd/yy): ___-___-___ Page ___ of ___

Saplings: tree species <2.54 cm in diameter at breast height and ≥50 cm in height.

Whitebark Pine: tally whitebark pine saplings by subplot and by condition category, moving from left to right across the table. If no saplings are found in a category, place a zero in the table.

Sub Plot	Healthy (no evidence of blister rust	Cankers present	Browse wound	Chlorotic or dead needles > 25% of crown	Dead, from blister rust	Dead, other cause
Center						
North						
East						
South						
West						

Figure 9.8. Whitebark Pine Sapling Data Form.

Sapling Form – Part 2

Park: __ MORA __ NOCA __ OLYM Plot No.: __-__ __ __ __ Date (mm/dd/yy): ___-___-___ Page ___ of ___

Saplings of all other species: List species and tally number within each subplot 20 m² (2.53 m radius).

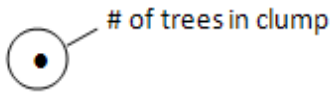
Species	Seedling Tally by Subplot				
	Center	North	East	South	West

Figure 9.9. Data Form for recording numbers of tree saplings for other species.

Plot Diagram Form

This form is used when both establishing and monitoring plots. On this form plot the location of all whitebark pine trees (Figure 9.10).

Whitebark pine trees in each plot should be mapped. The azimuth to and distance to each tree should be measured and recorded on the tree data form. Using this data the trees should be mapped as accurately as possible on the coordinate plane. All whitebark pines should be marked with a '●' and the tree tag number shown. If several whitebark pine are found grown together in a clump, the clump should be marked with the following symbol:



The tag numbers of the trees in the clump should be included. They should be listed as encountered if moving clockwise from north around the plot.

Once back in the office, the plot diagram should be scanned, labeled, and the scanned image file name should be entered in the Task List section of the Event Log form (see **SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log**).

Reference photographs

Reference photographs are taken at all plots. Photographs should be taken from the plot center facing 0, 90, 180, and 270 degrees. A whiteboard should be held in each photograph. Write on the whiteboard the following information:

1. Plot number
2. Photograph orientation (up-slope, down-slope, across-slope 1, across-slope 2, or azimuth if the plot has no slope)
3. Date (MM/DD/YYYY)

These details will ensure that the photograph is accurately filed. The whiteboard will help provide scale for researches looking at the photograph. All photos are recorded on the Event Log as mentioned in **SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log**.

Plot Diagram Form

Page ___ of ___

Park: __ MORA __ NOCA __ OLYM Plot No.: __-__ __ __ __ Date (mm/dd/yy): ___-___-___

Directions: Draw a diagram of the plot showing the location of the center, all numbered whitebark pine trees (i.e. trees ≥2.54 cm at DBH), and clearly label the 3 reference trees. Use an X to show location of reference trees and O for locations of all other whitebark pines.

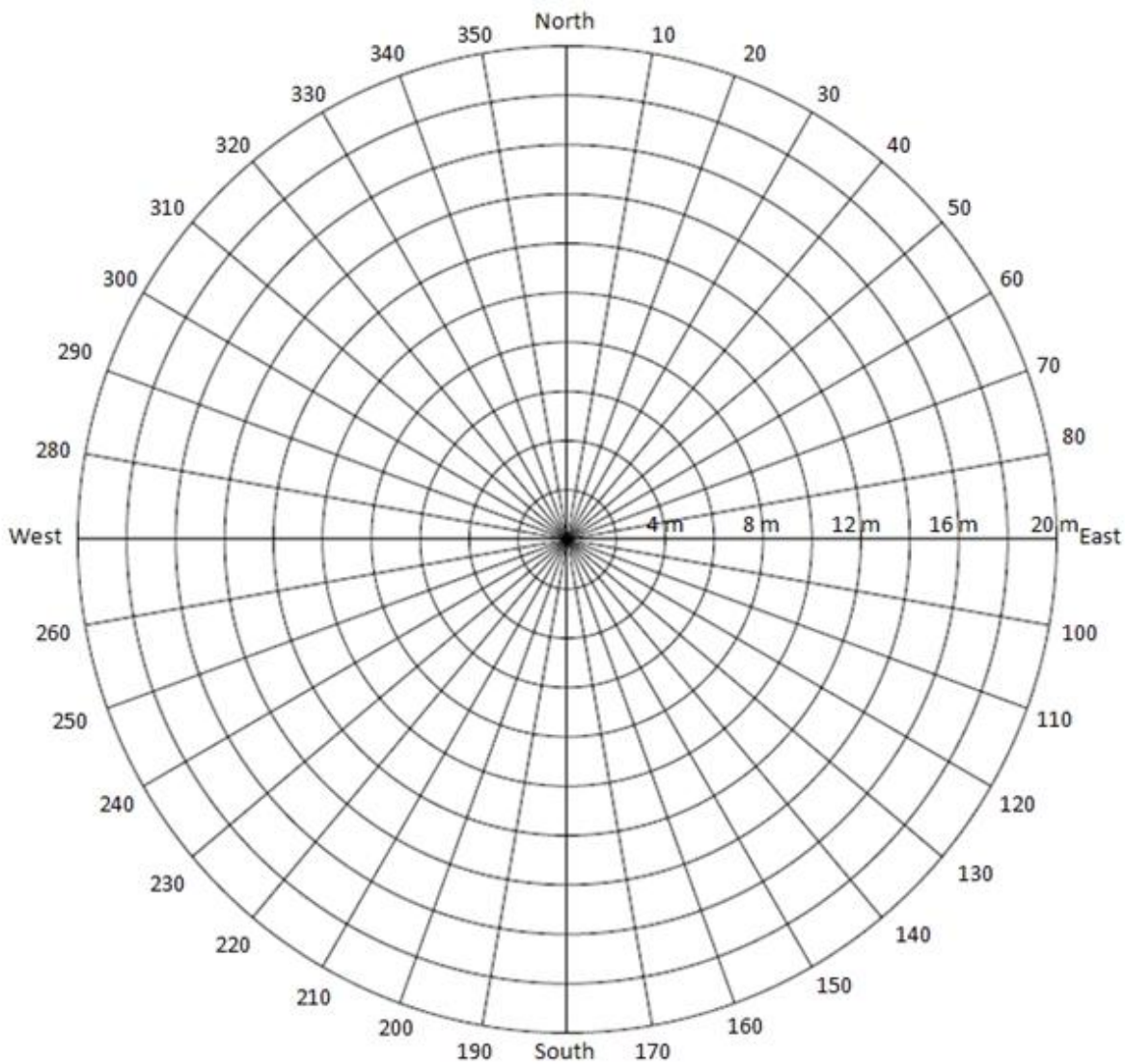


Figure 9.10. Plot Diagram Form.

Tree Data Form

Park: __ MORA __ NOCA __ OLYM Plot No.: __-__ __ __ __ Date (mm/dd/yy): ___-___-___ Page ___ of ___

Species	Tag #	Clump (A, B …)	Dist. (m)	Azimuth	L, D, or M	dbh (cm)	Height (m)	Bole cankers (N, A, I, U)	Branch cankers (N, A, I, U)	Crown kill (%)	Cones			Mt Pine beetle (Y / N)	Browse or gnawing (Y / N)	Fire scars (Y / N)	Mistletoe (Y / N)	If mistletoe present, rate by 1/3 of tree canopy (0-2)		
											Mature (Y / N)	First year (Y / N)	Pollen (Y / N)					Bottom 1/3	Middle 1/3	Top 1/3

Figure 9.11. Tree Data Form used to record data on all trees ≥2.54 cm dbh.

Collecting and Recording Data on the Tree Data Form

All trees (≥2.54 cm dbh) are documented within the 17.84 m radius plot using the *Tree Data Form* (Figure 9.11). Some fields are only for whitebark pine trees. It is indicated below which species provide data for each field.

Species: Data entered for all species. Identify the tree species and record the 6-letter code that represents the first three letters of the genus and the species.

Tag #: Data entered only for whitebark pine.

All live and dead whitebark pine trees must be marked with an aluminum numbered tag attached to the tree with an aluminum nail or wire. Wire should be used on trees less than 5 cm dbh or trees that for any reason cannot hold a nail. The tag should be placed at dbh facing plot center. (Whitebark pine legacy plots have tags installed 30 cm from the tree base.)

When placing a tree tag the nail should be driven in only as far as necessary to firmly anchor it in the wood to leave room for future tree growth. Angle the nail so that gravity pulls the tag down toward the head of the nail. The tree may grow over the tag if this is not done.

Do not use a tag number more than once in a plot, even if the number had previously been used for a tree that is no longer alive. When installing a replacement tag, ensure that the number does not already occur in the plot. If possible, temporary tags, on which a number can be inscribed with a pen or knife, should be carried into the field. Effort should be made to follow the previous number system to give the tree the number it had previously.

Clump (A, B…): Data entered for whitebark pine only.

Whitebark pine trees are frequently found growing in multi-individual clumps. These clumps typically form when multiple seeds from a Clark's nutcracker cache germinate. However, in some cases, one individual has multiple trunks.

A whitebark pine separated by >2.54 cm at ground level from other whitebark pine trees is considered an individual and not a member of any clump. Trees separated by ≤2.54 cm are considered members of a clump. In the clump column, all trees in the same clump are given the same letter designation.

Within a clump it is important to differentiate between an individual tree and a branch. Each potential tree must satisfy all of the following criteria to be recorded as a tree (Figure 9.12):

1. There must a discernible growth groove that separates the stem from all other tree stems,
2. The diameter of the stem must be >25% the diameter of the largest stem,
3. The angle of the stem must be <45 degrees from the main stem in the clump.

In rare cases an apparent clump of trees may be formed by the germination of seeds by existing whitebark pine (Figure 9.13). If a large, dead whitebark pine is found in an apparent clump with young healthy whitebark pine, the dead tree should not be included in the same clump as the young trees if it is suspected that the live trees germinated after the dead tree.

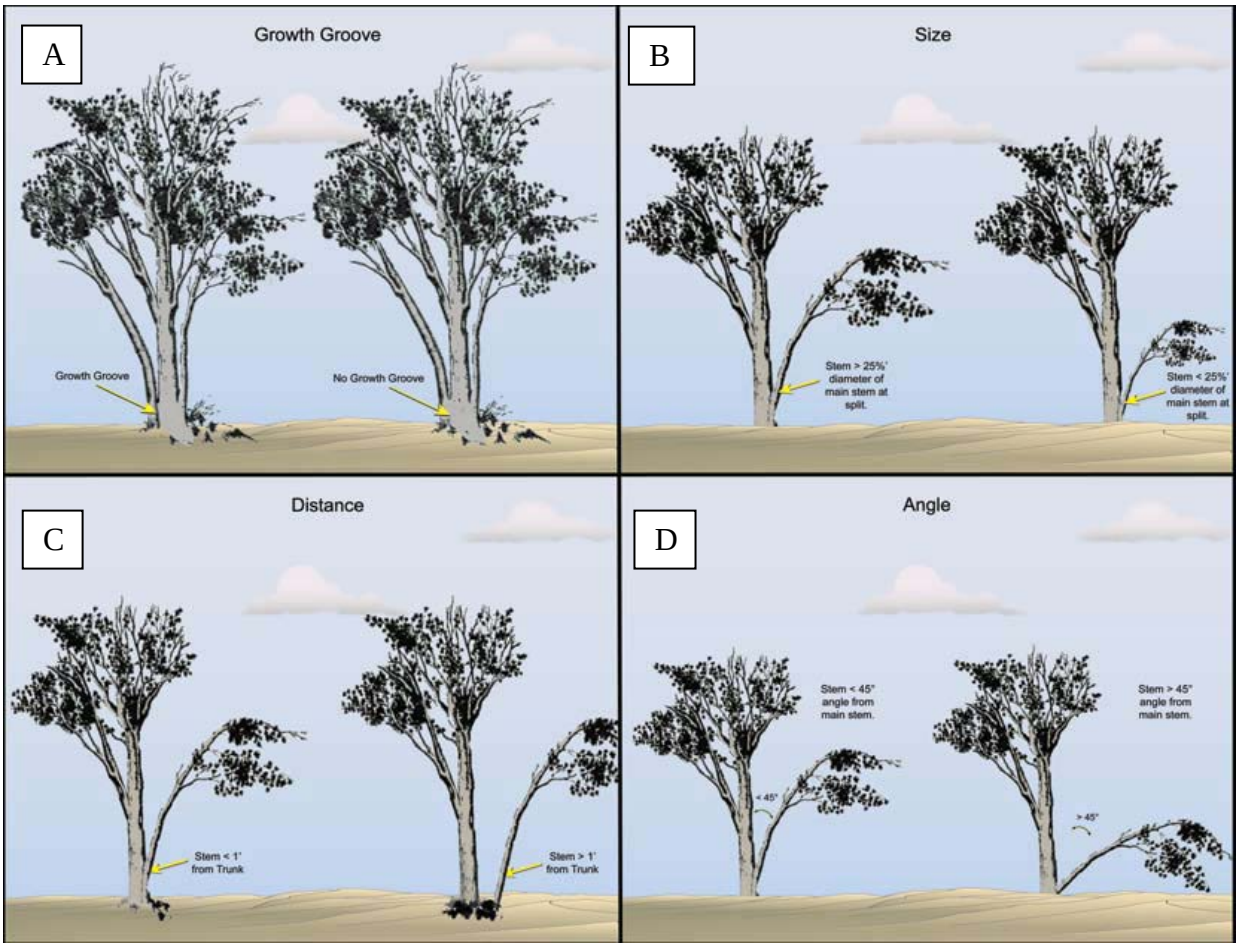


Figure 9.12. Diagram of criteria by which potential tree in a clump is determined to be a tree. The small stems on the left side in frames A, B, and D are considered trees in a clump while the small stems on the right side of the frames are branches. In frame C the small stem on the left side of the frame is considered a tree in a clump, while the small stem on the right side is an individual tree due to its distance from the other whitebark pine trees (Adapted from Greater Yellowstone Whitebark Pine Monitoring Working Group 2007).

Figure 9.13. Photograph of a whitebark pine sapling (right) growing next to a larger dead whitebark pine (left). These two trees are not considered a clump as it is presumed that the whitebark pine sapling germinated well after the larger whitebark pine (Photo credit: Mike Buffo, NPS).

Dist (m): Data entered for whitebark pine only.

Record the distance from plot center to the germination point of each whitebark pine in meters. Measurements should be taken to the nearest 1.0 cm. Measurements can be taken with a tape measure or a laser range finder, though a laser range finder is preferred.

If a laser range finder is used, the instrument should be set to horizontal distance, not slope distance. The measurement should be taken from directly over plot center to a point to the bole of the tree. If it is not possible to get a completely clear view of the tree bole one surveyor should hold a reflector next to the bole of the tree.

If it is not possible to use the laser range finder to measure the distance to each tree a tape measure can be used. Try to get a measurement of true horizontal distance (i.e., slope corrected), if possible.

Azimuth: Record the azimuth (degrees) to each tree. Be sure to account for declination (see **SOP 4: Orientation and Training for Field Crews).**

L, D, or M (live, dead, or missing): Indicate if tree is alive or dead. On repeat visits, if you cannot locate a whitebark pine tree, write M for missing. If tags are missing, replace the tag and record the new tag number on the Tree Data Sheet and on the Event Log.

Dbh cm: Measure diameter at breast height (1.37 m) for each tree using a metric dbh tape. Breast height is measured from the point of germination (Figure 9.14).

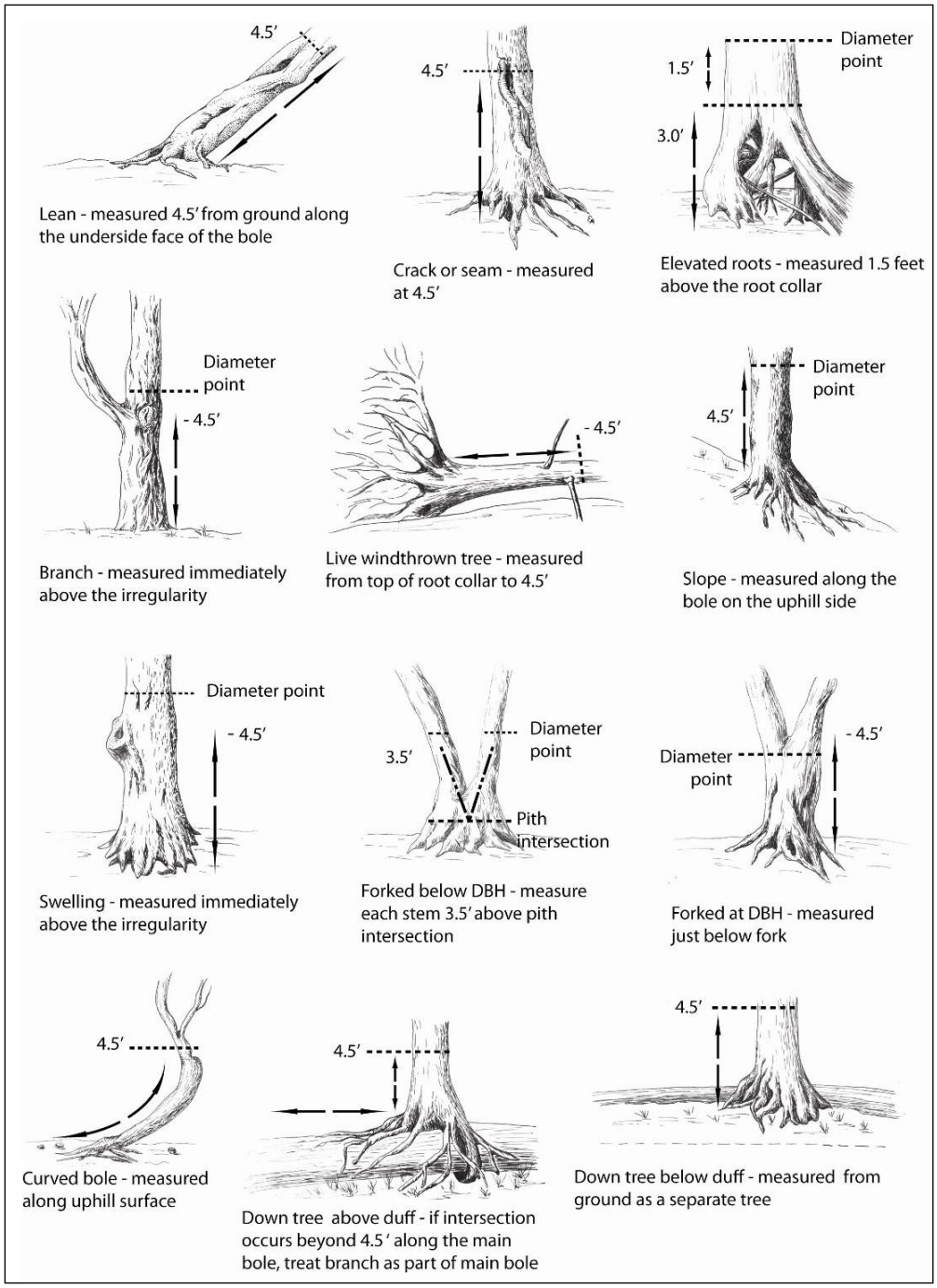


Figure 9.14. Illustration of location where dbh should be measured for various bole architectures. (Evelyn Greiner, NPS).

Height (m): Estimated height from the ground to the topmost foliage. If a tree is leaning **do not** measure along the length of the stem. Measure the tree from the ground from the point of germination vertically to the topmost vegetation.

Bole cankers: Indicate the presence or absence of white pine blister rust on the bole of each whitebark pine tree using the categories listed in Table 9.4. Figure 9.15 shows an active blister rust canker on a whitebark pine. If canker status is unknown make a note of the tree tag number and the reason the status is unknown.

Table 9.4. White pine blister rust status and codes for use in assessing bole and branch cankers on whitebark pine.

White pine blister rust status	Code
None (no cankers present)	N
Active (orange blisters present)	A
Inactive (no orange blisters; localized bark damage apparent)	I
Uncertain	U

Figure 9.15. Photograph of active white pine blister rust canker on the bole of a whitebark pine tree (Photo credit: NPS).

Branch cankers: Indicate the presence or absence of white pine blister rust on one or more branches of each whitebark pine tree using the categories in Table 9.4.

Crown kill (%): Indicate percent of total crown of whitebark pine trees that is dead.

Cones (Y or N): This field includes three subfields. The first subfield is for number of mature cones on whitebark pine trees (Figure 9.16). The second subfield is for the number of first year cones (Figure 9.17). The third subfield is for the number of pollen cones (Figure 9.18). In each

subfield, circle Y or N (yes or no) to indicate presence and write the number of cones if present. Note that one tree may have all cone types.

Figure 9.16. Photograph of mature whitebark pine cones (Photo credit: Lisa Landenberger, USGS).

Figure 9.17. Photograph of first year mature whitebark pine cones (Photo credit: Richard Sniezko, USFS).

Figure 9.18. Photograph of whitebark pine pollen cones (Photo credit: Karla Sartor, NPS).

Mt pine beetle (Y or N): Indicate if evidence of mountain pine beetle is present on each whitebark pine. Mountain pine beetle infestation can be identified by small popcorn-shaped masses called pitch tubes, the presence of live mountain pine beetles, and the presence of J-shaped galleries under the bark. These galleries are best seen in places where the bark as sloughed off (Figure 9.19).

Figure 9.19. Mountain pine beetle galleries in the bole of a whitebark pine tree (Photo credit: Connie Mehmel, USFS).

Browse or Gnawing: Indicate presence or absence of damage to bark or foliage by animals for each whitebark pine.

Fire scars: Indicated presence or absence of fires scars for each whitebark pine.

Mistletoe: Indicate presence or absence of mistletoe. If mistletoe is present fill out the next field.

If mistletoe is present, rate each 1/3 of tree canopy as 0, 1, or 2 for infection severity (Table 9.5).

Table 9.5. Rating (0-2) for each 1/3 of tree crown following Hawksworth 1977 (Hoffman 2004).

Rating	Description
0	No visible infections
1	Light infection, ½ or less of total number of branches in the third infected
2	Heavy infection, more than ½ of total number of branches in the third infected

Literature Cited

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2007. Interagency whitebark pine monitoring protocol for the Greater Yellowstone Ecosystem, Version 1.00. Greater Yellowstone Coordinating Committee, Bozeman, MT.

Hawksworth, F. G. 1977. The 6-class dwarf mistletoe rating system. USDA Forest Service General Technical Report RM-48. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO.

Hoffman, J. T. 2004. Dwarf mistletoe management. USDA Forest Service Rocky Mountain Research Station General Technical Report GTR-98. Ogden, UT.

SOP 10: Monitoring Legacy Alpine Vegetation Plots

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP contains instructions for monitoring legacy alpine vegetation plots established at MORA in 1983-1984 (Edwards 1985). These procedures follow those described in Edwards (1985) and were originally designed for a survey team with basic ecological expertise under the supervision of a trained ecologist. Edwards subdivided the alpine zone for sampling, in order of decreasing scale, into 'localities', 'sampling areas', 'permanent plots', and 'quadrats'. She established permanent plots in four localities within the park: Muir Snowfield, Ptarmigan Ridge, Mount Ruth, and Curtis Ridge. Within each locality, there were sampling areas, and finally permanent plots. Boundaries of sampling areas were not delineated on maps or by description and were difficult to recreate, so this level of plot description will not be utilized. The term permanent plot was often used synonymously with transect and each had 5-20 quadrats or subplots (Table 10.1). This SOP follows that convention for plot identification purposes except that it does not reference the 'sampling areas' as these were not well defined.

Table 10.1. List of Edwards' plots by locality.

Locality	Permanent plot	Elevation (m)	Number of Quadrats
Muir	1	2256	10
	2	2304	20
	3	2646	20
	4	2379	20
	5	2433	20
	6	2149	20
	7	2048	20
	8	2076	20
	11	1953	20
	12	2646	5
Ptarmigan Ridge	9	2146	20
Curtis Ridge	10	2292	20
Mount Ruth	13	2744	20

Monitoring the legacy alpine plots consists of the following activities:

- Relocating the permanent plots in the field
- Re-marking the permanent plots and quadrat locations, if necessary

- Recording and sketching plant and substrate cover values for each quadrat
- Photo-documenting the sites:
  - To assist with permanent plot relocation on future visits and to locate the transect endpoints
  - To portray exact plant and substrate cover in the quadrats to augment information on the quadrat sketch maps and to facilitate recognition of changes in plant and substrate cover in the quadrats

Equipment and Supplies

- Legacy Alpine Vegetation Plot Monitoring Forms: Vegetation Cover and Sketch Maps of Quadrats
- Measuring tape (100 m)
- Metal pencil rod (rebar), 3/8" diameter cut into 50 cm lengths
- Vice grips to hold cut rod
- Paint, permanent outdoor orange (not spray paint)
- Paint applicator, foam-tipped
- Compass
- Altimeter
- Digital camera, spare batteries
- Quadrat frame, PVC pipe and elastic cord
- File cards or white board and markers
- GPS unit, spare batteries if applicable
- Radio, spare batteries

Relocating Permanent Plots

The Project Lead will consult with the GIS Specialist to make maps of the permanent plot locations and to have the coordinates of the plots loaded onto a GPS unit so that the field crew can navigate to them. Historic data field forms may also assist with descriptions of where the plots are located and can be photocopied to take into the field. The Field Lead should check with the Project Lead to see what historic forms and maps are available.

Re-marking Permanent Plots

If the start or end of a transect ('anchor points') or if any of the 20 quadrat locations along a given transect needs to be re-marked with a permanent marking system, the metal pencil rod and orange paint will be used. The anchor points for the transect should be conspicuous enough to be seen in the photographs yet out of public view to avoid vandalism. These are installed by making a paint patch on a large, deep-set boulder or rock outcrop, as close to the transect start or end as possible. The paint patch should be roughly 15 cm above the ground. As close to the paint patch as possible, pound the metal rod into the ground as far as possible and cut off any surplus at 30 cm above the ground.

Most quadrats were originally established on the left side of the transect as the observer faced up-slope towards the summit of Mt. Rainier. Quadrat locations should be marked at the down-

slope corner that is along the transect, thus usually the lower left corner as one faces the quadrat. Mark the quadrat location by driving a 50 cm metal rod into the soil and paint the end. If it is impossible to sink the rod into the ground at that corner, try another corner and be sure to record this position on the Sketch Map of Quadrats Field Form (Figure 10.4).

Recording Quadrat Data

Completing the Legacy Alpine Vegetation Monitoring Form

Park: Enter the park code. This is primarily for situations where additional legacy plots from other projects/parks have been added for monitoring.

Locality: Enter the name of the locality as assigned by Edwards (1985).

Permanent Plot No.: Enter the number of the plot.

Date: The month, day, and year that the plot was set up and established.

Sheet #: Enter the sheet number and total number of sheets for this plot.

Observers: Enter the first and last name of all observers

Recorder: Enter the first and last name of the recorder.

Species Cover: Cover values are best determined in mid-summer (July-August) when all species have attained maximum canopy coverage. The quadrat frame should be subdivided into 25 sub-squares to facilitate the estimation of percent cover, i.e., it is easier to estimate the cover in each sub-square and then sum the values than estimating cover for the entire quadrat. All cover values are estimated to the nearest 1% (¼ of a sub-square). First, estimate the cover of six broad cover types within each quadrat: rock (large enough so as not to be moved by meltwater), gravel, bare soil, litter and dead plants, moss and lichen, and vascular plants (Figure 10.3). Assume the six cover types are in one plane; the total of the six broad cover types must add up to 100%. Where a plant overlaps a rock, gravel, or bare soil, count the cover as plant and do not estimate rock or soil cover. Next, count the number of seedlings in the quadrat.

Last, estimate the cover for each vascular plant species as if a polygon was drawn around the canopy of each plant. Once again, assume the plant canopy lies in a single plane and do not lift up a plant and estimate canopy cover of species found under the highest canopy. Record the cover of each species with the quadrat and then sum the covers of all species and insure that total equals the total of the vascular plant cover for the quadrat recorded previously.

Sketch Maps of Quadrats Field Form

The sketch maps are made to accompany the quadrat photographs and serve to identify individual plants and other cover components in the photographs (Figure 10.4). This information may assist in future quadrat relocation if corner markers are missing. The sketches should show the exact position of individual plants, rocks, and the intervening gravel, sand, litter, moss, etc. This may be challenging where several species grow intermingled, as in heath communities; the

use of an ID code for each species facilitates recording them all. In the lower right area of the data form is the field "Plant species and other cover component IDs." This space is reserved to write a key to the plant species and other cover component IDs used in the quadrat diagrams.

Two sheets of the data form are needed to complete all 20 quadrats (10 quadrats per page). The sub-squares on each quadrat sketch map correspond to those of the quadrat frame.

Place and asterisk (*) in the appropriate corner of each quadrat to record the position of the permanent marker rod, normally the lower left (down-slope) corner as one faces the quadrat.

Photo-documentation

Photographs are used to indicate the general vicinity of a plot and to document cover in each quadrat. For plot orientation, try to orient the view-frame to show the site aligned with distinctive features such as well-known landmarks or easily recognizable skylines (Figure 10.1). While up-slope photos are typically the most helpful, taking a down-slope photo can capture additional distinguishing features.

Figure 10.1. View of north end of permanent plot 3 showing orientation of transect with respect to skyline.

Photographs are also taken of each quadrat. These photos can be used to visualize cover changes in the quadrats, but are also helpful in relocating the quadrat if the rebar has been removed. Each photo should include a file card or whiteboard with the locality, permanent plot number, quadrat

number and date. The photographer should try to take the photo looking directly down on the quadrat (i.e., not obliquely), fill most of the frame with the quadrat, and take the photo without any shadows (Figure 10.2).

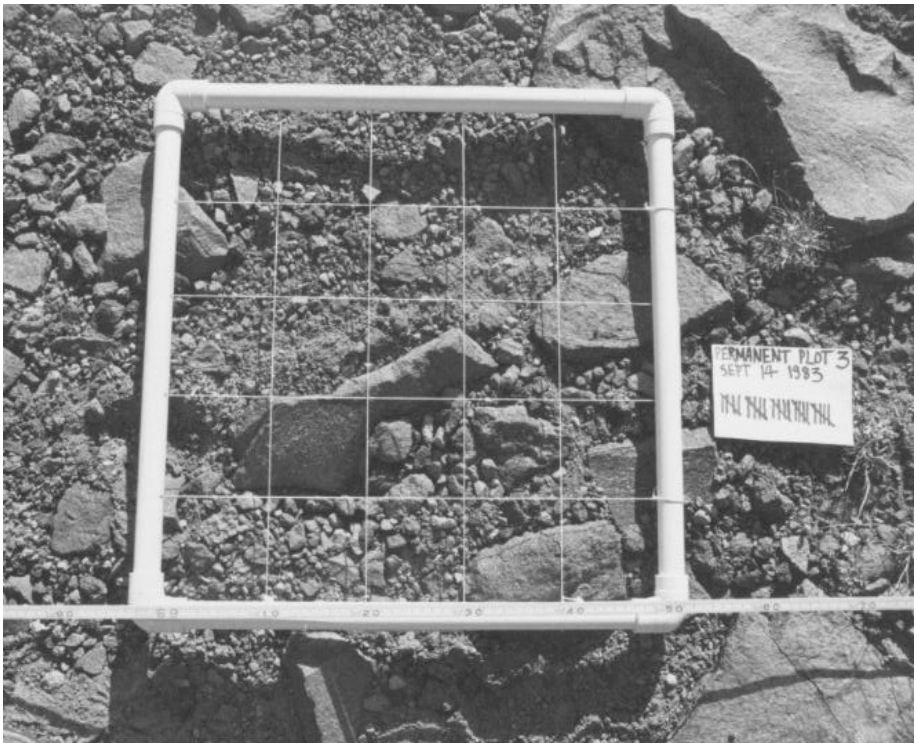


Figure 10.2. Quadrat photographs of Muir locality, permanent plot 3, quadrat 25 in 1983 and 2008. Note the rocks at the center have not moved between dates, but gravel, bare soil, and plant cover has changed.

Office use only (use initials and mm/dd/yy)
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

Legacy Alpine Vegetation Plot Monitoring Form – Vegetation Cover

Park: _____ Locality: _____ Permanent Plot No. _____
Date (mm/dd/yy): _____ Sheet #: ____of_____
Observers: _____ Recorder: _____

Quadrat No.	1	2	3	4	5	6	7	8	9	10
Distance from origin (m)										
Cover (%)										
stone										
gravel										
bare soil										
litter and dead										
moss and lichen										
vascular plants										
Seedlings (no.)										
Vascular Plant Cover by Species (to nearest 1%)										

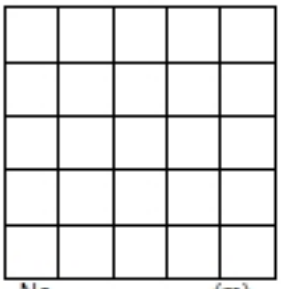
Species in plot but not in quadrats: _____
_____
_____

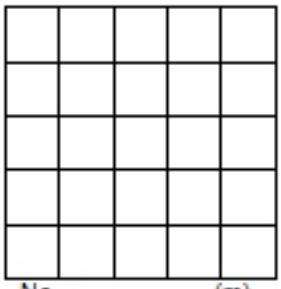
Comments: _____
_____
_____

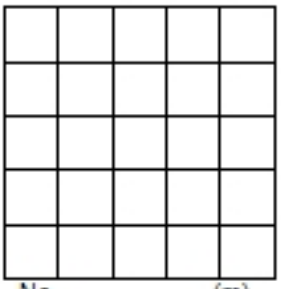
Figure 10.3. Legacy Alpine Vegetation Monitoring Data Form: Vegetation Cover.

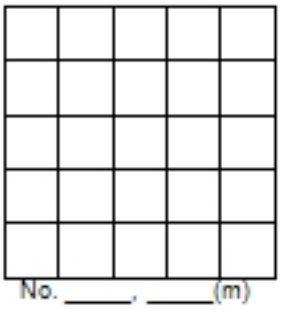
Legacy Alpine Vegetation Plot Monitoring Form – Sketch Maps of Quadrats

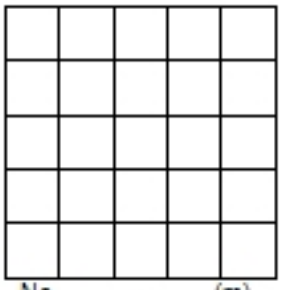
Park: _____ Locality: _____ Permanent Plot No. _____
Date (mm/dd/yy): _____ Sheet #: ____of_____
Observers: _____ Recorder: _____

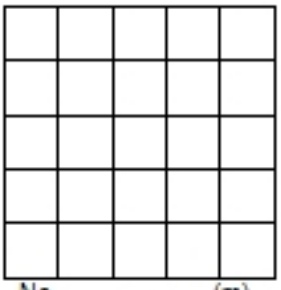

No. _____, _____(m)

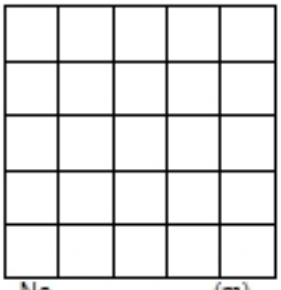

No. _____, _____(m)

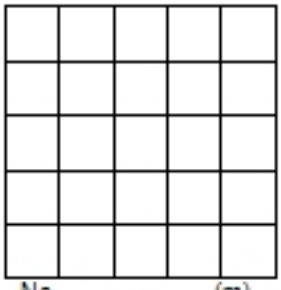

No. _____, _____(m)

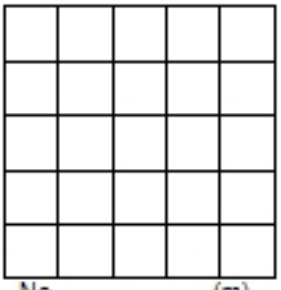

No. _____, _____(m)

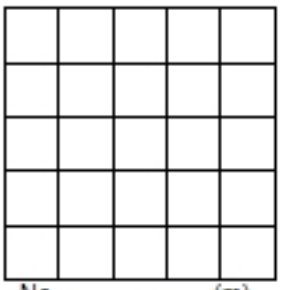

No. _____, _____(m)


No. _____, _____(m)


No. _____, _____(m)


No. _____, _____(m)


No. _____, _____(m)


No. _____, _____(m)

Plant species and other cover component IDs:

Figure 10.4. Legacy Alpine Vegetation Monitoring Data Form: Sketch Map of Quadrats.

Literature Cited

Edwards, O. 1985. Human impact on the alpine ecosystem of Mount Rainier. Final Report submitted to Mount Rainier National Park. University of Washington, Seattle, WA.

SOP 11: Collecting Plant Voucher Specimens

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

Herbarium specimens provide a permanent physical record of the plant species occurring at the sampling locations. It is an essential component of recording plant identification and can be helpful in documenting distribution of plant species and timing of flowering, fruiting and seed set. Specimens, housed in each park's herbarium, will become a resource for future field crews and researchers

These guidelines will ensure that minimum standards must will be observed so that the specimens can be identified and also be of lasting scientific value.

Methods

When and Where to Collect

Voucher specimens of all unknown or problematic plants observed in or around the plot will be collected at the time the plot is installed. Specimens should be collected outside the plot following guidelines described below. The voucher will serve as a record of the species present in the plot at the time of monitoring and can be used to train crew members on prior to field surveys. Addition specimens will be collected when new species are encountered in subsequent sampling events.

How to Collect

Look for plants with well-developed flowers and/or fruits. The taxonomy of vascular plants is based on complete and mature specimens. The exceptions are trees and shrubs, which generally can be determined from mature leaf and stem structures alone. Take plants that are representative of the population you are sampling. Ideally, to the extent possible, the appearance of the finished specimen should look like the living plant. It is important to include all parts of the plant that are required for identification. Whenever possible, entire plants should be collected. Remember that mature fruits are needed for grass, sedge, rush and Umbelliferae species. Flowers and fruits are generally essential, but for many species, basal leaves and roots are needed for identification as well. Whenever possible, show the upper and lower surfaces of leaves, and dissect flowers to reveal all parts. Remove as much soil from the roots as possible prior to pressing the specimen.

Do not collect specimens from the monitoring plot. Use the 1 in 20 rule as follows. Survey the area; if there are at least 20 plants of the species, a collection can be made. If there are insufficient numbers in the population, take a photo or try to locate more individuals in other localities.

Voucher specimens are placed on a single sheet of newspaper to be pressed. Collections should fill the newspaper page. Plants that are too large may need to be cut into sections and placed on multiple sheets and will be considered a single collection. Make sure to retain at least a representative leaf with petiole and short section of attached stem, the inflorescence, and the stem base with a portion of the root. In the case of small plants, enough specimens should be collected to cover the newspaper page. Trees, shrubs and vines only need representative portions collected. Fleshy fruits, leaves and roots can be difficult to dry; these maybe sliced into two or more sections prior to placement on the page. Cones or large dry fruits are not pressed but tagged with the same collection number as the vegetative portions of the collected plant.

A pocket knife is adequate for collecting portions of trees, shrubs, and large herbs. For roots of plant, a more substantial tool maybe required such as a trowel or hori hori knife.

Plant presses may be taken to the field; however, when backpacking, the weight and size of a press may be unmanageable. Specimens should be collected at the end of the day for day trips and on the last day, if possible, of a multi-day trip. Plants collected in the field can be placed in ziplock bags or small, rigid, Tupperware-like plastic boxes. If the plants are collected in plastic bags, blowing air into the bag prior to sealing it can help protect delicate plant parts; the air will act as a cushion and offer some protection against damage while in a backpack.

Press specimens as soon as possible, either at the vehicle or as soon as you return to the office. Refrigerate specimens if it is impossible to press them the day the crew has returned from the field.

Documentation

The scientific value of specimens depends on the specimen and on the data you record when making the collection. It is important to adopt a system to ensure that the data for each specimen are recorded fully and consistently. Remember that these notes must be intelligible to another worker who may be processing your plants later on. If you are collecting just a few plants, you may write all the field notes directly on the newspaper in which the plant is pressed. Preferably, every collector should keep a pocket-sized field notebook in which he or she records each collection. Do not mix different species of plants on a sheet.

Each specimen should be assigned a unique field collection number to link the recorded collection data with the pressed specimen. The field collection number should have three components: *collector's last name – year – number.* The first collection of the season, for each collector, should be 01 and each successive collection number should proceed consecutively so that each collection has a unique number. Assign a new collection number to each specimen from a single locality on any one day. If the same species is collected on the same day, but at a different locality, assign it a different collection number. If the same species is collected again at the same location as before, but on a different day, give it a different collection number also.

Essential data include where (general and specific locality, general and specific habitat, elevation), when (day, month, year), and by whom collected (your name). Additional information may include exposure (N, S, E, W), slope angle (flat, gentle, steep), soil texture (gravel, sand, loam) and moisture (wet, moist, dry), flower color (some blossoms fade with drying, some colors intensify), odor, relative abundance (abundant, common, infrequent, rare), and associated species. A page of your field notebook may look like this:

Species: Erigeron salishii
Field collection number: Bivin 2012-06
Site: Black Peak
Date: 8-08-1984
Location: Growing on granite cliffs about 3 m from a way-trail on the south slope of Black Peak.
UTM: (note: be sure to include datum)
Elevation: 6800'
Slope: (note: be sure to record whether in degrees or percent)
Aspect: (in degrees)
Associated species: *Carex brevicaulis, Erigeron composites, Sedum stenopetalum, Penstemon davidsonii,* and *Polemonium viscosumum*.

Additional information to document in the notebook includes: Size of the population, either by square meters, acres or numbers of individuals per unit area, who collected it, and any other pertinent information.

When pressing the specimens, the collection number is placed on the sheet of newspaper containing the specimens, which relates those specimens back to the data in your notebook. Ideally, this field notebook becomes part of the permanently curated collection.

Specimen Preservation

Place the fresh specimens in a sheet of folded newspaper. When folded, the size of the paper should conform to the size of the plant press, blotters, and cardboard ventilators. The dried specimens will be mounted on a sheet of herbarium paper a bit smaller than the folded newspaper, thus each newspaper sheet of specimens equals a minimum of one finished herbarium sheet.

A little extra time taken while pressing plants will make a critical difference in the quality of the herbarium specimens. Lay out the plant(s) in a natural looking shape. Bend or fold the stems into V or N shapes as necessary to fit the plants within the folded sheet of newspaper. Be certain that both leaf surfaces are exposed and flower/fruit parts are clearly visible, i.e., not covered by stems or leaves.

When placing several small plants in a sheet of newspaper, arrange them so they do not overlap. In essence, attempt to display all diagnostic features so they will show after the plant has been dried and firmly glued to a herbarium sheet. Cut open thick, moist stems, rootstocks, dense cushions, etc., so the specimens will be flatter and dry more quickly. A deep longitudinal cut will allow you to expose the inner portions of both halves of thick roots and stems with the uncut portion serving as a hinge.

Place each sheet of specimens between two botanical blotters and these in turn between two cardboard ventilators. Repeat this arrangement until all the specimens have been processed. Tie the press tightly with straps or rope. Place the press in the sun where it will be exposed to breezes or over a source of gentle heat.

Dry the plants as quickly as possible. Dried correctly, the specimens retain much of their original color. The best practice is to check your press every day to determine progress and to remove dry plants. Be alert for signs of mold or darkening plant tissues; the appearance of either of these means the plants are drying too slowly and a heat source is called for. You can increase the rate of drying by exchanging wet blotters for dry ones (the first change after 24 hours), using extra cardboard, and putting the thicker and more succulent specimens toward the outside of the press.

Mounting of specimens

Herbarium specimens are mounted on archival (acid free, pH neutral) paper. The dried voucher is mounted on an 11.5” x 15.5” sheet of herbarium paper. The specimen is glued to the paper with archival quality glue or taped with archival tape. Seeds or plant parts that have come loose from the specimen can be attached to the voucher in small packets which are glued or taped to the herbarium sheet. Care should be taken to avoid obscuring plant structures that may be critical for identification.

SOP 12: Recording Plot Visit Details and Taking Digital Photos: Event Log

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides directions for recording information on visits to permanent plots for data collection. Information recorded includes logistics, recent disturbances, status of measurement tasks, and photo-documentation. The data form for this purpose is referred to as the 'Event Log' (see Figures 12.1, 12.2).

Completing the Event Log

Identification and Location

Park: The four-letter code for the park where the plot is located (MORA, NOCA, or OLYM).

Plot No: Enter a five digit plot code _ - _ _ _ _. The code is created by using:

- One-letter code indicating the park (e.g. "M" for MORA).
- Four digit plot number: the original GRTS firing-order number given to that location prior to reconnaissance.
- For example, M-0156 indicates this is a plot selected at MORA and it is the 156th point in the GRTS firing order.

Site name: A local name that describes the area where the plot lies, usually something easily found on a map such as the name of a creek, a crossing, a ranger station etc. This site name will be created upon plot establishment.

Date: Enter the date the sampling occurred (MM/DD/YYYY).

Declination: The magnetic declination or angle (degrees) that must be added or subtracted from an azimuth to convert between the needle direction on a compass (magnetic north) and longitude (true north). See **SOP 4: Orientation and Training of Field Crews**, for more information.

Routine visit: If this is a routine visit to the site circle Y (yes). If the visit is prompted by an event such as a fire or avalanche, circle N (no) and note the reason for the visit.

Crew: Enter the last names and first initials of all crew members that are part of this sampling event.

Directions to plot: First determine if the directions in the Navigation Report are adequate. If so, check the box for "No change (same as previous)" and leave the field blank. If no directions exist, or if the existing directions are not adequate, check the box for "Replace/New" and provide detailed directions as follows. Start from a road, known trailhead, or other mapped landmark. Include distances traveled in meters or to the nearest 0.1 miles and record compass direction. Keep in mind that an entirely new crew may be returning to the plot in future sampling events. For challenging routes, consider including GPS locations on a marked map in a separate trip report. Include key information such as river crossings, trail junctions, and additional helpful information. If the existing directions are useful, you may still wish to add to or revise them (check the appropriate box and update as needed).

Task list: Plot needs, special instructions, or adjustments to consider before plot revisit. These notes will be printed in the Navigation Report to review and take in the field when revisiting a plot. This may include, for example, notes about bringing rebars that are missing or a need for tree tags.

Weather conditions: Briefly describe the weather conditions during the sampling event (clear skies, overcast, rain, snow, freezing, high winds, foggy). Weather can affect the plot environment as well as the performance and endurance of the crew. Knowing the weather conditions may help to explain why certain decisions or observations were made.

Logistical problems: List any logistical problems here. These notes will help future crews prepare for visits to this plot. Also, it may be possible for some problems to be addressed back in the office with the help of supervisors.

<u>Task check list</u>

Complete this section while in the field and indicate if the following data were collected (circle Y or N for each type of data). This information becomes part of the Navigation Report that is printed and taken to the plot during each return visit. **Note**: Circle Y only if task was completed.

Whitebark Pine plots:

- *Tree measurements*: Indicate if tree diameters were measured and associated data were collected.
- *Whitebark pine seedlings and saplings*: Indicate whether all of the seedling and sapling measurements were made.
- *Mortality data and infection rates*: Indicate whether mortality and infection rate data were collected.
- *Mountain pine beetle*: Indicate whether trees were inspected for mountain pine beetle infestation, and checked for bore holes, frass, and/or pitch tubes.

- *Understory cover vegetation data*: Indicate whether the understory vegetation data were recorded.

- *Tree tags replaced*: Indicate if any tree tags were replaced (Y/N). Tags may need to be replaced if they are missing, damaged, or if a mistake was made in the numbering system. The tags are first replaced with a temporary aluminum tag that can be written on in pencil and may be replaced with a permanent aluminum tag on the next visit. Use the original tree number. Use the tree stem map and tree size and species data to verify the tree identity. Write the tag number(s) replaced.

- *Tree tags added*: Indicate if any tree tags were added to the plot (Y/N). Trees that were missed initially or that have grown to qualifying size will need to be tagged in subsequent years. Write the tag number(s) added.

Subalpine/Alpine Plots:

- *Tree cover in alpine/subalpine plots*: Indicate whether the tree cover was documented.

- *Quadrats monitored*: Indicate whether quadrats were monitored. For quadrats in plots that were not monitored, be sure to record why in the Significant Events field if relevant.

Whitebark Pine and Alpine/Subalpine plots:

- *Plot diagram*: Each visit a diagram of the plot (and each quadrat for alpine/subalpine plots) will be completed. Indicate whether the plot diagram was completed (Y/N) and if not, or only partially complete, state the reason. The plot diagram should be scanned back in the office. Enter the scanned image file name in the space provided.

- *Rebar replaced*: Indicate if any stakes were replaced (Y/N). Write in the stake number for those replaced. Stakes may need to be replaced if they are missing.

- *Improved GPS coordinates*: Indicate if new GPS coordinates were collected for the plot (Y/N). If yes, write the GPS file name in the space provided.

- *Observed changes to plot*: Notes regarding changes that have occurred to the plot may be recorded here.

- *Evidence of animals*: Describe animal evidence that has been observed in the plot. Include trails, tracks, herbivory, scat, hair, burrowing, bones or antlers.

- *Significant events*: Use this space to record sightings of rare or exotic species, severe weather, lightening, snow cover (% of plot), or other significant events.

- *Disturbance indicators since last visit*: Use this space to indicate new indicators of disturbance that have been observed in the plot. Include fire, wind throw, avalanche, and rock slides.

<u>Data Loggers details</u>

For each logger location (C, N, S, E, and W), record whether a data logger was installed and/or retrieved (Y/N) and the time of the action. The 'Notes' field is used to record any problems or observations that may influence data quality. The 'File name' field is to be completed in the office after data download.

Photo Documenting Permanent Plots and Establishing Photo points

The crew photographer should take all photos as outlined in the Photos tables on the data form. These photos are taken during each field visit. However, photos of diseased vegetation, landscape disturbances, or wildlife evidence can help clarify a written observation, and the crew is encouraged to photo-document these and other plot observations. These photos should be recorded in the Optional Photos log.

Photo-documentation provides the following benefits to the project:

1. A graphical depiction of aspects of the vegetation and the landscape context of each plot – a snapshot in time.
2. A graphical depiction of any nearby features that might prove significant in understanding changes that could occur within a plot, such as ecotones, potential sources of disturbance, and conspicuous landmarks.
3. Once out of the field, plot photographs allow us a way to 'revisit' a plot if questions arise during data entry or analysis.
4. A method to actually analyze and graphically display apparent changes in the vegetation cover of a plot – sometimes a picture will capture changes that have occurred when other measurements do not capture the change.

The following guidelines should be used to insure that photos are comparable from year to year:

1. All photos should be taken horizontally or landscape view.
2. Photo point data sheets should be filled out each field visit. When planning a field visit, data sheets from the previous year should be copied and taken to the field to provide reference material for the current year's visit. In addition, field crews will take copies of the original photo point documentation including copies of photos and any maps of photo point locations.
3. The time of day, camera type, focus distance, compass bearing, and height of camera above the ground should be recorded.
4. Each photo location should be recorded on the data sheet
5. If a reference point is needed, the distance, azimuth, and description of the reference point will be recorded. If no reference point is needed, record on the data sheet.
6. Locations of photo points and reference points will be recorded with GPS and marked on an aerial photo (NAIP imagery).
7. Each photo point will be given an identification name and number to be used throughout the duration of the monitoring.
8. Download the raw, unedited images from the camera into the new folder.
9. Delete photographs of poor quality – e.g., out of focus, light levels, etc. Low quality photographs might be retained if the subject is highly unique, or the photo is an irreplaceable data photo.

One technician will be assigned the lead role for photo-documentation. Often other technicians will shoot some of the required photos, but the lead technician for this role is responsible for ensuring that all required photos are taken, and any good photo opportunities to illustrate the plot condition or landscape are utilized. The lead technician should become familiar with the camera manual and guidelines for downloading and processing images (**SOP 14: Managing Photographic Images**).

Responsibilities of the Lead Technician

The lead technician for the photo-documentation protocol will need to:

1. Become proficient in the operation and features of the digital camera prior to going into the field, and must be skilled at the following functions of the camera: image resolution, image file size, zoom or wide-angle capabilities, and the 'macro' feature.
2. Make sure that the data sheet is completely and correctly filled out, which is crucial to the photo-documentation process, and that any notes are entered into the project data base at the end of each tour.
3. Check that the correct date and time are entered in the camera.
4. Ensure that a sufficient number of charged batteries and storage cards are brought into the field each day.
5. Ensure that the equipment is well-cared for, and that the camera is stored in dry conditions during inclement weather.
6. Be familiar with the methods, hardware and software required to download the images following a trip.
7. Ensure that the images get correctly downloaded, copied, renamed, sorted, and entered into the database at the end of each tour, as described below.
8. Be responsible for recharging the batteries such that they will be ready for use during subsequent field excursions.
9. Make recommendations at the end of the field season about lessons learned and improvements to this procedure.

Guidelines for Shooting and Recording Photos

- *Before sampling*. Plot photos are taken before sampling the plot. It is essential that you take the plot photos before the measurements are made, so that images of the plot represent its most natural, undisturbed state.
- *Consider time of day*. On sunny days, earlier or later in the day is best. Photos should not be taken into the glaring sun.
- *Weather*. If it is raining, do not risk getting the camera wet to take photos. Take advantage of any break in the rain to get images of the site.
- *Position*. Take photo from a standing position.
- *Resolution*. Use a medium resolution format for photos. The typical file size of photos ranges between 400 KB – 1 MB. Rarely will you need to store images in the highest resolution format for routine photo-documentation. Most often, field excursions last for eight days, and you must not exceed the storage capacity for images. There should be storage capacity for the required photos for three plots, at 25 photos per plot, plus room for additional photos. See **SOP 14: Managing Photographic Images**, for more details.

- *Photo #*. Every photo that is taken must be recorded on the data sheet. The camera automatically assigns a number to each image. Record this number beside the photo code on the data sheet. If the photo is not represented by a code, write an abbreviated description of the view being photographed. Avoid deleting images in the field. If you delete a photo for any reason, record it as a deleted image next to the associated number, so that all numbers in the sequence are accounted for. The camera will display two different numbers for each photograph: an identification number (i.e., 100_498.jpg) and a number relative to the total number of images stored on the camera (43/95). It is important that you record the identification number, as the first number will be the file name that appears when downloaded while the second number will change if images are deleted and will not appear when images are uploaded.
- *Description of view*. Briefly describe the image view. For example, "Large boulder upper left, small mountain hemlock to right of plot." This will help identify the photo if a mix-up occurs.
- *Image file name*. This is the file name that will be given to the image back in the office. The file name view type and extension (example: "___-_-__-Q3.jpg") is already populated on the Event Log for each photo.

<u>Alpine/Subalpine photos:</u>

For each alpine or subalpine plot, a photo of each quadrat within the plot and two plot overview photos (of the entire plot) will be taken on each monitoring visit to the plot. Total number of required photos is 22, and the views are described below. The first field, 'Quadrat #', of the Alpine/Subalpine section of the Photos table in the Event Log is already populated with the 20 quadrat numbers and two plot overviews. For each of these views, record the photo number and the description of the view in the corresponding fields in the Photos table.

The field 'Image file name' in the Photos table is to be completed in the office after photos are downloaded and renamed as needed (see **SOP 14: Managing Photographic Images**). However, filling in the park code, panel, and plot # on the Even Log, at least for the first photo, will help facilitate image naming back in the office.

- Photos of each quadrat should be taken from directly above and a file card or dry erase board with the date and name of the park, plot and quadrat number and the photographer's initials should be visible. To avoid taking a photo with the photographer's shadow, you may have to stand in a different spot for different photos. Be certain that the file card or dry erase board is situated so that it is right side up from the perspective of an observer standing on the south side of the quadrat. Since we are using digital cameras, you can rotate the image when you down-load it in the office.

6/3/12 **MORA** **A1-003** **Quad. 1** **L.G.**

- Two photos of the entire alpine or subalpine plot should be taken. These photos should capture the plot in context of the larger setting. The first overall view of the plot should

be taken from the south looking north. The distance and azimuths from the photopoint to the plot's SW and SE corner rebars should be recorded on the monitoring data form. A second plot overview photo will be taken from any of the other three sides (N, E, or W) of the plot, whichever best capture the vegetation physiognomic structure and features of the plot. Be sure to document distance and azimuth for this second photo to the two nearest plot corners on the monitoring data form as well. GPS points should be taken for both photopoints. This is described in more detail in **SOP 8: Establishing and Monitoring Alpine/Subalpine Vegetation Plots**.

Whitebark pine photos:

For whitebark pine plots, four reference photos are taken in each monitoring plot on each visit. The photographs are taken from the plot center and facing 0, 90, 180, and 270 degrees. The photograph should be taken in landscape view to best capture the overall stand structure in the context of the surrounding area. The first field, 'Azimuth', of the Alpine/Subalpine section of the Photos table in the Event Log is already populated with the four required bearings. For each azimuth, record the photo number and description of the view in the corresponding fields in the Photos table.

The field 'Image file name' in the Photos table is to be completed in the office after photos are downloaded and renamed as needed (see **SOP 14: Managing Photographic Images**). However, filling in the park code, panel, and plot # on the Even Log, at least for the first photo, will help facilitate image naming back in the office.

Optional (additional) photos:

Record the location, photo #, and a brief description of the view for each additional photo. Although these are not required, take photos if they help describe or clarify plot characteristics or work being conducted. Whenever possible, an object of known size should be placed in the photograph to provide scale. The field 'Image file name' is to be completed in the office after photos are downloaded and renamed as needed (see **SOP 14: Managing Photographic Images**).

1. If possible, take two to four photos at some distance from the plot showing the landscape context and vegetation mosaic in the vicinity of the plot. The distance and direction of these photographs will obviously depend upon what aspect gives the best overall picture of the area. Record aspect and position relative to the plot.
2. Take photos to illustrate interesting plant species, disease, or disturbance (for example, whitebark pine blister rust cankers or mountain pine beetle damage).
3. Occasionally photograph crew members and work in progress.

A GPS point can be recorded for photos taken far from the plot. Record in your notebook: the image number, a brief description of the subject, azimuth of the image (the direction you were facing when the image was taken), and the GPS file name.

Logistics Record

The logistics record is a very valuable tool for planning future plot visits. Fill this out at the end of each tour, before arriving back at the office. Estimate the number of hours spent on

transportation, hiking, and for each sampling activity. Indicate in the Notes column if planned data collection (including photos) was not completed. Record the total number of days devoted to the plot (including travel to and from the plot as well as time at the plot). Indicate any special transportation needs such as boating, ferrying, shuttling, or travel across the international border. Indicate whether the crew stayed at a campsite, ranger station, or in park housing, and the location. There is a space for notes to provide more detail on access and accommodation if needed.

Office use only *(use initials and mm/dd/yy)*
Entered by: _____ date: _____ Updated by: _____ date: _____
Verified by: _____ date: _____ Certified by: _____ date: _____

NCCN Alpine/Subalpine and Whitebark Pine Plot Event Log Form page 1

Identification and Location

Park: _____ Plot No. ___ - ___ ___ ___ ___ Site Name: _____
Date: (mm/dd/yy): _____ Declination (°): ____ Routine visit: Y/N If not, why? _____
Crew: _____ (*last name, first initial*)
Directions to plot (check one): ☐ No change (same as previous) ☐ Replace/New ☐ Add ☐ Revise

_____
_____
_____

Task list - Plot needs, special instructions, or adjustments to consider before next visit: _____
_____
_____
_____

Weather conditions _____

Logistical problems _____
_____

Task check list (circle Y only if task was completed)

Data collected	**Circle**		**Data collected**	**Circle**		
Tree measurements	Y	N	Tree tags replaced	Y	N	Tag #s replaced:
Seedlings and saplings	Y	N	Tree tags added	Y	N	Tag #s added:
Mortality and infection	Y	N	Tree cover in Alpine/Subalpine plots	Y	N	
Mountain pine beetle	Y	N	Quadrats monitored	Y	N	
Understory vegetation cover	Y	N	Plot diagram	Y	N	File name (*office*):
Rebar replaced	Y	N	Improved GPS coordinates	Y	N	GPS file name:
Notes (describe why any task above was not completed):						
Observed changes to plot:						
Evidence of animals (burrowing, browse, hair, bones, etc.):						
Significant events e.g., sightings of rare/exotic species, severe weather, lightning, snow cover (record % of plot) etc.:						
Disturbance indicators since last visit (fire, wind, avalanche, rock slide, etc.):						

Data Loggers details

Logger Location	Installed (Y/N)	Retrieved (Y/N)	Time (military)	Notes	Data file (*office*)
Center					
North corner					
South corner					
East corner					
West corner					

Special transportation needs: _____
Accommodation used (campsite, housing, ranger station): _____
Access and accommodation notes: _____

Figure 12.1. Plot Event Log Form, page 1.

NCCN Alpine/Subalpine and Whitebark Pine Plot Event Log Form page 2

Photos (see SOP 14: Managing Photographic Images for file naming convention)

Alpine/Subalpine plot			
Quadrat #	**Photo #**	**Description of view**	**Image file name** (*in office*) (Year_Park_Plot_quadrat.jpg)
Q1			_ _ _Q1.jpg
Q2			_ _ _Q2.jpg
Q3			_ _ _Q3.jpg
Q4			_ _ _Q4.jpg
Q5			_ _ _Q5.jpg
Q6			_ _ _Q6.jpg
Q7			_ _ _Q7.jpg
Q8			_ _ _Q8.jpg
Q9			_ _ _Q9.jpg
Q10			_ _ _Q10.jpg
Q11			_ _ _Q11.jpg
Q12			_ _ _Q12.jpg
Q13			_ _ _Q13.jpg
Q14			_ _ _Q14.jpg
Q15			_ _ _Q15.jpg
Q16			_ _ _Q16.jpg
Q17			_ _ _Q17.jpg
Q18			_ _ _Q18.jpg
Q19			_ _ _Q19.jpg
Q20			_ _ _Q20.jpg
Entire plot view 1			_ _ _V1.jpg
Entire plot view 2			_ _ _V2.jpg
Whitebark Pine plot			
Azimuth	**Photo #**	**Description of view**	**Image file name** (*in office*) (Year_Park_Plot_azimuth.jpg)
0˚(N)			_ _ _N.jpg
90˚(E)			_ _ _E.jpg
180˚(S)			_ _ _S.jpg
270˚(W)			_ _ _W.jpg
Optional photos			
Location	**Photo #**	**Description of view**	**Image file name** (*in office*)

Logistics Record - Fill out at end of each tour

Sampling event task	Time (hours)	# persons	Notes
Transportation office to trailhead			
Hike trailhead to campsite			
Hike campsite to plot			
Tree measurements			
Understory vegetation cover estimates			
Alpine/subalpine vegetation plot cover estimates			
Replacing data loggers			
Taking plot photos			
Hike campsite to trailhead			
Transportation trailhead to office			
TOTAL DAYS on plot			

Figure 12.2. Plot Event Log Form, page 2.

SOP 13: Procedures Following a Field Tour

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP outlines the procedures to be conducted following a field tour. These procedures are carried out directly upon returning from the field. The responsibilities are described in detail below.

Crew Tasks

Crew members are to complete the following tasks at the end of each field tour. Office time will be limited and there will be much to do, so it is imperative that the crew plan ahead and work efficiently. Also remember to be considerate of others sharing the same building. Work quietly and keep gear and paperwork organized.

1. Return trip. During the return trip, determine who will be doing each task upon arrival at the office. Make sure that the Logistics page on the Event Log is completed. Discuss what important information needs to be relayed to the supervisor or Project Lead. Take this time to check and organize the data sheets one more time; this may remind or apprise you of additional items to share with the supervisor or Project Lead.
2. Check in. Upon return, check in with the dispatch/communication center to let them know that you are back from the field. A radio call-in at the trailhead may be sufficient. Check-in is only necessary in parks where crews are in communication with dispatch and/or are required to send a wilderness itinerary.
3. Meet with supervisor. Meet with the supervisor to discuss how the tour went, any issues that came up, and how they can be addressed. If any additional training is needed, or any questions arise about procedures, let the supervisor know as soon as possible. Report the number of hours worked. It is preferable to report in person, but a detailed email may suffice.
4. Check work e-mail. Read messages from supervisor and Project Lead.
5. Travel voucher. Inform your supervisor of the number of days and nights spent in the field that tour. Complete any forms that are needed to document travel and initiate reimbursement.
6. Photocopy. Photocopy or scan all data forms. File originals in their respective folders for later data entry. Scanned copies are maintained in the project workspace in a sub-folder

for scanned field forms within the crew folder for the year. Photocopies can be kept in a second building (agreed upon by your supervisor), to protect the information from mishaps such as fire.

7. Batteries. Recharge, replace, and/or dispose of batteries as described in **SOP 4: Orientation and Training of Field Crews**. Make sure that there will be two good sets ready for the field the following tour for the GPS, camera, laser range finder, and any other battery-operated equipment.
8. Clean. Clean cooking pots, bear canisters, and water filters.
9. Gear. Return gear to field box. Address any gear maintenance issues.
10. Fuel. Return fuel to the approved fuel storage area.
11. Vehicle. Clean out and gas the vehicle. Address any vehicle issues. Wash the vehicle if dirty, but not more than once per month.
12. Return keys. Always return vehicle keys to the key drawer or key board as specified by the supervisor.
13. Photos. Download and name the photo images as outlined in **SOP 14: Managing Photographic Images**.
14. GPS. If plot UTMs were recorded with the GPS, download and save the raw data files in the \Rover_files\Raw folder of the project workspace for the GIS Specialist. Recharge the battery if a rechargeable type.
15. Data entry. Enter data into the project database, and verify correct transcription of data from field forms into the database. The front-end database application is found in a subfolder of the seasonal workspace. Refer to **SOP 15: Data Entry and Verification**.
16. Prepare for next tour. If all tasks are complete, begin preparations for the next tour. Check that data forms and maps are assembled and ready to go.

Trip Report

During the office day the Field Crew Lead should write a report summarizing tasks completed in the field and issues that need to be addressed immediately or in the future. Writing the report should take less than one hour. Trip reports are very helpful for trying to piece together what happened on a tour at some time in the future. The report should include:

1. Dates and locations
2. Crew members
3. What was done
4. What was not done
5. Expected or unexpected problems
6. Interesting observations.

SOP 14: Managing Photographic Images

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP describes procedures for downloading, processing and naming photographic images collected by project staff or volunteers while conducting plot monitoring and other project-related activities. Images that are acquired by other means – e.g., downloaded from a website or those taken by a cooperating researcher – are not project records and should be stored separately and named in such a way that they can be readily identified as non-NPS images and not be mistaken for project records.

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 files from the camera
    b. Rename the image files according to prescribed convention detailed below
    c. Copy and store the original, unedited versions
    d. Review and edit the photos; delete unneeded or poor quality photos
    e. 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 photographs from incidental or opportunistic photographs taken by project staff. Data photographs are those taken for the following reasons:

- To document a particular feature or perspective for the purpose of site relocation
- To capture site characteristics and to document gross structural and compositional changes to a site over time
- To document a species detection that is also recorded in the plot 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. Other photographs – e.g., showing field crew members at work, or documenting the morphology of a particular species or presence of disease in an individual – may also be retained but are not necessarily linked with database records.

Image Workspace Setup

Prior to each season, 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]	Arrange files by park – OLYM, MORA, etc.
1_Originals	Unedited versions of image files
[Download date]	Arranged by download date to preserve file names
2_Processing	Temporary processing workspace
[Site code]	Arranged by plot, for images taken at a plot
[Capture date]	Arranged by date, for images not taken at a plot
3_Data	Data images for required photos at plots
[Site code]	Arranged in subfolders by site
4_Miscellaneous	Non-data images taken by project staff
[Site code]	Arranged by plot, for images taken at a plot
[Capture date]	Arranged by date, for images not taken at a plot
5_Not_NPS	Images acquired from other sources

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. 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 20 characters or fewer.
- Date names should be formatted as YYYYMMDD.
- Plot folder names are typically a five-character string with the underbar character separating the one letter code indicating the park (e.g. "M" for MORA) from the four-digit plot number, which is the GRTS number (e.g., 0140).

Image Acquisition Standards

Capture images at an appropriate resolution that balances space limitations with the intended use of the images. Although photographs taken to facilitate future navigation to the site do not need to be stored at the same resolution as those that may be used to document gross environmental

change at the site, it may be more efficient to capture all images at the same resolution initially. 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

1. Under the appropriate "Originals" subfolder, create a subfolder for the download date (e.g., 20120715). Other suffixes may be used to distinguish downloads when multiple sites or parks are downloaded on the same date.
2. Download the raw, unedited images from the camera into the new subfolder. 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.
   - Plug in the camera to the USB port and turn the camera on.
   - 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).
   - 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.
     - For name prefix, use the naming conventions indicated later in this SOP.
     - For image file format, select the default (JPG).
     - For photo destination, browse to the appropriate "Originals" subfolder.
3. 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).
4. Finish renaming the images in the "Processing" folder according to convention (refer to the Image File Naming Standards section).
   - If image file names were noted on the field data forms, be sure to update these 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 **Section 4D, Data Entry and Processing**).
   - 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.
5. Process the images in the "Processing" folder, using the edit features built into image software programs such as ThumbsPlus or Microsoft Office Picture Manager. At a minimum, the following processing steps should be performed on all image files:
   - Delete photographs of poor quality – e.g., out of focus, poor light levels, etc. Low quality photographs might be retained if the subject is highly unique, or the photo is an irreplaceable data photo.
   - Duplicates should also be deleted unless they provide unique information. Other non-data photographs should be evaluated for their potential long-term value.
   - Rotate images to make the horizon level.
   - Remove 'red eye' glare in photographs of people.

- Crop non-data images to remove edge areas that grossly distract from the subject.

6. Optional processing steps may include enhancing contrast or brightness, or resizing images to make them small enough for use in documents or on the web. These steps are not recommended for data photos.
7. When finished processing the current download, move the image files that are to be retained to the appropriate folder – i.e., data images to the appropriate "Data" subfolder, other images under the appropriate "Miscellaneous" folder.
8. Photos of potential interest to a greater audience should be uploaded to the NCCN Digital Library.
9. Delete files from the "Processing" folder between downloads to minimize the chance for accidental deletion or overwriting of needed files.

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 and year should either be included in the file name (preferred), or specified by parent folders in the directory structure.
- 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, separated by an underbar character:

1. The date on which the image was taken (formatted as YYYYMMDD)
2. The four-character park code (MORA, NOCA, or OLYM)
3. Plot location code (one-letter code indicating the park followed by an underbar and then the 4-digit plot number (GRTS firing order))
4. For data photos taken from defined points in the plot, the photographic view code (see **SOP 12: Recording Plot Visit Details and Taking Digital Photos: and Event Log** for description of the required photographic views and codes for each plot type).
5. Optional file name components:
    a. A brief descriptive word or phrase (indicating the content of the image) following the park code instead of the plot code and view type.
    b. A sequential number if multiple images were captured of a given subject.
    c. Time of image acquisition (formatted as HHMM).

Examples:

- 20120612_MORA_0007_Q4.jpg MORA Plot #0007, quadrat #4, taken on June 12, 2012
- 20120809_NOCA_0043_W.jpg NOCA Plot #0043, facing west, taken on August 9, 2012.

- 20120518_OLYM_training_4.jpg 4th photo taken during training at OLYM on May 18, 2012

Post-season Cleanup Procedures

At the end of the season, field crew members should organize images within the seasonal workspace and notify the Project Lead, after making sure that all processing folders are empty. For crew members stationed at remote parks who need to work on local copies, a CD or DVD should be prepared and delivered to the Project Lead.

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 empty and may be deleted.
3. Files in the "Not_NPS" folder may be refiled 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. If storage space is limiting, originals may be stored on a local hard drive or external drive.
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. Set the images in the project workspace to read-only to prevent unintended changes.

SOP 15: 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.
6. At regular intervals and at the end of the field season the Field Crew Lead should inspect the data that have been entered to check for completeness and perhaps identify avoidable errors. The Field 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 17: 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., Subalpine_Veg_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 co-located 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:

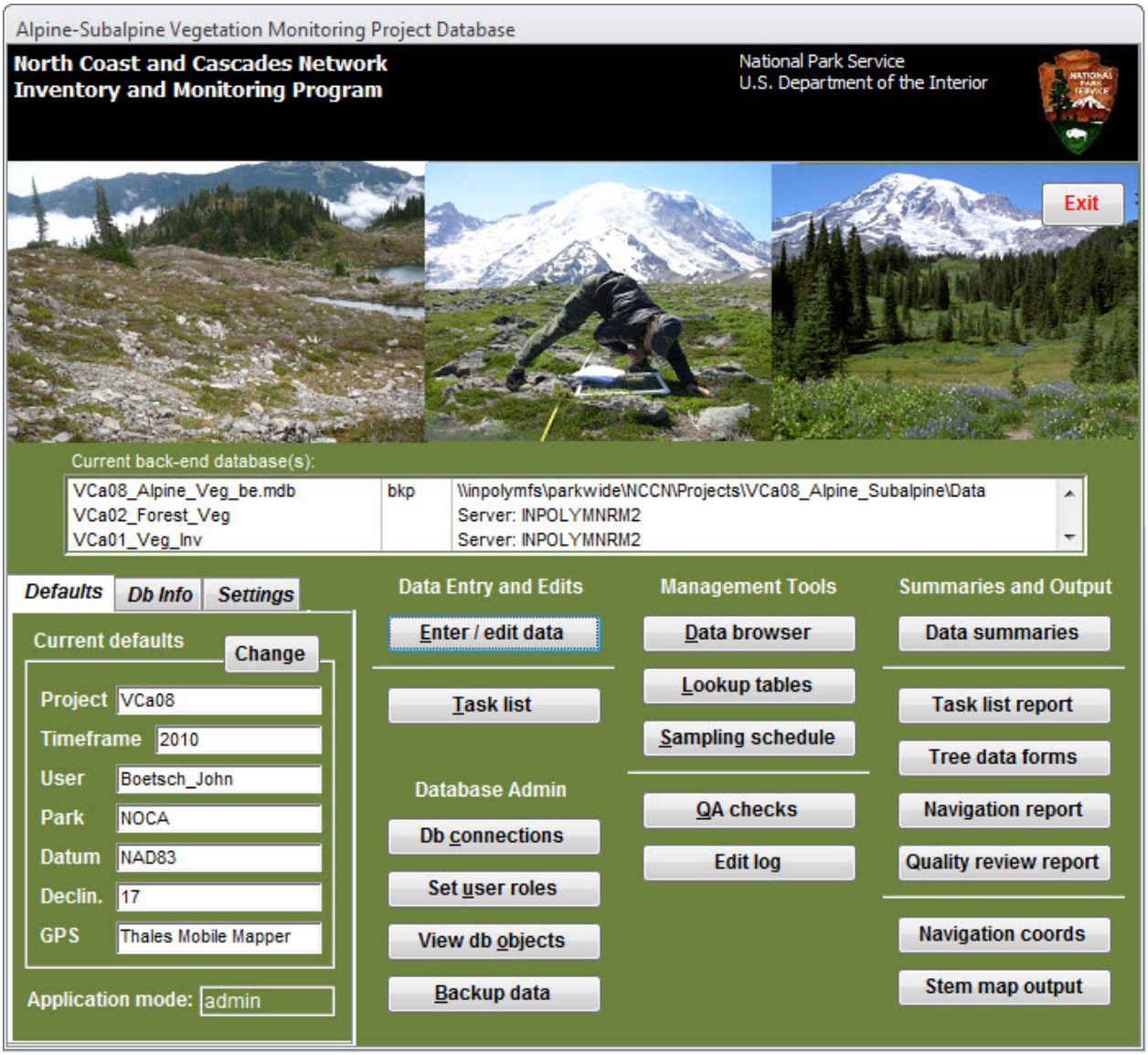
- Data Entry and Edits
    - Enter / edit data – Opens a form to confirm default settings (e.g., park, coordinate datum) prior to continuing to the project-specific data entry screens.
    - Task list – Keeps track of unfinished tasks associated with sample locations (for example, forgotten equipment, 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.
  - Backup data – Makes a zipped copy of the back-end file and stores this backup in a subfolder. This button is visible only when one or more of the back-end databases is implemented in Microsoft Access.

- 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 17: 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).
  - Tree data forms – Generates tree data forms for repeat visits to monitoring locations, with tree identification information already populated. Reports are for a specified park or sample location (default is for all locations).
  - Navigation report – Generates the field season Navigation Report used to relocate sample locations and brief the crew on tasks that need to be accomplished.
  - 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 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.

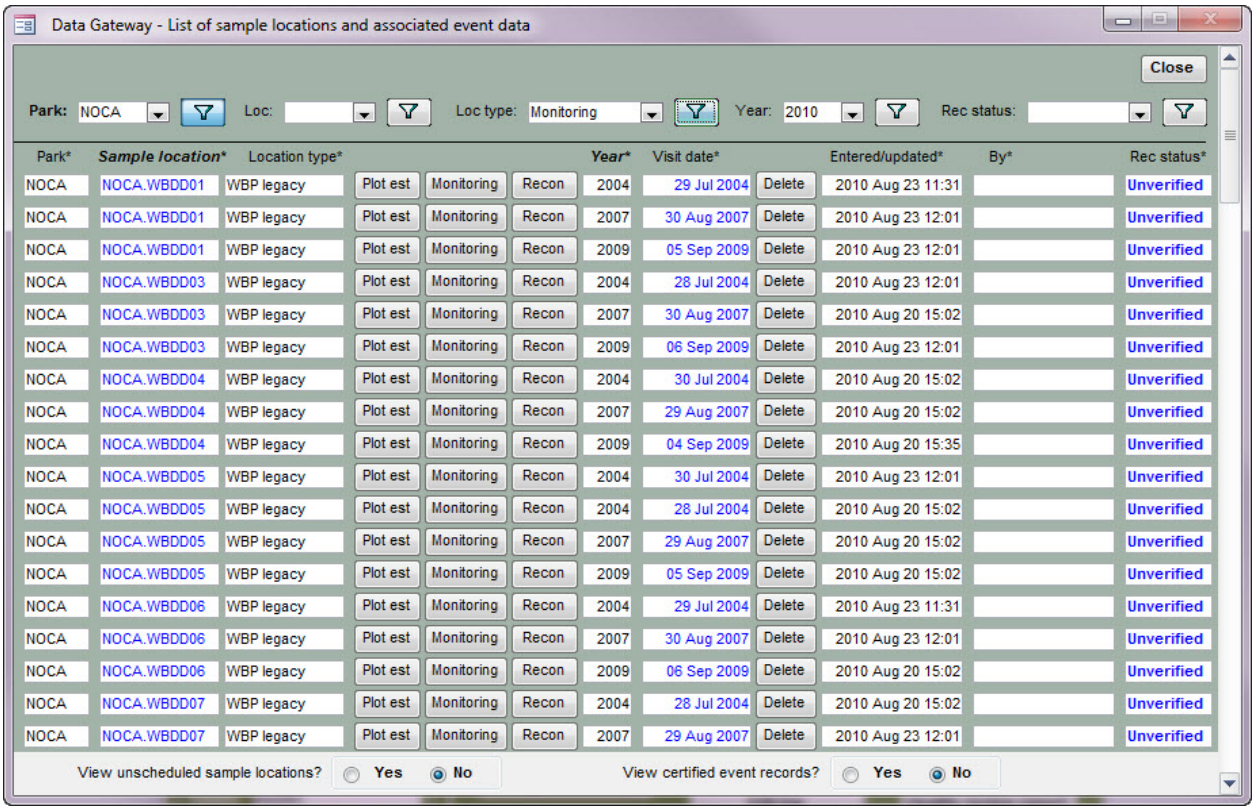
- Prompt for backup on exit – The user will be prompted to make a data backup when the application closes. Default is on, which means that the user will be prompted each time the application closes if there is at least one Access back-end for which backups are specified.
- Compact back-end on exit – 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 (reconnaissance vs. monitoring), 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.

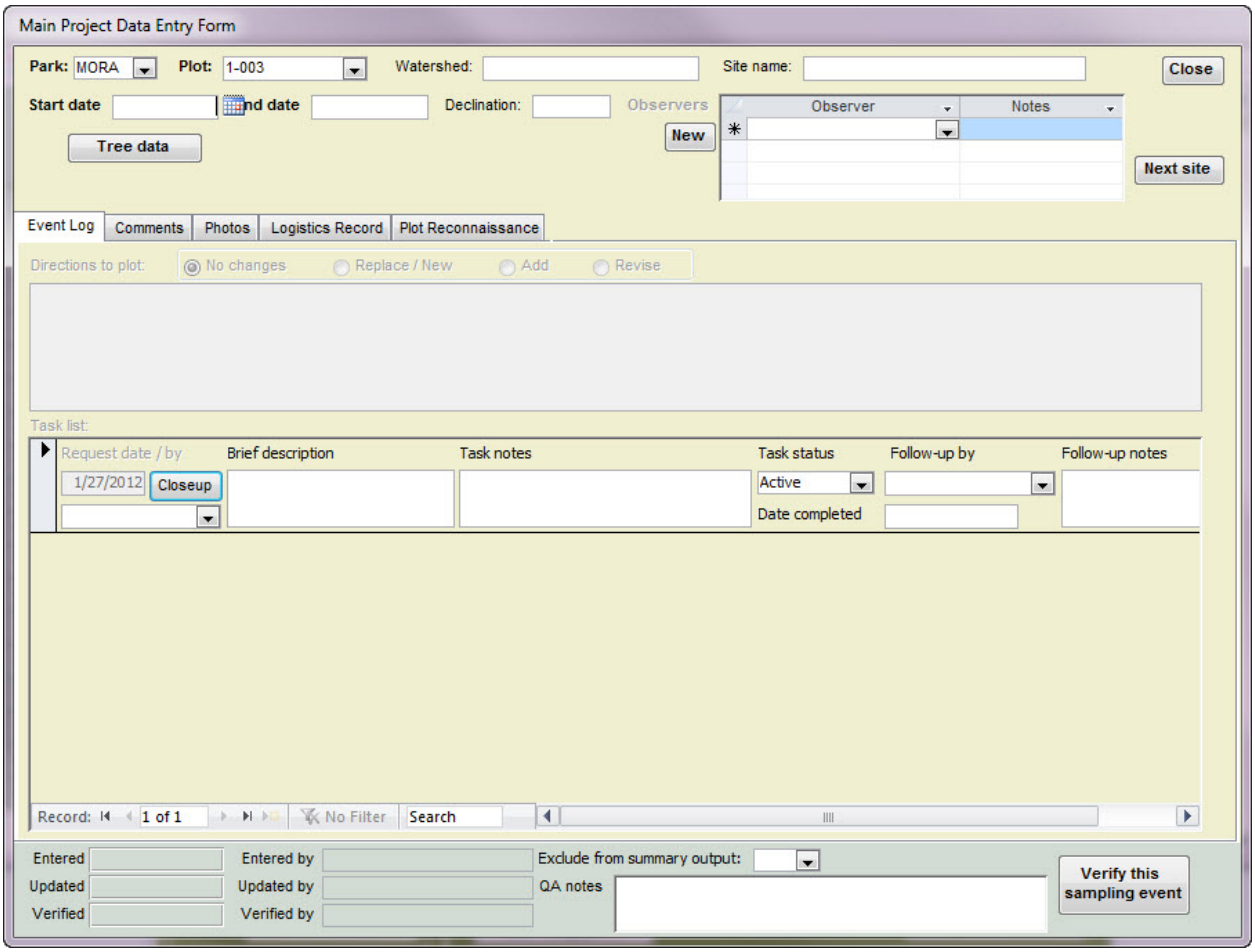


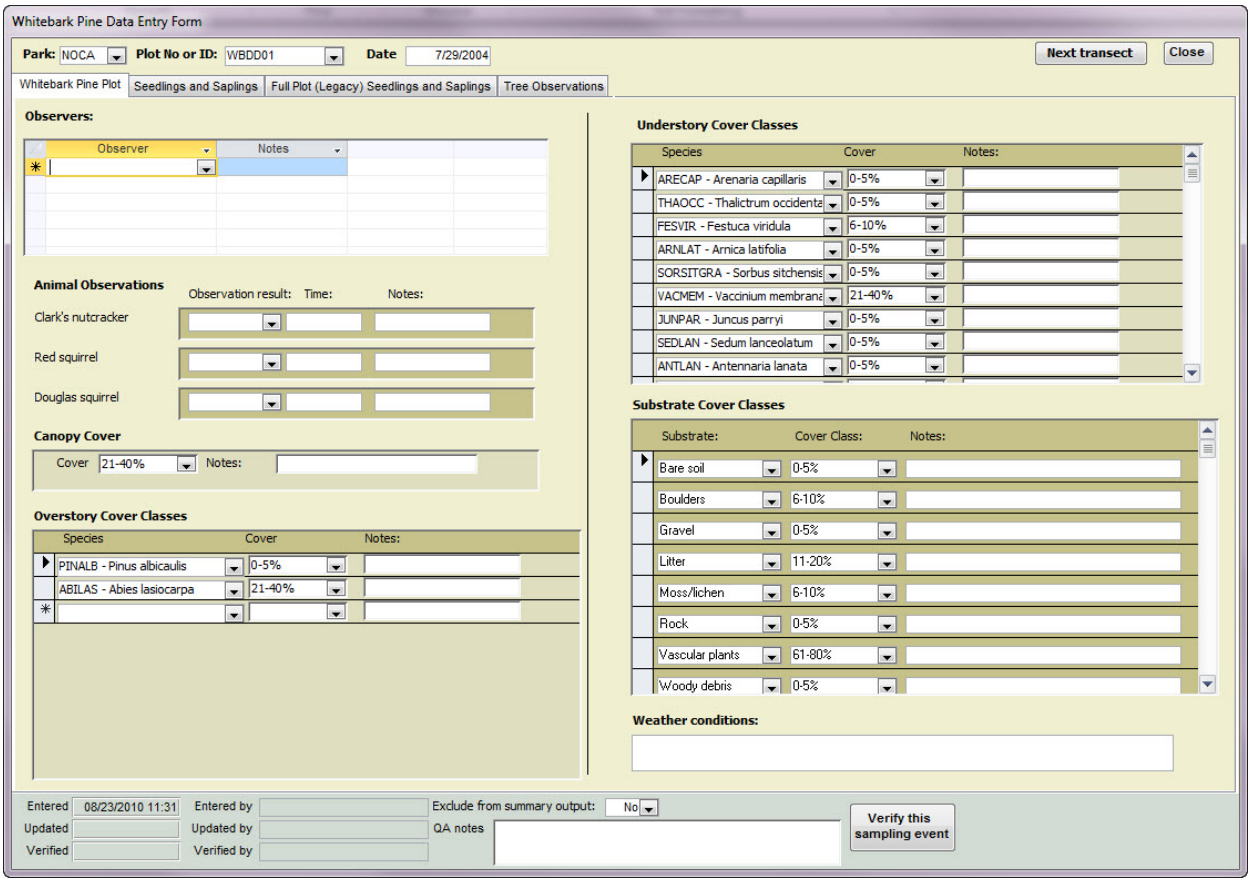
Park*	Sample location*	Location type*				Year*	Visit date*		Entered/updated*	By*	Rec status*
NOCA	NOCA.WBDD01	WBP legacy	Plot est	Monitoring	Recon	2004	29 Jul 2004	Delete	2010 Aug 23 11:31		Unverified
NOCA	NOCA.WBDD01	WBP legacy	Plot est	Monitoring	Recon	2007	30 Aug 2007	Delete	2010 Aug 23 12:01		Unverified
NOCA	NOCA.WBDD01	WBP legacy	Plot est	Monitoring	Recon	2009	05 Sep 2009	Delete	2010 Aug 23 12:01		Unverified
NOCA	NOCA.WBDD03	WBP legacy	Plot est	Monitoring	Recon	2004	28 Jul 2004	Delete	2010 Aug 23 12:01		Unverified
NOCA	NOCA.WBDD03	WBP legacy	Plot est	Monitoring	Recon	2007	30 Aug 2007	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD03	WBP legacy	Plot est	Monitoring	Recon	2009	06 Sep 2009	Delete	2010 Aug 23 12:01		Unverified
NOCA	NOCA.WBDD04	WBP legacy	Plot est	Monitoring	Recon	2004	30 Jul 2004	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD04	WBP legacy	Plot est	Monitoring	Recon	2007	29 Aug 2007	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD04	WBP legacy	Plot est	Monitoring	Recon	2009	04 Sep 2009	Delete	2010 Aug 20 15:35		Unverified
NOCA	NOCA.WBDD05	WBP legacy	Plot est	Monitoring	Recon	2004	30 Jul 2004	Delete	2010 Aug 23 12:01		Unverified
NOCA	NOCA.WBDD05	WBP legacy	Plot est	Monitoring	Recon	2004	28 Jul 2004	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD05	WBP legacy	Plot est	Monitoring	Recon	2007	29 Aug 2007	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD05	WBP legacy	Plot est	Monitoring	Recon	2009	05 Sep 2009	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD06	WBP legacy	Plot est	Monitoring	Recon	2004	29 Jul 2004	Delete	2010 Aug 23 11:31		Unverified
NOCA	NOCA.WBDD06	WBP legacy	Plot est	Monitoring	Recon	2007	30 Aug 2007	Delete	2010 Aug 23 12:01		Unverified
NOCA	NOCA.WBDD06	WBP legacy	Plot est	Monitoring	Recon	2009	06 Sep 2009	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD07	WBP legacy	Plot est	Monitoring	Recon	2004	28 Jul 2004	Delete	2010 Aug 20 15:02		Unverified
NOCA	NOCA.WBDD07	WBP legacy	Plot est	Monitoring	Recon	2007	29 Aug 2007	Delete	2010 Aug 23 12:01		Unverified

At the bottom of the form are radio buttons to allow the user to view unscheduled sampling locations if needed (e.g., an unscheduled site was visited after the sampling plan was made at the beginning of the season). Another set of radio buttons allows the user to view certified records from previous seasons (power users only).

Data Entry Form

To access this form from the Data Gateway Form, either click on the “Monitoring” button associated with the desired record, or double-click on the appropriate “Sample location” cell, or on the “Visit date” cell. This form includes several tabs for various sections of the Event Log form. Note that the task list section will contain the full set of tasks for the sample location, not just those from the current sampling event. This allows the user to update task information from previous visits.


Main Project Data Entry Form
Park: MORA
Plot: 1-003
Watershed:
Site name:
Close
Start date
nd date
Declination:
Observers
Observer
Notes
New
Tree data
Next site
Event Log
Comments
Photos
Logistics Record
Plot Reconnaissance
Directions to plot:
No changes
Replace / New
Add
Revise
Task list:
Request date / by
Brief description
Task notes
Task status
Follow-up by
Follow-up notes
1/27/2012
Closeup
Active
Date completed
Record:
1 of 1
No Filter
Search
Entered
Entered by
Exclude from summary output:
Updated
Updated by
QA notes
Verified
Verified by
Verify this sampling event



Verifying Data Records

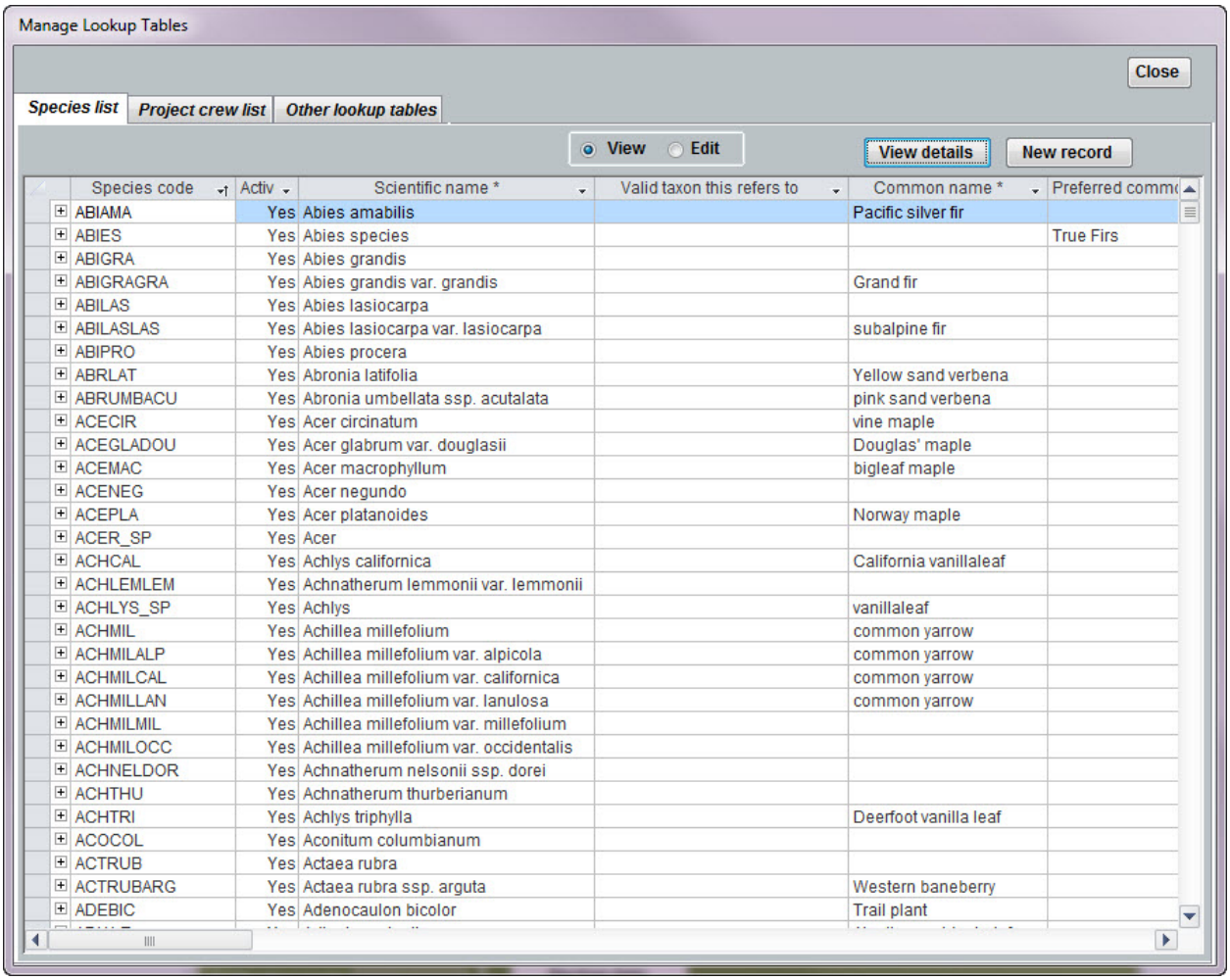
Field crews must verify all sampling events throughout the field season. The recommended approach is for one crew member to do all of the data entry for one sample location, then have another crew member review and verify records for that location. The current record status for each sampling event is 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.

To complete the verification step: 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 – Event Log, Reconnaissance and Plot Establishment – 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 have 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 all data for the plot – e.g., tree data, sapling data, etc. – will need to be verified before clicking the "Verify" button on the main Event Log form. Also, if more than one category of data was collected during a visit – for example, reconnaissance data and plot establishment information –

both forms will need to be verified separately, even though the record status in the Data Gateway may indicate "Verified".

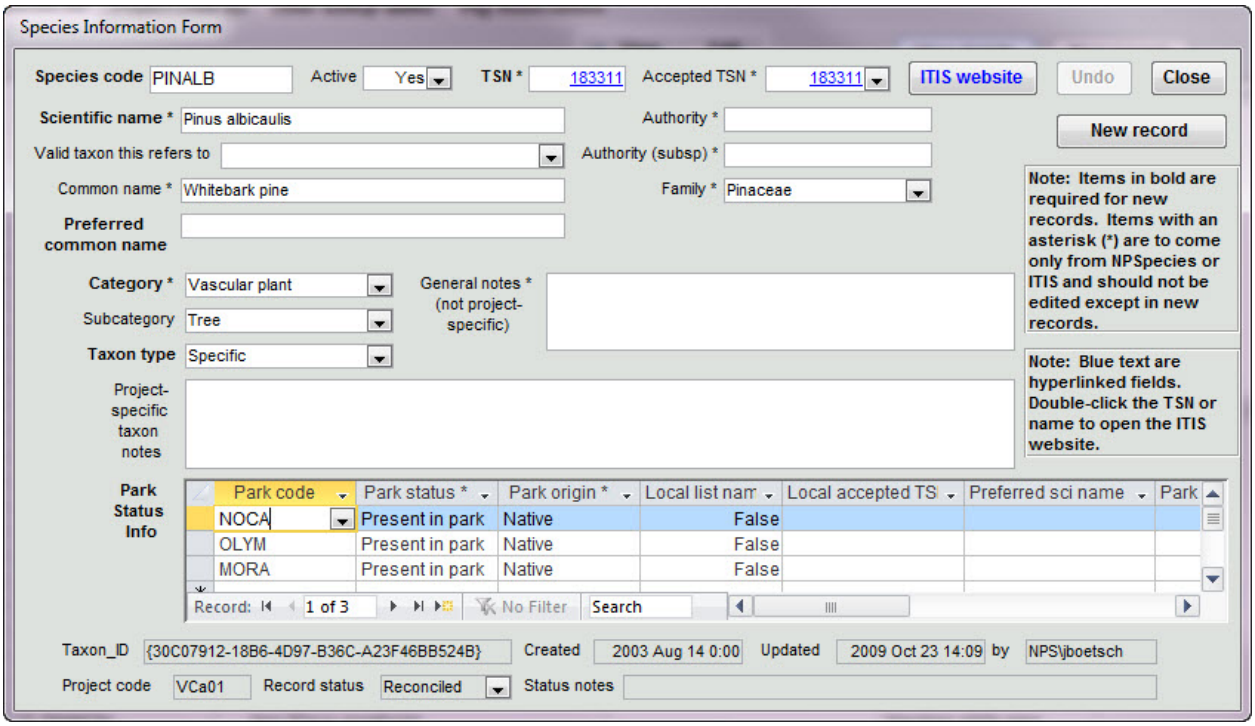
Manage Lookup Tables

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.’

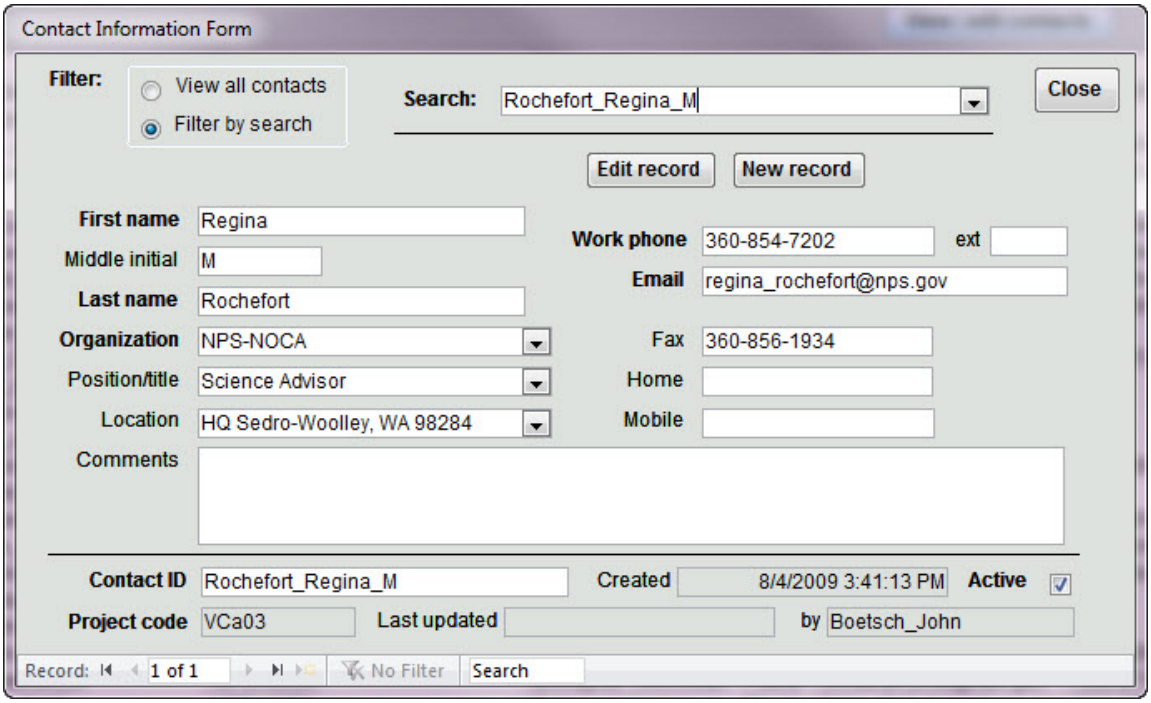


Species code	Activ	Scientific name *	Valid taxon this refers to	Common name *	Preferred comm
ABIAMA	Yes	Abies amabilis		Pacific silver fir	
ABIES	Yes	Abies species			True Firs
ABIGRA	Yes	Abies grandis			
ABIGRAGRA	Yes	Abies grandis var. grandis		Grand fir	
ABILAS	Yes	Abies lasiocarpa			
ABILASLAS	Yes	Abies lasiocarpa var. lasiocarpa		subalpine fir	
ABIPRO	Yes	Abies procera			
ABRLAT	Yes	Abronia latifolia		Yellow sand verbena	
ABRUMBACU	Yes	Abronia umbellata ssp. acutalata		pink sand verbena	
ACECIR	Yes	Acer circinatum		vine maple	
ACEGLADOU	Yes	Acer glabrum var. douglasii		Douglas' maple	
ACEMAC	Yes	Acer macrophyllum		bigleaf maple	
ACENEG	Yes	Acer negundo			
ACEPLA	Yes	Acer platanoides		Norway maple	
ACER_SP	Yes	Acer			
ACHCAL	Yes	Achlys californica		California vanillaleaf	
ACHLEMLEM	Yes	Achnatherum lemmonii var. lemmonii			
ACHLYS_SP	Yes	Achlys		vanillaleaf	
ACHMIL	Yes	Achillea millefolium		common yarrow	
ACHMILALP	Yes	Achillea millefolium var. alpicola		common yarrow	
ACHMILCAL	Yes	Achillea millefolium var. californica		common yarrow	
ACHMILLAN	Yes	Achillea millefolium var. lanulosa		common yarrow	
ACHMILMIL	Yes	Achillea millefolium var. millefolium			
ACHMILOCC	Yes	Achillea millefolium var. occidentalis			
ACHNELDOR	Yes	Achnatherum nelsonii ssp. dorei			
ACHTHU	Yes	Achnatherum thurberianum			
ACHTRI	Yes	Achlys triphylla		Deerfoot vanilla leaf	
ACOCOL	Yes	Aconitum columbianum			
ACTRUB	Yes	Actaea rubra			
ACTRUBARG	Yes	Actaea rubra ssp. arguta		Western baneberry	
ADEBIC	Yes	Adenocaulon bicolor		Trail plant	

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.



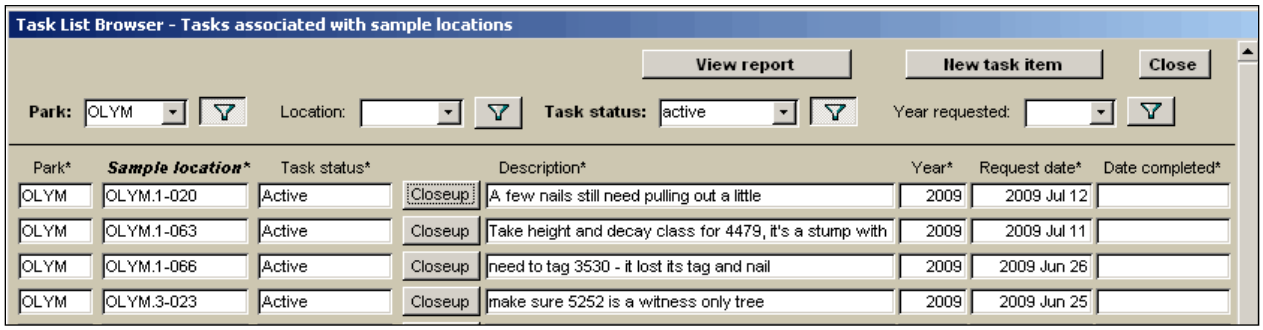
The second tab of the lookups module is a list of contacts for the project. By selecting a contact record and clicking on the "View / edit" button, or by double-clicking on a contact record, the Contact Information Form is opened in edit mode. Once edits are accepted with the "Done" button, the user 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.



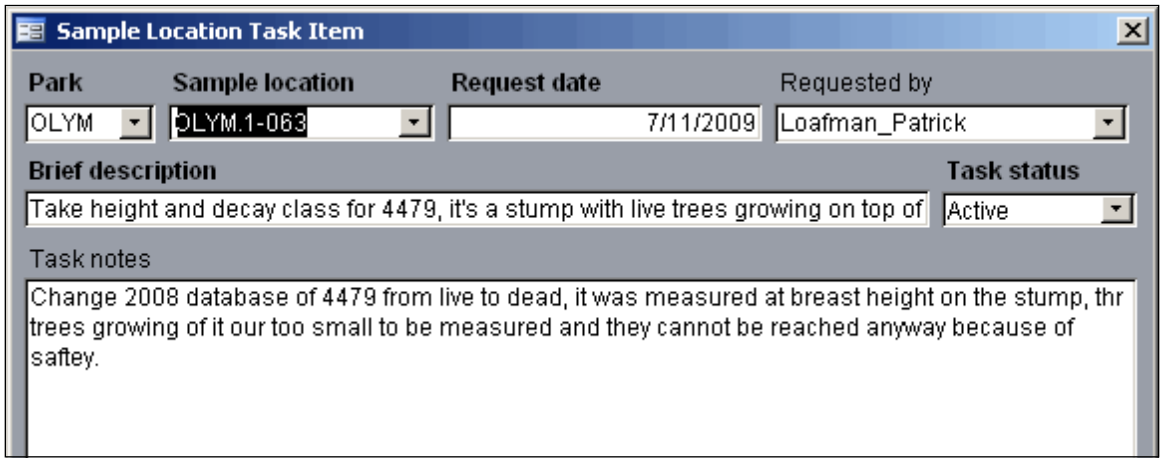
The third tab in the Manage Lookups Form has a dropdown pick list for selecting other lookup tables in the database. This can be useful when a user needs to learn more about the domain values and definitions for the project. These lookups may be edited only by power users and administrators.

Site Task List

The Task List Browser Form functions in much the same way as the Data Gateway Form, and can be sorted or filtered by park, location type, task status or request year. Click on the "Closeup" button to view or edit information for that record.

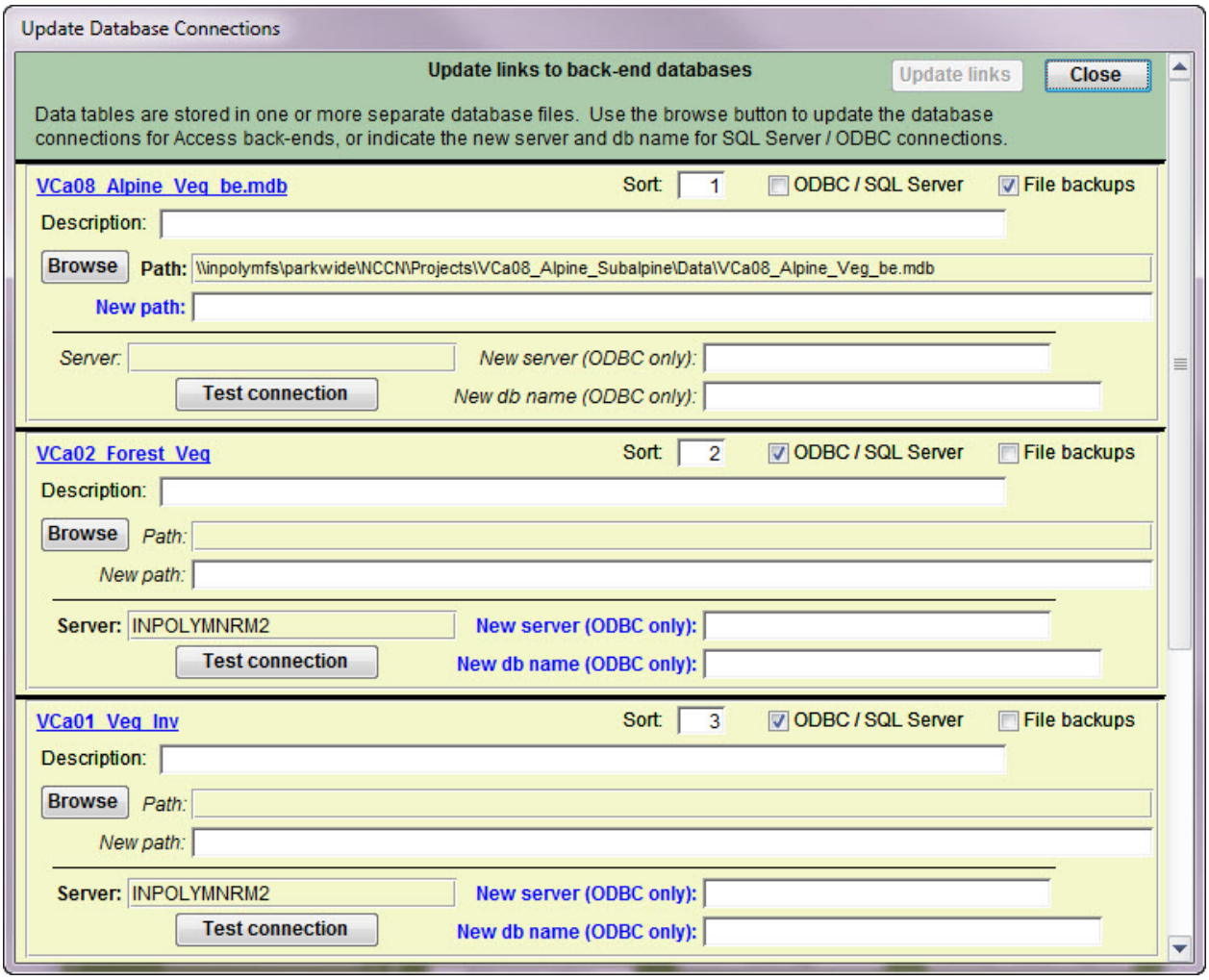


Close-up view for entering/editing location task items:



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'.


Update Database Connections
Update links to back-end databases
Update links
Close
Data tables are stored in one or more separate database files. Use the browse button to update the database connections for Access back-ends, or indicate the new server and db name for SQL Server / ODBC connections.
VCa08_Alpine_Veg_be.mdb
Sort: 1
ODBC / SQL Server
File backups
Description:
Browse
Path: \\inpolymfs\parkwide\NCCN\Projects\VCa08_Alpine_Subalpine\Data\VCa08_Alpine_Veg_be.mdb
New path:
Server:
New server (ODBC only):
Test connection
New db name (ODBC only):
VCa02_Forest_Veg
Sort: 2
ODBC / SQL Server
File backups
Description:
Browse
Path:
New path:
Server: INPOLYMNRM2
New server (ODBC only):
Test connection
New db name (ODBC only):
VCa01_Veg_Inv
Sort: 3
ODBC / SQL Server
File backups
Description:
Browse
Path:
New path:
Server: INPOLYMNRM2
New server (ODBC only):
Test connection
New db name (ODBC only):

SOP 16: End of Field Season Debriefing and Close-out

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP outlines the procedure for meeting to debrief the crew and close out the field season. This is to occur during the last week of work for the seasonal field technicians.

Preparation

By the end of the field season all data should be entered into the database and verified by the crew. In addition, all images, scanned field forms, and GPS files should be accounted for, named and filed appropriately in the project workspace. The crew should be prepared for debriefing on the scheduled day during the last week of work. Equipment should be inventoried and any borrowed equipment returned. The Field Crew Lead should prepare a "Field Season Report," noting any unfinished work, so that the Project Lead can arrange for its completion.

Debriefing

The objective of the debriefing is to understand and summarize how the field season went, what worked and what can be improved for next year. The Project Lead and the park plant ecologists should let the crew know ahead of time that there will be a meeting to discuss the accomplishments and challenges of the field season. The crew should review this SOP before beginning their last week of work, write down their thoughts and responses to the items below for discussion at the debriefing, and add additional items that come to mind. Meeting notes should be recorded for future reference. The subjects to be covered include the following:

<u>Organization Issues</u>
How did you feel about each of the following parts of the field season? What went well and where could improvements be made?

- Orientation – Was it helpful, well-organized, logical, and applicable? Review orientation agenda.
- Planning
- Scheduling
- Tours
- Communication – Project Lead to Field Leads, Field Lead to Field Crew, between crew members, between crews, within park, between parks, with park plant ecologists.

Field issues

How did you feel about each of the following:

- Field tours - Were you mentally and physically prepared for your season?
- Training – Was the training adequate for packing, hiking, GPS use, navigating with map and compass, and safety? (training for data collection is addressed in the next section)
- Transportation – were vehicles adequate, functional and safe?
- Field safety - Did you encounter any safety issues; what did you do to address them?
- Suggestions for avoiding injuries next year (Updates to the Job Hazard Analysis)
- Field equipment - Did you have the right equipment for backpacking and camping?

Data Collection

How did you feel about each of the following parts of data collection? What went well and where could improvements be made?

- Training – Was the training adequate for data collection?
- Locating plots with GPS
- Plot set-up
- Sampling
- Event Log
- Taking digital images
- Alpine and subalpine vegetation identification
- Data forms
- Whitebark pine pest and pathogen identification
- Whitebark pine tree measurements and tagging

Technical Issues

- Field equipment - Did you have the right equipment to get the job done safely and efficiently? (e.g., GPS, Laser rangefinders, cameras, altimeter, clipboards, paper, etc.)
- GPS / GIS support at each park
- Did the GPS procedures work and how can they be improved?
- Radio use at each park

Office

- Office time
- Computers and network access
- Office supplies
- Database and data entry (with database support person)
- Field form scanning
- Image management procedures
- Status of the data – Note: All sampling event database records should be verified at the close of the season (see **SOP 15: Data Entry and Verification**).

Plans for next year

Go over the plans for next year. Let the crew know about rehire status for their current position, approximately when the job announcement will be on USAJOBS should they wish to apply, and what incentives may be available to them should they return.

Contact information

Consider collecting contact information from the crew. If any questions arise about the data, we may need to contact the crew person that collected the data. Ideally data quality review and certification will have been conducted by the end of the field season, but with our short season, this may not be possible.

Equipment Assessment and Return

The Field Crew Lead is responsible for ensuring the inventory, return, and documentation of field equipment. By the last day the crew will return all equipment that was borrowed for the field season. This should include field notebooks. Use the original check-out list to check in the equipment. Note any equipment that was lost or damaged. Record what needs to be fixed or replaced and indicate if an improved model is desired. Organize and store the equipment so that it is contained and easily accessible for the next season. Create a list of needed items in the folder \Documents\Reference\Travel_Logistics\Equipment_Lists in the project workspace, indicating the year in the file name, so that it is easily accessible when it is time to order equipment and supplies for the next field season. GPS units will need to be returned on the day determined by the GIS Specialist at the time of unit check-out as they are used by multiple projects during the field season. The GPS units should be returned to the GIS Specialist so they can be recharged and programmed for the next user.

Check Out

On the last day of work the field crew members will go through the NPS check-out procedure, unless they will be working on another project. Check-out entails getting the check-out form signed off by various authorities as equipment and keys are turned in.

Field Season Reporting

The Field Crew Lead should prepare a brief report (generally not more than three pages) that includes the following:

- Clear enumeration of which plots were completed, and which were only partially completed during the season.
- Description of any logistic difficulties that arose and explanation of how they were addressed.
- Clear documentation and explanation of any deviations from established procedures.
- Discussion of any interesting or potentially important observations about the parks' vegetation or wildlife that may have been noted during the field season (e.g., apparent changes in composition from previous years, or notable changes in apparent abundance of exotic or rare species).
- Suggestions for improving the training or field season logistics.
- An inventory of field equipment, quantity and condition.

SOP 17: 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

The database application contains a set of a pre-built database queries that check 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., dbh measurements) 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 monitoring location 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 below). 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 species 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 – 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:

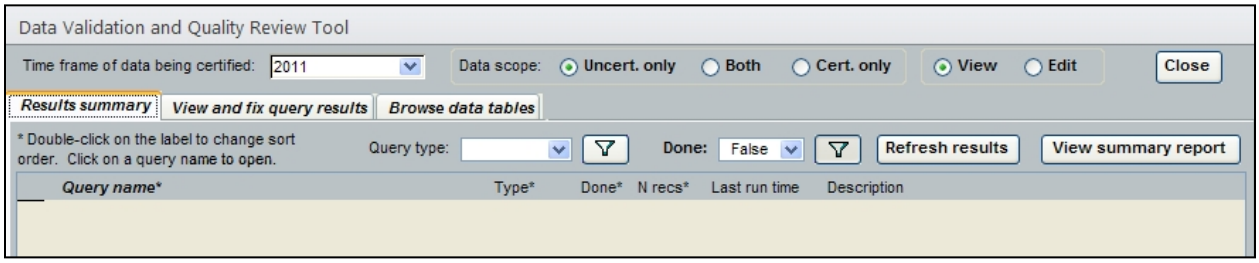
- Uncertified data only (default) – Only uncertified events (i.e., those from the current sampling year) will be considered in validation queries. Note that by design, certain queries will evaluate for problems in records that are associated with certified data anyway – for example, all location records 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.

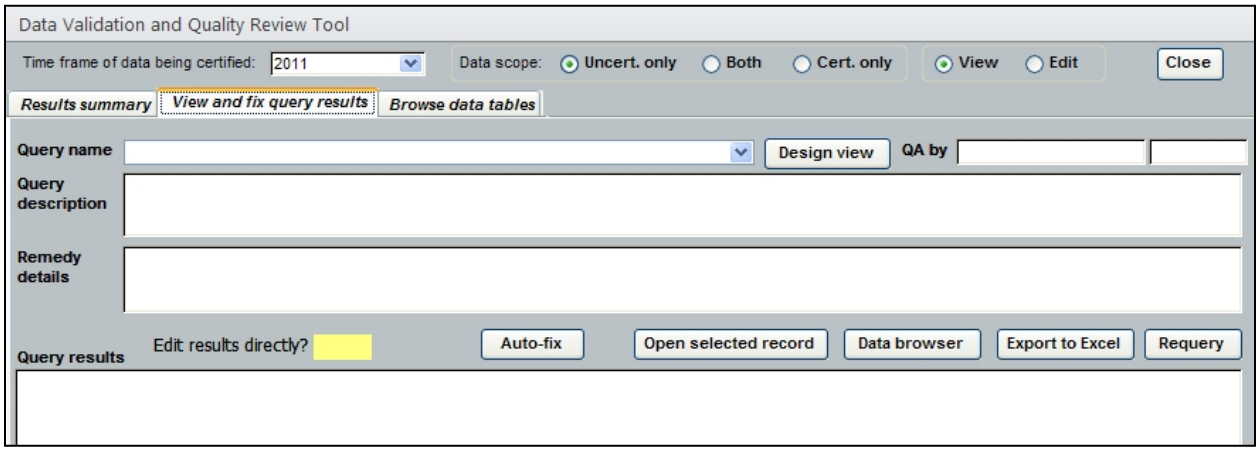
The first tab of the quality review form contains a results summary showing each validation query, the type of query (i.e., Critical, Warning or Information), the number of records returned by the query, the most recent query run time, and the description. At the top of the page, there is a button for 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 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.

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 C: Yearly Project Task List**. Refer to **SOP 18: 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 18: 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 18.1). Details are also provided on posting products to websites and clearinghouses, and on responding to data requests.

Product Delivery Schedule and Specifications

Table 18.1. Schedule and instructions for project deliverables.

Deliverable Product	Primary Responsibility	Target Date	Delivery Instructions
Field season report	Crew Lead	Sep 15 of the same year	Upload digital file in Microsoft Word format to the NCCN Digital Library.
Raw GPS data files	Crew Lead	Sep 15 of the same year	Store in appropriate sections of the project workspace.
Processed GPS data files	GIS Specialist	October 15 of the same year	
Digital photographs	Project Lead	November 30 of the same year	Organize, name and maintain photographic images in the project workspace according to **SOP 15: Managing Photographic Images**.
Certified back-end database	Project Lead	November 30 of the same year; data are not published until two years after the certification date	Refer to the section in this SOP on delivering certified data and related materials.
Certified geospatial data	Project Lead with GIS Specialist		
Data certification report	Project Lead		
Metadata interview form	Project Lead		
Full metadata (parsed XML)	Data Manager and GIS Specialist	March 15 of the following year	Upload the parsed XML record to the NPS Data Store [1].
Annual I&M report	Project Lead	Apr 30 of the following year	Refer to the section in this SOP on reports and publications.
5-year analysis report	Project Lead and Data Analyst	Every 5 years by September 1 of the following year	
Other publications	Project Lead and Data Analyst	As completed	

Table 18.1. Schedule and instructions for project deliverables (continued).

Deliverable Product	Primary Responsibility	Target Date	Delivery Instructions
Field data forms	Project Lead	April 30 of the 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 6 years after data collection.
Other records	Project Lead	Review for retention every January	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 of 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://home.nps.gov/applications/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 select 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., "VCa08" for Alpine and Subalpine Vegetation Monitoring)
- 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 4J, 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 above information in a text file or accompanying email.

Park Collections

The collections at MORA, NOCA, and OLYM will serve as the park of record for the Alpine and Subalpine Vegetation Monitoring Project. Voucher specimens, hardcopy field forms, and printouts of annual reports, technical reports, and other publications will be filed there. 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.

The Project Lead should contact the Park Curator during the project planning if voucher specimens will be collected. All specimens must be labeled with NPS accession and catalog numbers, and with advance notice the Park Curator can help to provide these numbers ahead of time so they can be included in label printouts. Specimen label information will be entered by the Park Curator into the ANCS+ database. The Park Curator will help to decide which and how many specimens can be maintained at the park versus sent to another institution or collection. Collected materials remain NPS property even if they later reside in a non-NPS collection (e.g., university herbarium).

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 17: 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 17: 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 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 ("VCa08") and the year or span of years for the data being certified. For example: VCa08_2012_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., VCa08_Alpine_Veg_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 4J, 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 4J, 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. Develop, parse and post the XML metadata record to the NPS Data Store.
8. 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 trend 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 trend 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 field season reports, which are intended to be internal communications only.)

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 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.
3. 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.
4. 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. Store both the Word document and PDF copy in the appropriate section of the project workspace (see **SOP 1: Project Workspace and Records Management**).

5. 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.
6. 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.

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., “VCa08”), network code (“NCCN”) or park code, and year in the file name.

Examples:

- NCCN_VCa08_2012_Annual_report.pdf
- NCCN_VCa08_2012_Field_season_report.doc
- NCCN_VCa08_2012_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., “VCa08”), network code (“NCCN”) or park code, and year as appropriate (e.g., NCCN_VCa08_2012_cert_package.zip). Specific standards for images are described in **SOP 14: Managing Photographic Images** and in **SOP 20: 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 4J, 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 July 2012 and certified in January 2013 becomes generally available through the NPS Data Store in January 2015). In certain circumstances, and at the discretion of the Project Lead, 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, and the NPS Inventory and Monitoring Program should be acknowledged in any professional publication using the data.
- NPS retains distribution rights; copies of the data 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 4J, 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 data request with other network and park staff members (e.g., Network Plant Ecologists) as necessary to decide on an appropriate response to the request.
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 (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 4J, 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 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 4J, Identifying and Handling Sensitive Information** for more information.

References Cited

North Coast and Cascades Network (NCCN). 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 (NCCN). 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 (NCCN). 2007b. GIS naming conventions. USDI National Park Service. Available at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm.

SOP 19: Sensitive Information Procedures

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

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://home.nps.gov/applications/npspolicy/DOrders.cfm).

These guidelines apply to all NCCN staff, cooperators, 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.

What Kinds of Information Can and Cannot Be Shared?

Do not share: Project staff and cooperators should not share any information outside NPS that reveals details about the "nature or specific location" of protected resources, unless a confidentiality agreement is in place. Specifically, the following information should be omitted from shared copies of all data, presentations, reports, or other published forms of information.

- *Exact coordinates* – Instead, public coordinates are to be generated that include a random offset azimuth and distance. These offset coordinates can be shared freely.
- *Other descriptive location data* – Examples may include travel descriptions, location descriptions, or other fields that contain information that may reveal the specific location of the protected resource(s).
- *Protected resource observations at disclosed locations* – If specific location information has already been made publicly available, the occurrence of protected resources at that location cannot be shared outside NPS without a confidentiality agreement. For example, if the exact coordinates for a monitoring station location are posted to a website or put into a publication, then at a later point in time a spotted owl nest is observed at that monitoring station, that nest cannot be mentioned or referred to in any report, presentation, data set, or publication that will be shared outside NPS.

Do share: All other information about the protected resource(s) may be freely shared, so long as the information does not reveal details about the "nature or specific location" of the protected resource(s) that are not already readily available to the general public in some form (e.g., other published material). Species tallies and other types of data presentations that do not disclose the precise locations of protected resources may be shared, unless by indicating the presence of the species the specific location is also revealed (e.g., in the case of a small park).

Details for Specific Products

Whenever products such as databases and reports are being generated, handled and stored, they should be created explicitly for one of the following purposes:

1. *Public or general-use* – Intended for general distribution, sharing with cooperators, or posting to public websites. They may be derived from products that contain sensitive information so long as the sensitive information is either removed or otherwise rendered in a manner consistent with other guidance in this document.
2. *Internal NPS use* – These are products that contain sensitive information and should be stored and distributed only in a manner that ensures their continued protection. These products should clearly indicate that they are solely for internal NPS use by containing the phrase: "Internal NPS Use Only – Not For Release." These products can only be shared within NPS or in cases where a confidentiality agreement is in place. They do not need to be revised in a way that conceals the location of protected resources.

Data Sets

To create a copy of a data set that will be posted or shared outside NPS:

1. Make sure the public offset coordinates have been populated for each sample or observation location in tbl_Locations.
2. Delete all data from the following database objects to ensure consistent omission of fields that may contain specific, identifying information about locations of protected resources:
   a. tbl_Coordinates – delete all records
   b. tbl_GPS_Info – delete all records
   c. tbl_Locations – Travel_notes, Location_desc, and Location_notes
   d. tbl_Target_Coords – Target_UTME and Target_UTMN

The local, master copy of the database contains the exact coordinates and all data fields. The Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

Maps and Other GIS Output

General-use maps and other geographic representations of observation data that will be released or shared outside NPS should be rendered using offset coordinates, and should only be rendered at a scale that does not reveal their exact position (e.g., 1:100,000 maximum scale).

If a large-scale, close-up map is to be created using exact coordinates (e.g., for field crew navigation, etc.), the map should be clearly marked with the following phrase: “Internal NPS Use Only – Not For Release.”

The Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

Presentations and Reports

Public or general-use reports and presentations should adhere to the following guidelines:

1. Do not list exact coordinates or specific location information in any text, figure, table, or graphic in the report or presentation. If a list of coordinates is necessary, use only offset coordinates and clearly indicate that coordinates have been purposely offset to protect the resource(s) as required by law and NPS policy.
2. Use only general-use maps as specified in the section on maps and other GIS output.

If a report is intended for internal use only, these restrictions do not apply. However, each page of the report should be clearly marked with the following phrase: “Internal NPS Use Only – Not For Release.”

Voucher Specimens

Specimens of protected taxa should only be collected as allowed by law. Labels for specimens should be clearly labeled as containing sensitive information by containing the following phrase: “Internal NPS Use Only – Not For Release.” These specimens should be stored separately from other specimens to prevent unintended access by visitors. As with any sensitive information, a

confidentiality agreement should be in place prior to sending these specimens to another non-NPS cooperator or collection.

Procedures for Coordinate Offsets

1. Process GPS data, upload into the database, and finalize coordinate data records. Update tbl_Coordinates.Is_best as appropriate, especially where there is more than one set of coordinates per sample location.
2. Set the minimum and maximum offset distances (project-specific, typically up to 2 km).
3. Apply a random offset and random azimuth to each unique set of coordinates.
4. Coordinates may then be either rounded or truncated so the UTM values end in zeros to give a visual cue that the values are not actual coordinates.
5. Do not apply independent offsets to clustered or otherwise linked sample locations (e.g., multiple sample points along a transect). Instead, either apply a single offset to the cluster so they all remain clustered after the offset is applied, or apply an offset to only one of the points in the cluster (e.g., the transect origin) and store the result in the public coordinates for each point in that cluster.
6. These "public" coordinates are then the only ones to be shared outside NPS – including all published maps, reports, publications, presentations, and distribution copies of the data set – in the absence of a confidentiality agreement.

The following components can be used to create individual offsets rounded to the nearest 100 m in Microsoft Excel:

- Angle = rand() * 359
- Distance = ((Max_offset – Min_offset) * rand() + Min_offset)
- Public_UTME = Round(UTME_final + (Distance * cos(radians(Angle – 90)), -2)
- Public_UTMN = Round(UTMN_final + (Distance * sin(radians(Angle + 90))), -2)

Sharing Sensitive Information

Note: Refer to **SOP 18: Product Delivery, Posting and Distribution** for a more complete description of how to post and distribute products, and to keep a log of data requests.

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.

<u>Responding to Data Requests</u>

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 (e.g., the full data set that includes sensitive information) may only be shared after a confidentiality agreement is established between NPS and the agency,

organization, or person(s) with whom the sensitive information is to be shared. All data requests will be tracked according to procedures in **SOP 18: Product Delivery, Posting and Distribution**.

Once a confidentiality agreement is in place, products containing sensitive information may be shared following these guidelines:

- Always clearly indicate in accompanying correspondence that the products contain sensitive information, and specify which products contain sensitive information.
- Indicate in all correspondence that products containing sensitive information should be stored and maintained separately from non-sensitive information, and protected from accidental release or re-distribution.
- Indicate that NPS retains all distribution rights; copies of the data should not be redistributed by anyone but NPS.
- Include the following standard disclaimer in a text file with all digital media upon distribution: "The following files contain protected information. This information was provided by the National Park Service under a confidentiality agreement. It is not to be published, handled, re-distributed or used in a manner inconsistent with that agreement." The text file should also specify the file(s) containing sensitive information.
- If the products are being sent on physical media (e.g., CD or DVD), the media should be marked in such a way that clearly indicates that media contains sensitive information provided by the National Park Service.

Confidentiality Agreements

Confidentiality agreements may be created between NPS and another organization or individual to ensure that protected information is not inadvertently released. When contracts or other agreements with a non-federal partner do not include a specific provision to prevent the release of protected information, the written document must include the following standard Confidentiality Agreement:

> **Confidentiality Agreement -** I agree to keep confidential any protected information that I may develop or otherwise acquire as part of my work with the National Park Service. I understand that with regard to protected information, I am an agent of the National Park Service and must not release that information. I also understand that by law I may not share protected information with anyone through any means except as specifically authorized by the National Park Service. I understand that protected information concerns the nature and specific location of endangered, threatened, rare, commercially valuable, mineral, paleontological, or cultural patrimony resources such as threatened or endangered species, rare features, archeological sites, museum collections, caves, fossil sites, gemstones, and sacred ceremonial sites. Lastly, I understand that protected information must not be inadvertently disclosed through any means including websites, maps, scientific articles, presentation, and speeches.

Note: Certain states, including the State of Washington, have sunshine laws that do not have exemptions for sensitive information. NPS should not create confidentiality agreements or share sensitive information with these states without first seeking the advice of an NPS solicitor.

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.

Literature Cited

National Park Service. 2006. Management policies. Available at: http://www.nps.gov/policy/mp/policies.html (accessed 5 May 2010).

SOP 20: 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 Alpine and Subalpine Vegetation 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:

1. Draft documents – Documents that have been drafted or revised but have not been reviewed and approved yet.
2. Review documents – Draft documents that have been sent out for peer review or administrative review.

3. 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.
4. Inactive documents – Older versions of approved protocol components that are no longer in active implementation.
5. 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.
6. 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 are 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_Subalpine_Protocol_DRAFT_20100523.doc for the review draft on 5/23/2010).

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 prior to making modifications. It is especially 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.

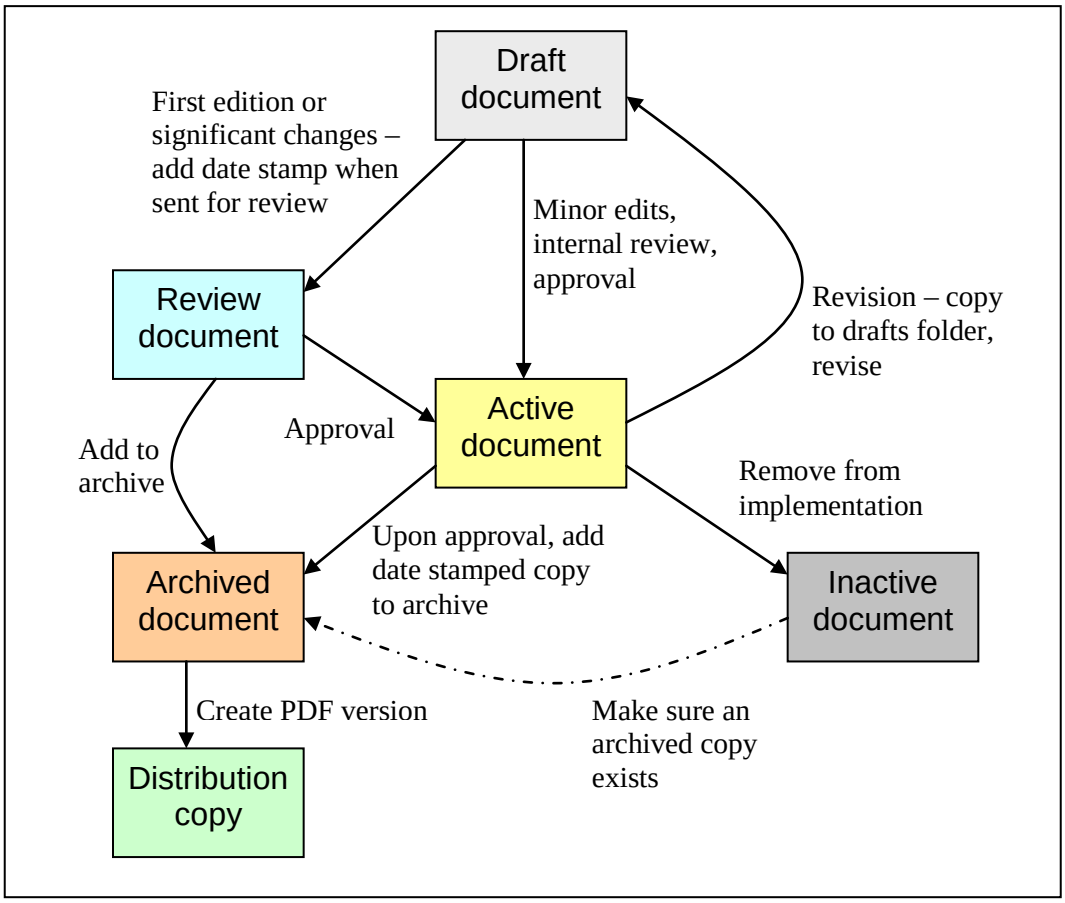


Figure 20.1. Process for creating and revising protocol documents. Boxes represent document life cycle stages, and connecting arrows indicate procedures.

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 20.1, 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 above), 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.

SOP 21: Data Analysis

Prepared by: Regina M. Rochefort, NPS NCCN-NOCA and Shay Howlin, WEST, Inc., Cheyenne, WY.

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This SOP provides an overview to the approach that will be used in data handling, analyses, and the development of annual and five-year reports for alpine and subalpine vegetation and whitebark pine stands. Three sources of data are available to investigate status and trends of vegetation in the alpine treeline ecotone of MORA, NOCA, and OLYM. Data are primarily sourced within a probability-based sample design (i.e. GRTS) that is the core of this protocol. The target population for this sample design includes locations of alpine and subalpine vegetation and whitebark pine stands that can be safely accessed by crews traveling on foot within a reasonable amount of time (i.e., within 1.5 km of trails and roads where the slope is ≤35° as described in **Appendix E**). Sample sizes for analysis of status and trends of alpine and subalpine vegetation and whitebark pine populations are summarized in Table 21.1.

Table 21.1. Summary of sample sizes for data analysis.

Monitoring Objective	Sample Size for Region of Inference		
	MORA	NOCA	OLYM
Alpine vegetation	20-30	20-30	20-30
Subalpine Vegetation	20-30	20-30	20-30
Whitebark pine	24	24	5-10

The other two sources of data are two legacy monitoring studies which will be continued as part of the monitoring protocol to assist in interpretation of long term trends. The first study includes permanent plots established along four alpine ridges in MORA by Dr. Ola Edwards (ca. 1983). The second study was initiated in 2004 to monitor whitebark pine in MORA and NOCA (as described in **Appendix B**). Locations of the Edwards plots were subjectively selected, and thus cannot be used to make inferences to the alpine vegetation across the park; nonetheless, these plots can provide key insights on long term changes in high elevation vegetation. Even though the whitebark pine monitoring sites were selected using a random design, and thus having inference to a wider population, the sample frame was based on the mapped distribution of whitebark pine within each park. Distribution maps for MORA were developed in 1936 (NPS

1936), and maps for NOCA were established based on volunteer observations. Following the establishment of these plots, we found additional populations of whitebark pine that were not in our sample frame. Therefore, we decided to establish new monitoring sites using the GRTS sample frame to provide a wider geographic range of inference. Legacy alpine and whitebark pine plots will be monitored twice, at interval years five and ten, data will be analyzed and trends in historic plots will be qualitatively compared with those displayed in the GRTS sample.

Annual Reports

Due to the short field season and hiking distance to the high-elevation plots, establishment of the permanent monitoring plots may take 3-5 years. During this establishment phase, annual reports will chronicle the plots established in each park by vegetation type (i.e., alpine, subalpine, or whitebark pine) by providing descriptive statistics of each response parameter and environmental variable (see Table 2, Table 21.2, and Table G.1 in **Appendix G).** The basic estimates of current status will include calculating the mean, standard deviation, range, and coefficient of variation (CV = standard deviation / mean). Estimates of the variation in a parameter are the standard deviation and CV of the individual parameter values. A 95% confidence interval for the true mean response can be made using normal approximations if the measurements are approximately normally distributed. If a particular response is not approximately normal, bootstrap methods (Manly 1997) should be employed to construct appropriate confidence intervals.

Data quality will be checked during the data entry and processing, review, and certification steps (see Chapter 4 Data Management, Analysis and Reporting and **SOP 18: Product Delivery, Posting and Distribution**) and as annual report summaries are produced. Graphical exploration of data will be used to visualize the patterns in vegetation, check distribution patterns (i.e., normality of data, e.g. Figure 21.1), and to communicate these patterns to the public and park staff (e.g., Figures 21.2 and 21.3).

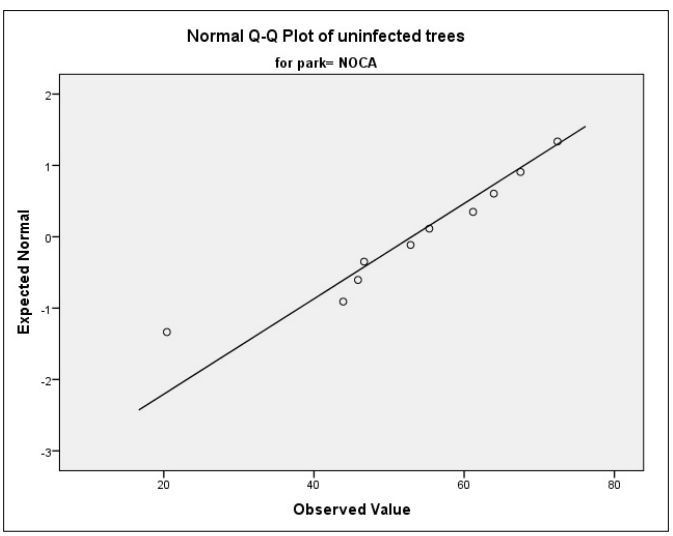


Figure 21.1. A normal probability plot illustrating quantiles of whitebark pine data compared with the quantiles of a standard normal distribution. Normality of data distribution is assumed because the points in the graph roughly follow a straight line, however a formal test of normality (e.g. Kolmogorov-Smirnov or Shapiro-Wilk) should also be performed.

Table 21.2. Summary of response variables, units and analysis methods for vegetation analysis.

Response Variables	Raw / Derived	Units or Index	QA/QC	Analysis Level	Statistical Tests
Objectives 1 and 2: Composition and structure of subalpine and alpine vegetation					
Surface cover of rock, gravel, bare soil, litter and dead plants, moss and lichen, and vascular plants	Raw	%	Sum of all 6 categories, in each quadrat, should add up to 100%	Plot, subalpine or alpine, and park	Status: Descriptive statistics, community analysis Trends: linear mixed regression model
Relative cover by growth form: trees, shrubs, forbs, sedges, grasses, moss and lichens	Derived	%	Proportions of growth forms within each plot should add to 1	Plot, subalpine or alpine, and park	Status: descriptive statistics, community analysis Trends: linear mixed regression model Multivariate: community analysis
Native species richness	Derived	#	Count all species in plot, data sheet should have cover entry for each quadrat	Plot, subalpine or alpine, park	Status: Descriptive statistics Trends: linear mixed regression model
Exotic species richness	Derived	#	Count all species in plot, data sheet should have cover entry for each quadrat	Plot, subalpine or alpine, park	Status: Descriptive statistics Trends: linear mixed regression model
Identity of exotic species present	Raw	Categorical	Species list	Plot, subalpine or alpine, park	NA
Seedling number	Raw	Species	Count seedlings in each quadrat, data sheet should have an seedling entry for each quadrat	Plot, subalpine or alpine, park	Status: Descriptive statistics
Cover of individual species (vascular plants)	Raw	%	Value in quadrat data entry for each vascular species present	Plot, subalpine or alpine, park	Status: Descriptive statistics, community analysis Trends: linear mixed regression model Multivariate: community analysis
Plot classification (alpine or subalpine)	derived	%	All plots were classified as for classification as alpine, subalpine, or forest	Park	Status: Descriptive statistics Trends: Chi-square to detect change in plot classification

Table 21.2. Summary of response variables, units and analysis methods for vegetation analysis (continued).

Response Variables	Raw / Derived	Units or Index	QA/QC	Analysis Level	Statistical Tests
Plot elevation	Raw	m	Elevation is calculated in office from GIS location of plot	Subalpine or alpine zone within park	Status: average and range
Species frequency counts	Derived	%	Each species recorded in plot must have an entry in each quadrat.	Plot	NA
Relative frequency	Derived	%	Divide species frequency by total frequency. Sum of all species should be 100%.	Plot	Trends: linear mixed regression model
Objective 3: Composition and structure of alpine legacy plots					
Surface cover of rock, gravel, bare soil, litter and dead plants, moss and lichen, and vascular plants	Raw	%	the sum of all 6 categories, in each quadrat, should add up to 100%	Plot	Status: Descriptive statistics, community analysis Trends: linear mixed regression model Multivariate, community analysis
Relative cover by growth form: trees, shrubs, forbs, sedges, grasses, moss and lichens	Derived	%	Proportions of growth forms within each plot should add to 1	Plot	Status: descriptive statistics, community analysis Trends: linear mixed regression model Multivariate: community analysis
Native species richness	Derived	#	Count all species in plot, data sheet should have cover entry for each quadrat	Plot	Status: Descriptive statistics Trends: linear mixed regression model
Exotic species richness	Derived	#	Count all species in plot, data sheet should have cover entry for each quadrat	Plot	Status: Descriptive statistics Trends: linear mixed regression model
Identity of exotic species present	Raw	Categorical	Species list	Plot	NA

Table 21.2. Summary of response variables, units and analysis methods for vegetation analysis (continued).

Response Variables	Raw / Derived	Units or Index	QA/QC	Analysis Level	Statistical Tests
Seedling number	Raw	Species	Count seedlings in each quadrat, data sheet should have an seedling entry for each quadrat	Plot	Status: Descriptive statistics Trends: linear mixed regression model
Cover of individual species (vascular plants)	Raw	%	Value in quadrat data entry for each vascular species present	Plot	Status: Descriptive statistics, community analysis Trends: linear mixed regression model Multivariate: community analysis
Objective 4: Soil temperature and snow cover					
Hourly temperature	Raw	ºC	-40ºC>value<50ºC	Plot, subalpine or alpine	NA
Mean daily temperature	Derived	ºC	Mean of 24 hourly records from 1:00 to 24:00 hrs	Plot, subalpine or alpine	NA
Minimum daily temperature	Derived	ºC	Min of 24 hourly record	Plot, subalpine or alpine	NA
Maximum daily temperature	Derived	ºC	Max of 24 hourly record	Plot, subalpine or alpine	NA
Mean annual temperature	Derived	ºC	Mean of hourly record from Jan 1-Dec 31	Plot, subalpine or alpine	Trends: linear mixed regression model
Maximum annual temperature	Derived	ºC	Max of hourly record from Jan 1-Dec 31	Plot, subalpine or alpine	Trends: linear mixed regression model
Minimum annual temperature	Derived	ºC	Min of hourly record from Jan 1-Dec 31	Plot, subalpine or alpine	Trends: linear mixed regression model
Number of days above 38ºC in a given year	Derived	ºC	Count of days between Jan 1-Dec 31 where max daily temperature >38ºC	Plot, subalpine or alpine	Trends: linear mixed regression model

Table 21.2. Summary of response variables, units and analysis methods for vegetation analysis (continued).

Response Variables	Raw / Derived	Units or Index	QA/QC	Analysis Level	Statistical Tests
First/last date of snow cover	Derived	Julian day	First/last dates of continuous snow cover. Snow cover is present when standard deviation in daily temperature=0ºC	Plot, subalpine or alpine	Trends: linear mixed regression model
Number of days of continuous snow cover	Derived	Days	Julian date of last snow cover Julian day -first snow cover	Plot, subalpine or alpine	Trends: linear mixed regression model
First/last date of hard freeze	Derived	Dates	First/last dates where minimum hourly temperature >-3ºC	Plot, subalpine or alpine	Trends: linear mixed regression model
First/last date of snow cover	Derived	Julian day	First/last dates of continuous snow cover. Snow cover is present when standard deviation in daily temperature=0ºC	Plot, subalpine or alpine	Trends: linear mixed regression model
Accumulated growing degree days	Derived	Growing degree days	Use base of 0ºC; sum of (mean daily temperature-base) for days when mean>0ºC	Plot, subalpine or alpine	Trends: linear mixed regression model
Diurnal temperature range	Derived	ºC	Difference between daily max and min temperatures	Plot, subalpine or alpine	Trends: linear mixed regression model
Objective 5: Whitebark Pine					
% Uninfected, % Infected, % Dead	Derived	%	Each tree must have a rating of D or L and A or I for blister rust	Trees, saplings and seedlings by plot, park	Status: descriptive Trends: ANOVA for change after two years, generalized linear regression for trends

Table 21.2. Summary of response variables, units and analysis methods for vegetation analysis (continued).

Response Variables	Raw / Derived	Units or Index	QA/QC	Analysis Level	Statistical Tests
Whitebark pine – diameter, height	Raw	m, cm	Each tree must have an entry	Trees, saplings and seedlings by plot, park	Status: descriptive analysis Trends: linear mixed regression model
All tree species	Raw and derived (basal area)	# trees/ha, sq. m.	Each tree in plot must be identified to species and have measurement, only live trees used.	Trees, saplings and seedlings by plot, park	Status: descriptive analysis Trends: Multivariate methods to describe community and detect change over time and between parks

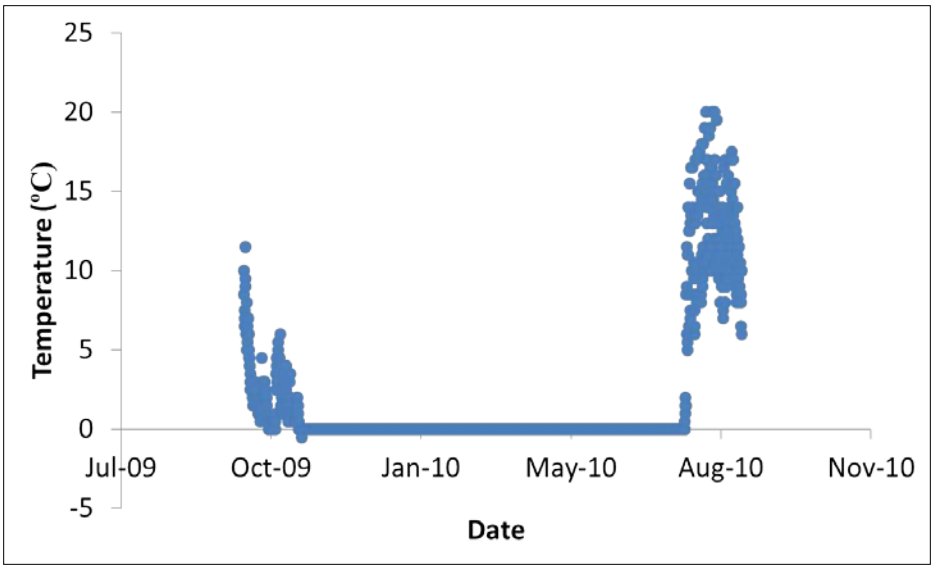


Figure 21.2. Soil temperatures resulting from an alpine site in Mount Rainier National Park illustrating changes in soil temperatures resulting from changes in snow cover (provided by Kevin Ford, University of Washington). Soil temperatures are stable (0ºC) when snow covers the site.

Soil temperatures illustrate growing season conditions in the root zone of alpine plants but are also used to estimate the length of the growing season (Figure 21.2) and identify the period of snow cover. Snow cover is an important limiting factor in the distribution of trees in the alpine treeline ecotone. Documentation of the length and period of snow cover are important explanatory factors in understanding tree distribution and growth forms in high elevation areas. As climate warms, changes in both length and timing of snow-free periods are expected to change. Soil temperatures will be monitored with data loggers at several locations within a plot. During the first two seasons of protocol implementation, five data loggers will be installed in each plot (Lundquist and Lott 2008). During the second season, data loggers installed during year one will be retrieved and data will be reviewed to determine sample size (i.e., we may reduce the sample size to two loggers per plot based on heterogeneity of the data).

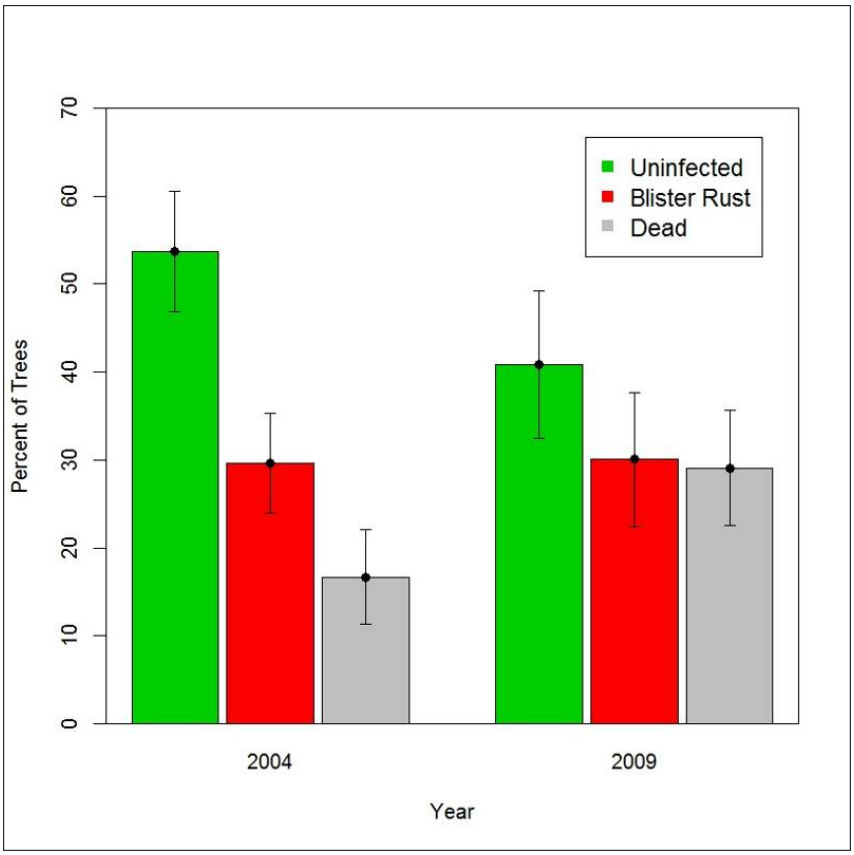


Figure 21.3. Bar graph illustrating status and change in condition of NOCA whitebark pine stands between 2004 and 2009. Bars and lines illustrate means and standard errors.

The health or condition of whitebark pine trees can be most simply represented by the proportion of trees that are infected with blister rust, dead, or uninfected. Figure 21.3 shows an example of a bar graph that can be used either in communication with the public (e.g., Resource Briefs) or to begin statistical analysis of data. In this example, data will be examined to determine if the mean percent of trees infected with blister rust, dead or uninfected is significantly different between the two years using an ANOVA. Data will be tested to insure that they meet assumptions of the ANOVA (e.g., normal distribution and homogeneity of variances); if data do not meet these assumptions, they will be transformed or tested using a non-parametric test. In this specific case, the data did meet the assumptions of normality and homogeneity of variances.

Five-year Reports

Five year reports will evolve over time in implementing this protocol. The first five year report will be written after all plots have been established and surveyed just one time. This report will provide an opportunity to review and revise monitoring methods and to closely examine vegetation patterns within and among the three parks. We will continue to use descriptive statistics to summarize all parameters, but will also use linear mixed effect models or nonparametric equivalents to examine the differences in parameters between zones and parks. Models will contain fixed factors (e.g., park, elevation) and random factors (e.g., aspect, length of snow-free season). Multivariate methods, such as cluster analysis, ordination, and indicator

species analysis will use percent cover of all species to explore vegetation community structure (i.e., growth form) and composition and variation across parks and zones (McCune and Grace 2006). Differences in vegetation community structure and composition, both in time and space, will be tested using techniques such as multi-response permutation procedures (MRPP) analysis of similarity, or PerManova (McCune and Grace 2006). Changes in plot classifications (i.e., subalpine, alpine, and in the future, forest) will be tested using chi-square analysis (Elzinga et al. 1998) to provide an overview of changing park landscapes and treeline locations. We expect this analysis will be conducted after plots have been visited two times.

When plots have been resurveyed, we will test for change (i.e., two years of data) or trends (i.e., three or more years of data) in response variables. Trend analyses can be conducted with linear mixed regression models for all plots that have been visited at least twice. Assuming approximately normally distributed response values, the trend analysis proposed by Piepho and Ogutu (2002) views responses as repeated measures and estimates a mixed linear model. The form of the model is:

$$y_{ij} = \mu + w_j\beta + b_j + a_i + w_j t_i + c_{ij}$$

Where y_{ij} is the response on the *i*th plot during the *j*th year, w_j is the year covariate equal to the year that y_{ij} was recorded, μ is the fixed intercept parameter, β is the fixed overall slope parameter that we wish to make inference about, b_j is the random effect of the *j*th year, a_i and t_i are random effects of the *i*th plot, and c_{ij} is the random effect of plot and year combined (i.e., interaction). Using restricted maximum likelihood (REML), it is possible to obtain an estimate of the fixed overall slope parameter accounting for correlation in the random effects of year and plot and to test whether or not the slope is significantly different from zero. If the slope is significantly different from zero, significant trend has been detected. Regional differences in trends can also be evaluated in this model with the inclusion of a fixed region effect (e.g., group of parks) using weights based on the inclusion probability for each plot. The weights are inversely proportional to the fraction of sampled plots in each park. For cases of extremely non-normally distributed responses, permutation methods can assess the significance of β. Trends in legacy plots will be examined similarly but will not be pooled with the GRTS based samples.

To provide an example of this approach, we estimated the trend in the cover of flowering plants, using monitoring data from the legacy alpine plots on Muir Snowfield in MORA. We fit a Linear Mixed Model following Piepho and Ogutu (2002) to data collected between 1983 and 1994. Data collected in 1983 and 1984 were treated as one year for this analysis, as were data collected in 1990 and 1991. All plots were visited in 1994 (Table 21.3, Figure 21.4). Year was included as a fixed effect to test for linear trends and as a random effect to account for annual variation. With an unstructured variance-covariance matrix, the estimate of the trend slope is -0.036 (standard error = 0.344). The F statistic for the null hypothesis of trend equal to zero is 0.01, with a p-value equal to 0.9344. There is no evidence of a trend in percent cover of flowering plants in these data.

Table 21.3. Average cover of flowering plants in MORA legacy alpine plots.

Alpine Plot Number	% Cover of Flowering Plants		
	1983/4	1991/2	1994
Muir Snowfield 1	27.60	21.90	21.70
Muir Snowfield 2	14.00	12.45	21.18
Muir Snowfield 3	20.10	15.65	32.95
Muir Snowfield 4	6.22	11.30	10.85
Muir Snowfield 5	83.80	82.40	83.25
Muir Snowfield 6	45.55	27.02	33.90
Muir Snowfield 7	68.65	66.75	72.65
Muir Snowfield 8	48.30	51.55	57.40
Muir Snowfield 11	29.40	43.20	28.85
Muir Snowfield 12	65.40	48.80	59.00

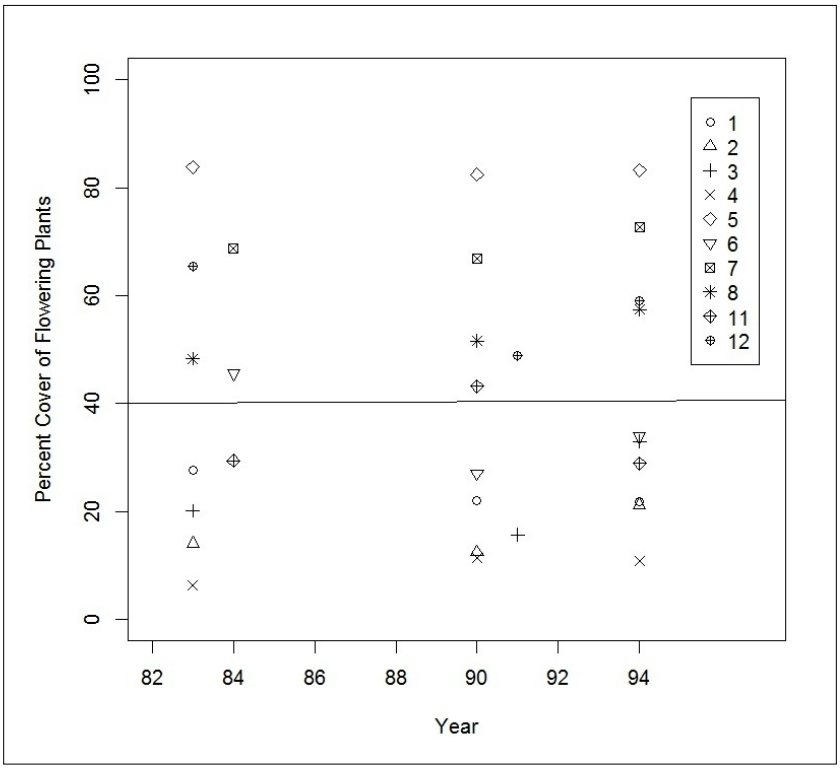


Figure 21.4. Average cover in flowering plants in Muir Snowfield alpine legacy plots between 1983 and 1994. The trend slope is not significant over this time period (p = 0.9344).

Literature Cited

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. BLM Technical Reference 1730-1. Denver, CO.

Kincaid, T., T. Olsen, D. Stevens, C. Platt, D. White, and R. Remington. 2009. spsurvey: Spatial survey design and analysis. R package version 2.1. Available at http://www.epa.gov/nheerl/arm/analysispages/software.htm (accessed 9 June 2011).

Lundquist, J. D., and F. Lott. 2008. Using inexpensive temperature sensors to monitor the duration and heterogeneity of snow-covered areas. Water Resources Research 44: W00D16, doi:10.1029/2008WR007035.

Manly, B. F. J. 1997. Randomization, bootstrap and Monte Carlo methods in biology, 2nd ed. Chapman and Hall, London, England.

McCune, B., and M. J. Mefford. 2006. PC-ORD. Multivariate analysis of ecological data. Version 5.06 MjM Software, Gleneden Beach, OR.

National Park Service (NPS). 1936. Vegetation cover survey for Mount Rainier National Park. National Park Service, Branch of Forestry, Civilian Conservation Corps. Published Report-132562.

Piepho, H. P., and J. O. Ogutu. 2002. A simple mixed model for trend analysis in wildlife populations. Journal of Agricultural, Biological and Environmental Statistics 7:350-360.

Stevens, D. L., and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics 14:593-610.

Appendix A. Administrative Record

The scoping, development, and submission of the Alpine and Subalpine Vegetation Protocol is summarized in Table A.1.

Table A1. Alpine and Subalpine Vegetation Protocol Administrative Record.

Date	Event	Discussion/Decision
November 15, 2001	Vegetation workgroup meeting	• Summarized all research and monitoring questions and identified priorities for vegetation workgroup: forests, subalpine, and prairies. Discussed whitebark pine and whether this should be incorporated within a high-elevation vegetation protocol or separately.
February 19, 2002	Vegetation workgroup meeting	• Developed a total of 19 monitoring questions that were divided into four general categories: system drivers (those critical processes or issues that have significant effects and/or are determining factors of vegetation); broad landscape level questions; community level questions; and questions related to specific vegetation types, communities or issues. Specific questions related to high-elevations: tree islands and changing species composition and community structure, rare species, introduced species, and human impacts.
November 2002	NPS NRAC meeting on Service-wide Comprehensive Call	• Submitted funding proposal to build on earlier whitebark pine surveys in MORA and NOCA. Proposal focused on collection of whitebark pine needles for surveys on genetic diversity and development of long-term monitoring methods. • Modified PNW CESU TA with Dr. Jean-Yves (Pip) Courbois to expand the scope of work from analyzing pilot MORA and NOCA whitebark pine data to developing sample size and sampling strategy for long-term monitoring of whitebark pine.
July-September 2003	Whitebark pine genetic surveys	• Received funding through NPS SCC and started collecting needles for genetic surveys in MORA and NOCA. • NPS developed Interagency Agreement with USFS Riverside Lab to conduct genetic testing and with Dorena Genetic Resource Center to start resistance screening.
June 30, 2004	Development of whitebark long-term monitoring design	• Began discussion with Robert Bennetts (YELL network), Michael Murray (CRLA), Steve Cherry (statistician, Montana State University), Pip Courbois, and Regina Rochefort on long-term monitoring in YELL and application to NCCN and CRLA.
July-September 2004	Whitebark pine genetic surveys and long-term monitoring protocol development	• USFS decided to also conduct genetic surveys. We partnered on collection on Olympic Peninsula. Continued with IAs with Riverside and Dorena Genetic Resource Center for genetic surveys and resistance screening. • Established whitebark pine permanent plots in MORA and NOCA with Dr. Courbois. Plot establishment was funded by USFS Forest Health program.
June 10, 2005	NCCN vegetation workgroup meeting	• Group decided to refocus our approach in subalpine and alpine areas. Rather than take the community-based approach we use for forests, we decided to monitor spatial patterns of vegetation within alpine and subalpine zones. The revised approach would constitute an assessment of changes in landscape patterns of alpine and subalpine plant communities. We arrived at this decision because plant associations would be different across the 3 high-elevation parks (MORA, NOCA, and OLYM) and we felt that spatial heterogeneity was a characteristic of this zone and as the zone became more homogeneous, this would be a change we would be interested in. Additionally, the statisticians advised us not to stratify based on community or associations which are likely to change.

Date	Event	Discussion/Decision
		• Discussed response variables (species richness, species frequency, species cover, tree frequency) and field methods (i.e., plot size) to accomplish this. Decided that Mignonne Bivin and crew would conduct pilot sampling in the 3 parks with various size plots and quadrats.
June- August 2005	Pilot data collection	Conducted pilot data collection to determine plot size and shape to capture the range of species diversity in OLYM and NOCA.
September 2005	Rocky Mountain I&M Alpine Monitoring meeting	• M. Bivin (NOCA) and L. Kurth (MORA) attend alpine scoping meeting organized by I&M people from the Rocky Mountain network to discuss issues in alpine zones and monitoring approaches
April 19, 2006	NCCN vegetation workgroup meeting and subsequent work with NCCN GIS staff	• At NCCN vegetation working group meeting developed definition for sample frame. • Subsequently worked with GIS staff to develop maps of subalpine and alpine areas in each park since we did not have adequate vegetation maps. We decided that we would use a union of Pacific Meridian and GAP analysis maps to identify a subalpine/alpine zone in each park. Then identified sample area and began checking maps with aerial photos.
March 11, 2008	NCCN vegetation workgroup meeting	• Revisited alpine/subalpine protocol since work on prairies and forests monitoring protocols was becoming less intense and we could concentrate our effort on alpine/subalpine. • Revisited alpine/subalpine maps and monitoring objectives. • Started summarizing pilot data
November 2008	NCCN vegetation workgroup meeting	• Reviewed budget for alpine/subalpine and GRTS points and monitoring objectives. • Completed analysis of pilot whitebark pine surveys and published in Natural Areas Journal.
Fall 2008	Subalpine/Alpine monitoring objectives	• Developed monitoring objectives. • Discussed stratifying the high-elevation zone into an alpine and a subalpine zone.
July-September 2009	Whitebark pine monitoring	• Re-inventoried all whitebark pine plots. • Entered data in YELL database and began summarizing data. • Received funding for YELL database revision for NCCN application through US Forest Health funds.
August 2009	Subalpine/Alpine zone delineation	Revised delineation with L. Grace. Began field review with aerial photos and some field review of maps.
November 2009	GRTS points	Received several versions of GRTS points from West review: one combined alpine/subalpine zone; two strata; and following our annual meeting an alpine/subalpine zone with a finer grid.
January 2010	NCCN 2009 annual meeting	• Presented objectives at NCCN meeting with overview of GRTS distribution. • Presented 5 objectives including GLORIA and whitebark pine. • Many NCCN biologists did not like our stratification based on elevation. • Following meeting decided to revise methods so we had one zone but would classify points into alpine and subalpine while in the field.
March-June 2010	Reconnaissance methods	• Developed criteria for GRTS review in both field and office and tested in office.
July – September 2010	Field review of GRTS	• Field crew reviewed GRTS points. • John Boetsch develop pilot database for storing data from field and office review of GRTS points.
August 2010	NCCN vegetation workgroup meeting	• Met in MORA at several field sites to review GRTS reconnaissance methods and data forms and to establish monitoring plot and discuss methods.

Date	Event	Discussion/Decision
May 2010	NCCN vegetation workgroup meeting with Mark Huff (Network Program Manager)	Reviewed monitoring objectives for alpine and subalpine monitoring. Discussed GLORIA methods and whether it had application to our sites. Decided to put it in as an optional method because other networks were using it, but it was not our first priority as it did not provide inference to park landscapes, which is important for applications to park management.
November 1, 2010	Submitted protocol	Submitted to Dr. Agee for peer Review
January 1, 2011	Received peer review comments	Received peer review comments from Dr. Agee and began working on suggested revisions
June 30, 2011	Submitted	Submitted revised document to Dr. Agee and Dr. Latham for review

Appendix B. Background of Whitebark Pine Protocol

Overview

Whitebark pine was recognized as an important component of high-elevation plant communities in MORA and NOCA during the late 1980s. At MORA, visitor inquiries about whitebark pine mortality in the Sunrise area led park resource specialists to consult with forest ecologists and air quality scientists to determine the cause of crown kill and tree mortality. Ultimately, white pine blister rust was identified as the stressor, rather than ozone, and the park initiated extensive surveys in collaboration with USFS Forest Pathologists Jerry Beatty and Jim Hadfield. Surveys were conducted from 1994-1998 in MORA and in 1999 in NOCA (Rochefort 2008). In 2003, the North Coast and Cascades Network (NCCN) identified whitebark pine as a potential vital sign for long-term monitoring. The NCCN vegetation working group decided to develop and implement long-term monitoring of whitebark pine in MORA and NOCA; monitoring in OLYM was not considered a priority due to the limited number and size of whitebark pine stands in the park. Sample design and plot methods were developed after reviewing inventory results and discussions with Dr. Michael Murray at Crater Lake National Park (Murray and Rasmussen 2000, 2003). Monitoring was implemented in 2004 and sites were revisited in 2009. During the development of the monitoring protocols for subalpine and alpine vegetation, NCCN staff discussed expanding the target population for whitebark pine to match that of the newly developed subalpine and alpine target population. Following this, we elected to select new sample sites, utilizing GRTS, in the same manner as the alpine/subalpine, resulting in a comprehensive approach to monitoring the alpine treeline ecotone. Appendix B provides a summary of the sample design and methodology for the original whitebark pine monitoring project that is referred to as legacy whitebark pine plots in this document.

Sample Design

We initially assembled maps of known locations of whitebark pine for each park. MORA's maps were based on a 1936 vegetation map (National Park Service 1936) that had been field-checked for relevancy during initial inventories. The results of these inventories documented that whitebark pine was still present in all sites although stand associations sometimes had changed (e.g., whitebark dominated stands were now often whitebark pine/subalpine fir stands). In NOCA, maps were assembled based on Agee and Kertis' (1986) cover type maps and reports of whitebark pine stands assembled from field staff; these observations were also field checked during our 1999 inventory. We decided that our sample unit would be a stand because: 1) travel time was a significant consideration for field crews, especially at NOCA and 2) we felt heterogeneity within stands (mapped as polygons) might be as much as between stands. Next we decided how many stands we thought we would be able to sample in each park per field season; 4-6 at NOCA and 8-10 at MORA. Then we calculated the number of plots per stand we would need to sample to estimate percent infection and mortality of whitebark pine, with precision levels of 0.01, 0.05, and 0.1 and power of 95% (Figures B.1, B.2). All calculations were based on the data we had collected during our initial surveys (Rochefort 2008).

After reviewing these data, we decided that we would sample 5 plots in each of 8 stands at MORA and 7 plots in each of 5 stands at NOCA (Figures B.3- B.17). We selected stands systematically, with a random, start in each park: 66 totals stands at MORA and 12 stands at

NOCA. Three polygons at NOCA were rejected because they were too far from trailheads for us to access; all polygons at MORA were utilized.

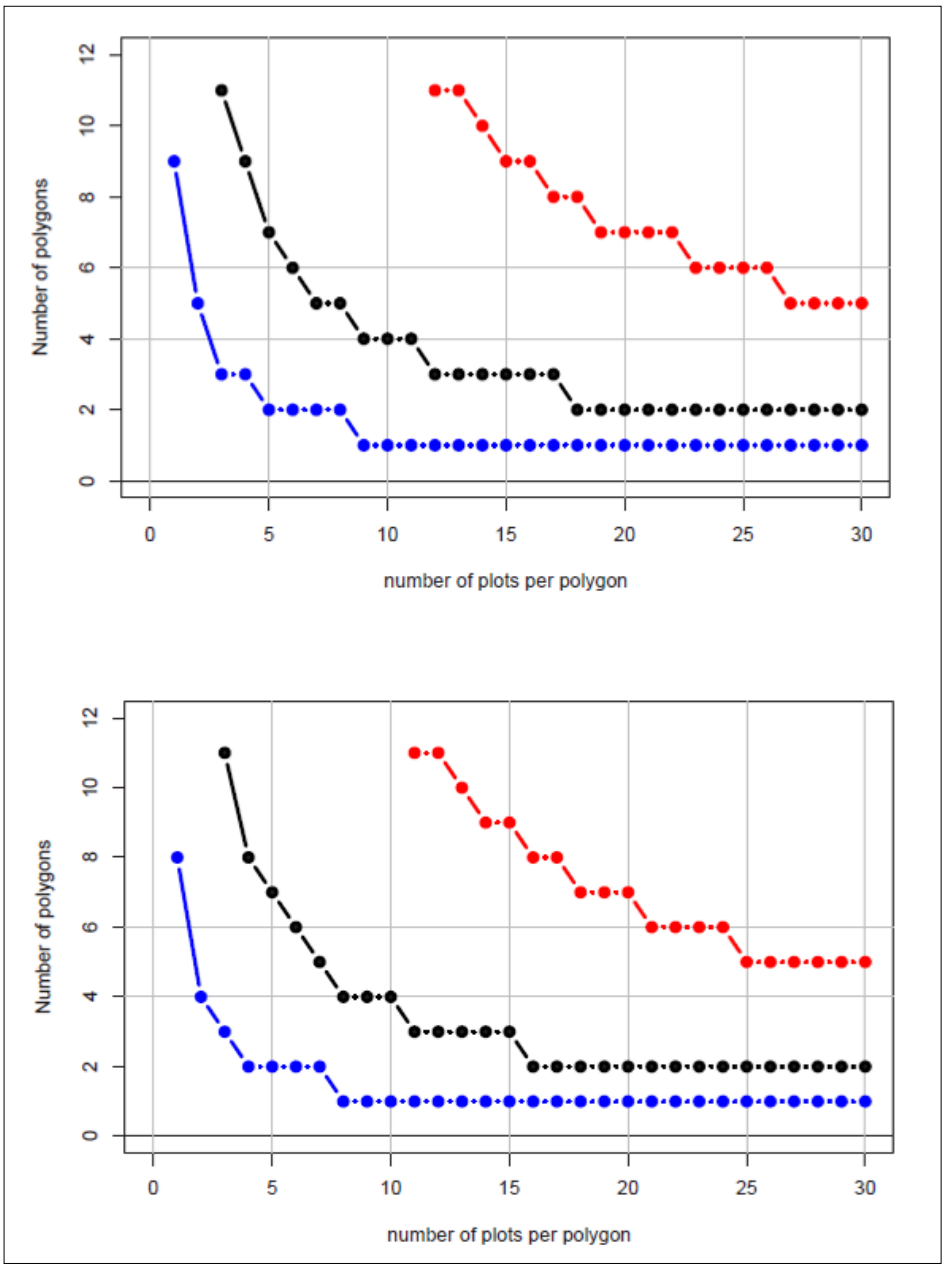


Figure B.1. Number of plots per polygon at NOCA to estimate mortality (top graph) and infection rates (bottom). Lines indicate three levels of precision: 0.05 (red), 0.1 (black), and 0.2 (blue). The gray horizontal lines are drawn at sample sizes of 4 and 6 polygons.

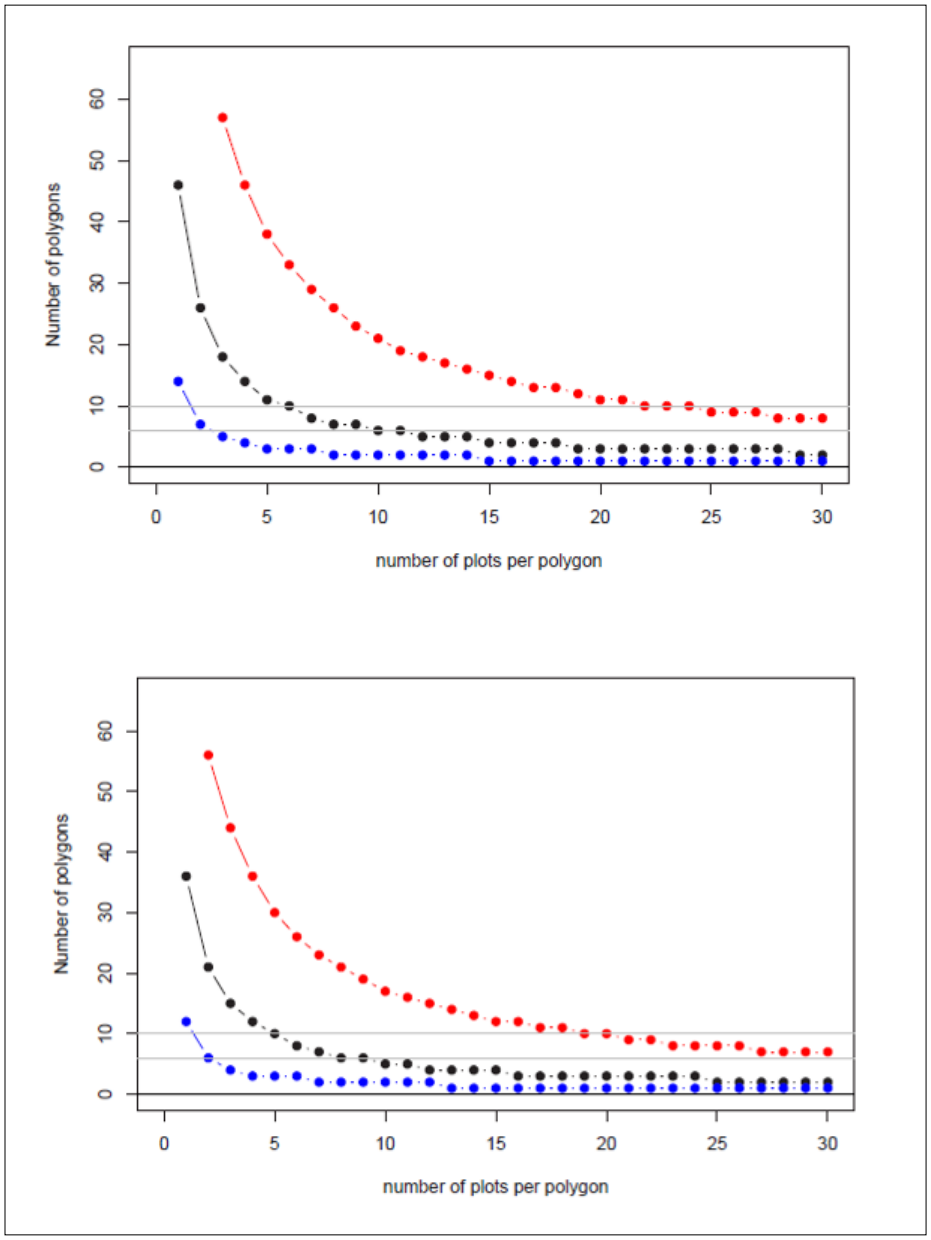


Figure B.2. Number of plots per polygon at MORA to estimate mortality (top graph) and infection rates (bottom). Lines indicate three levels of precision: 0.05 (red), 0.1 (black), and 0.2 (blue). The gray horizontal lines are drawn at sample sizes of 8 and 10 polygons.

Sample Site Selection and Plot Design

Within each polygon, 100 random points were distributed using ArcView 3.2 (ESRI 1999). Points were reviewed in the office for accessibility and safety and then were reviewed in the field in sequential order. Sites passed the field review if there was at least one living whitebark pine within the 11.3 m plot radius. If a plot center did not contain whitebark pine up to eight additional points (11.3 m from the original point) were evaluated: four cardinal and four ordinal directions, starting from a randomly selected direction, and proceeding clockwise. A plot was established at the first of these locations that was suitable. If no acceptable location was found the potential plot center was rejected and the next sequential point was checked. Due to the

sparse and clumped distribution patterns of whitebark pine, we often rejected the majority of random points in our polygons despite our rules for reviewing eight additional points.

Acceptable plots were marked with a rebar post and the location was recorded with a GPS unit. These files were downloaded to a desktop computer and the location data points corrected with GPS data from a surveyed ground station using Pathfinder software. The resulting point location was recorded and used to relocate the plot in future surveys.

Whitebark pine plots were 0.04 ha (11.3 m radius) and all trees (≥2.54 cm dbh) within the plot were measured (dbh and height) and examined for presence of fire scars, mountain pine beetle, and mistletoe. Whitebark pine trees were tagged and additionally examined for blister rust (cankers present on bole or branch), crown kill, and presence of cones. To increase the number of whitebark pine trees within our sample, if 30 whitebark pine trees were not found within the plot, crews would continue surveying trees outside the 11.3 m radius. Crews continued to walk counterclockwise, spiraling out, until they had surveyed (measured, tagged, and mapped) 30 whitebark pine trees or reached a maximum radius of 50 m. Within the 11.3 m radius plot, understory vegetation cover was estimated (in cover classes) and all seedlings (<50 cm in height) and saplings (≥50 cm in height and <2.54 cm dbh) were tallied. Whitebark pine saplings were also examined for presence of blister rust (cankers, chlorotic needles).

Summary

We established 29 plots in MORA and 35 plots in NOCA in 2004; all plots were resurveyed in 2009 (Table B.1). During the development of the sample frame and methods for monitoring herbaceous vegetation in the alpine treeline ecotone, we reviewed our methods and consulted with other Pacific West Region networks on whitebark pine sampling. During these discussions, we decided that revising our sample selection to a GRTS based design would allow more flexibility in the long-term and that with changing plant distributions or increased mortality in whitebark pine this might be advantageous. As a result, we altered our target and sample frame as discussed in this protocol (Chapter 2).

Table B.1. List of legacy whitebark pine plots.

Polygon/site	Code	Number of plots
MORA		
Antler Peak	AP	4
Crystal Ridge	CR	5
Fryingpan	FP	3
Glacier Basin	GL	5
Mystic Lake	ML	3
Skyscraper	SS	2
Sunrise Campground	SG	5
The Palisades	PA	2
NOCA		
Dee Dee Lake	DD	7
Juanita Lake	JL	7
Rainbow Lakes	RL	7
Rainbow Ridge	RR	7
Stiletto	ST	7

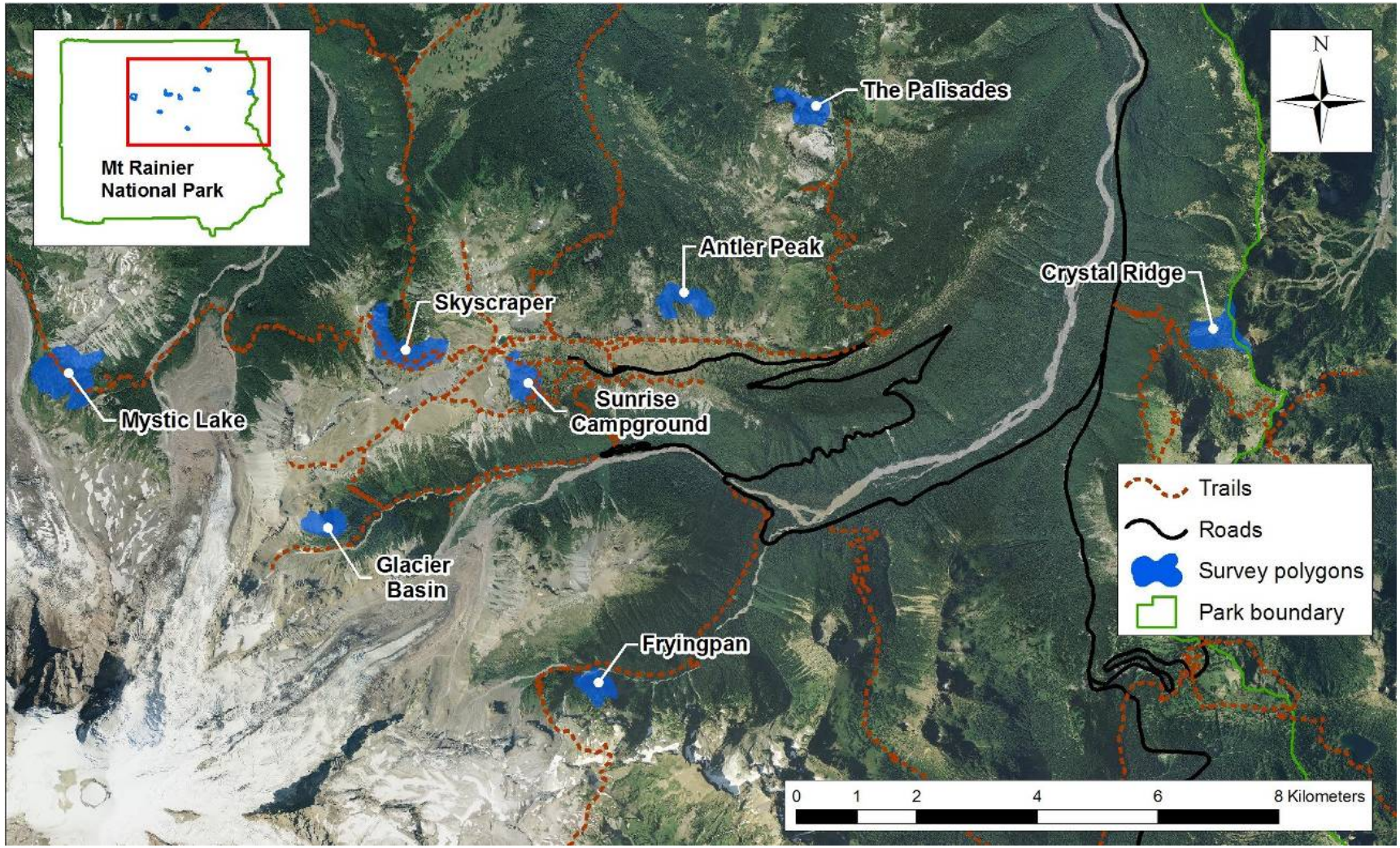


Figure B.3. Locations of legacy whitebark pine survey polygons in MORA.

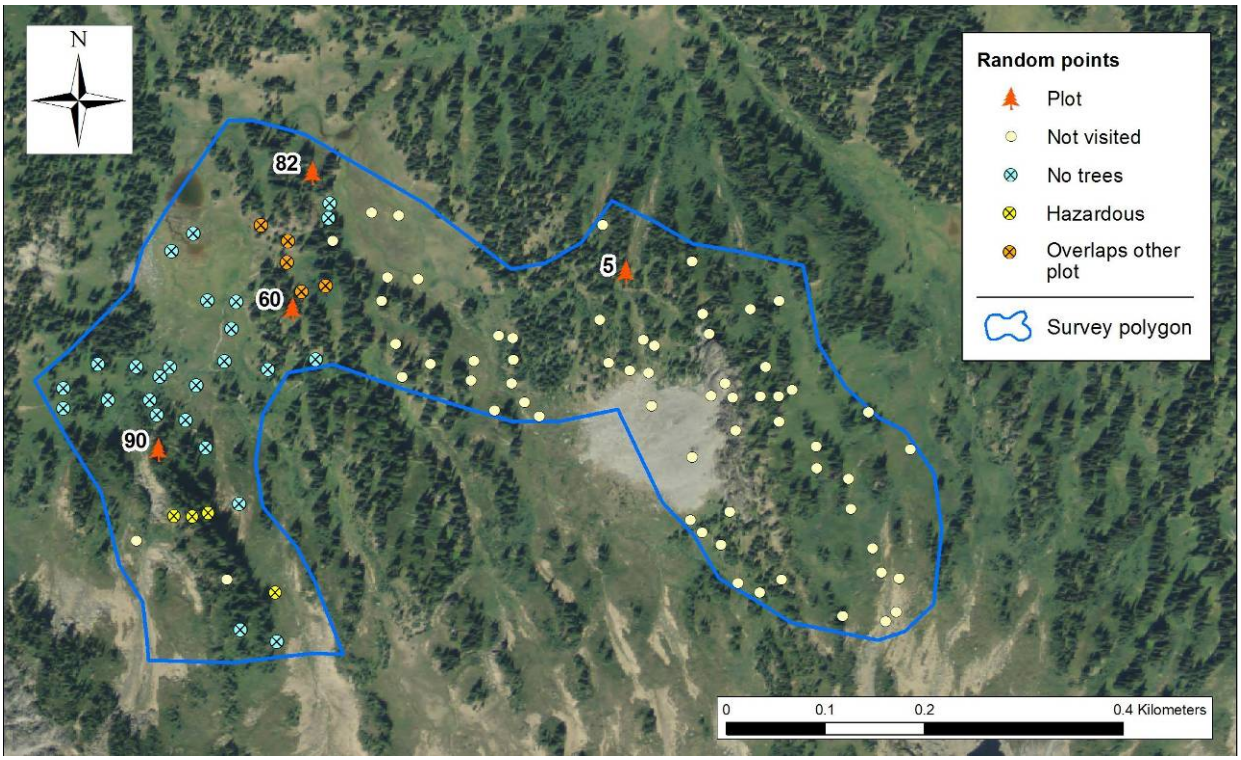


Figure B.4. Location of permanent plots in the Antler Peak (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

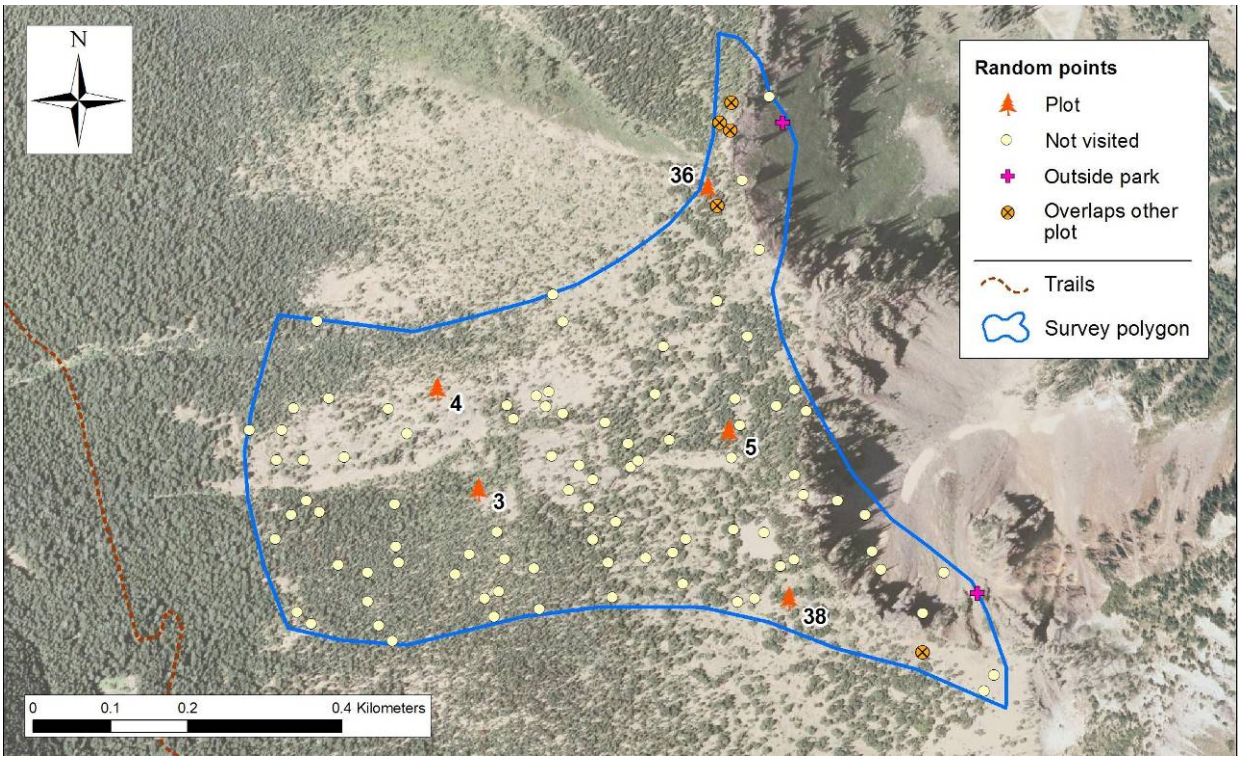


Figure B.5. Location of permanent plots in the Crystal Ridge (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

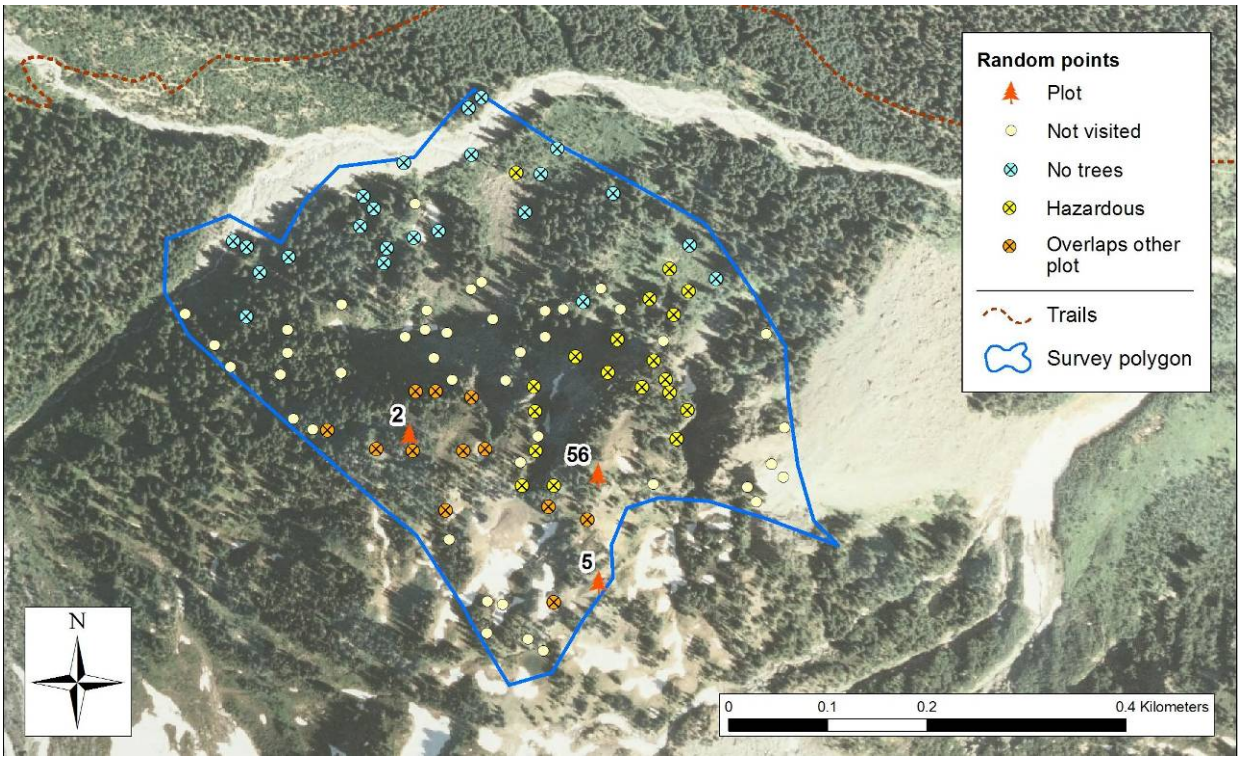


Figure B.6. Location of permanent plots in the Frying Pan (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

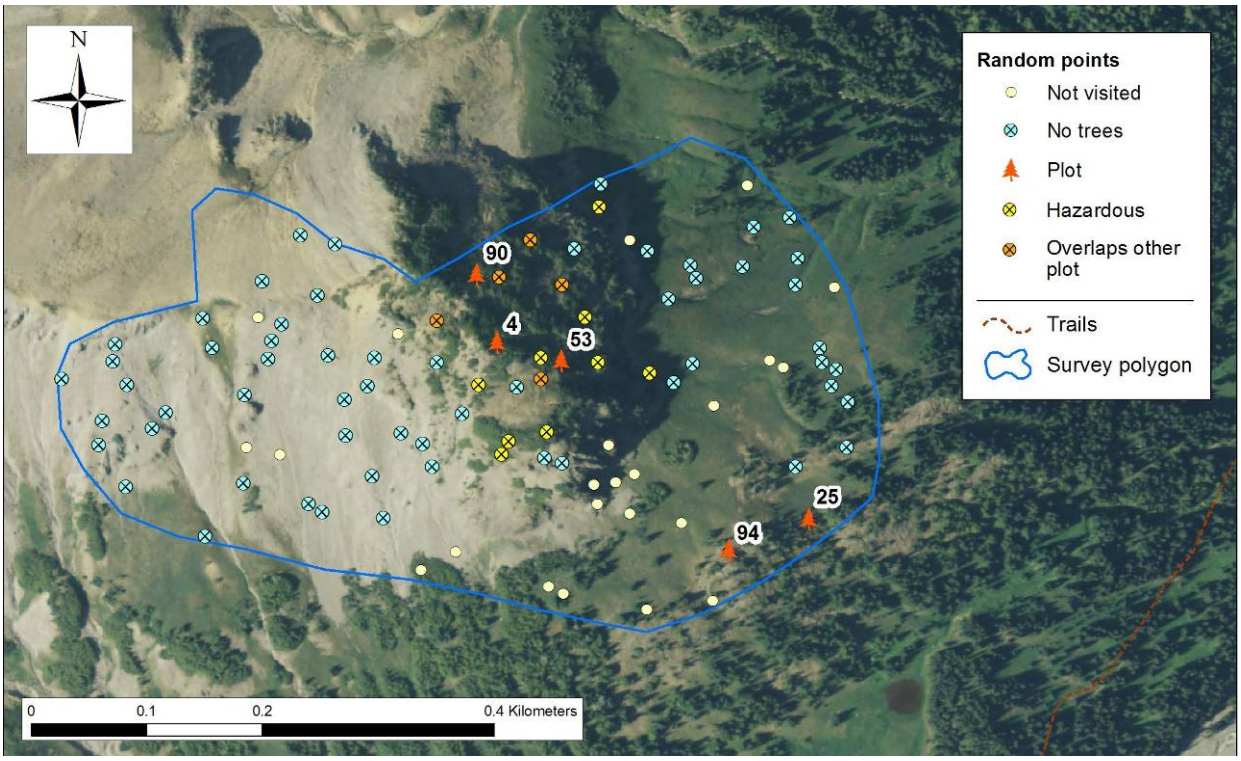


Figure B.7. Location of permanent plots in the Glacier Basin (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

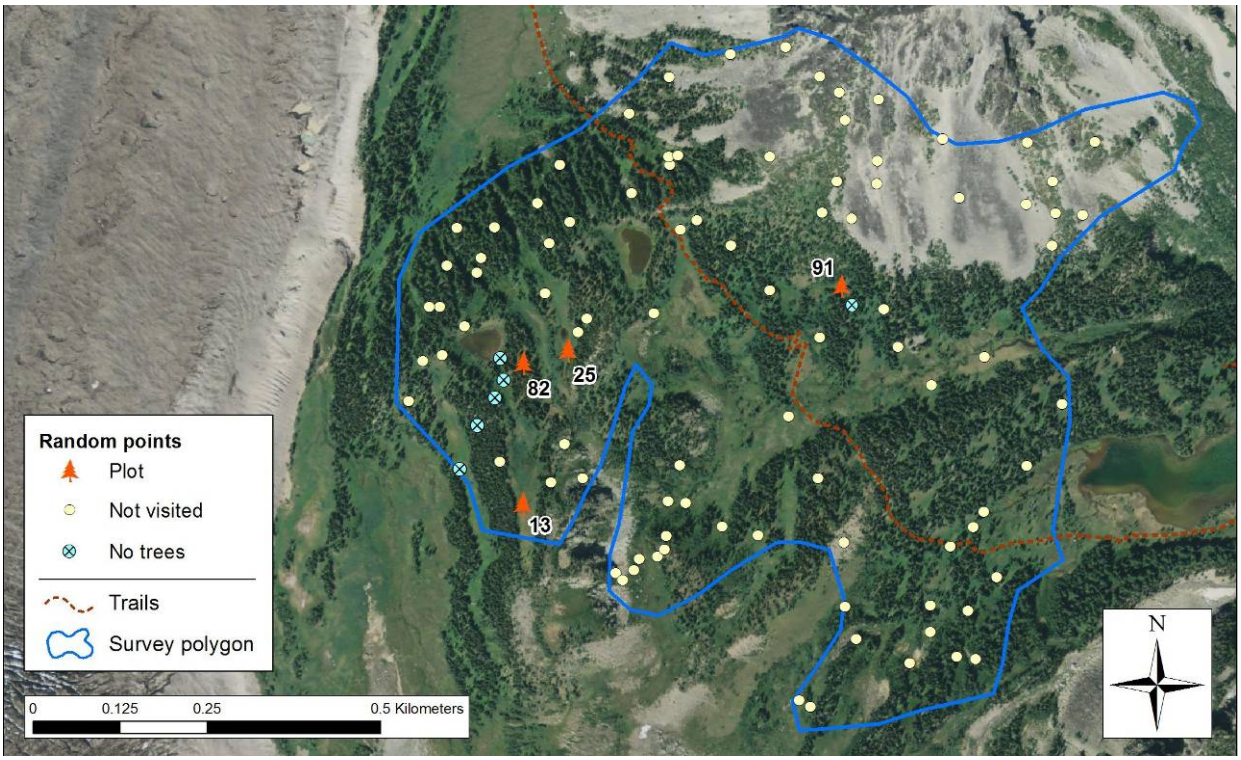


Figure B.8. Location of permanent plots in the Mystic Lake (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

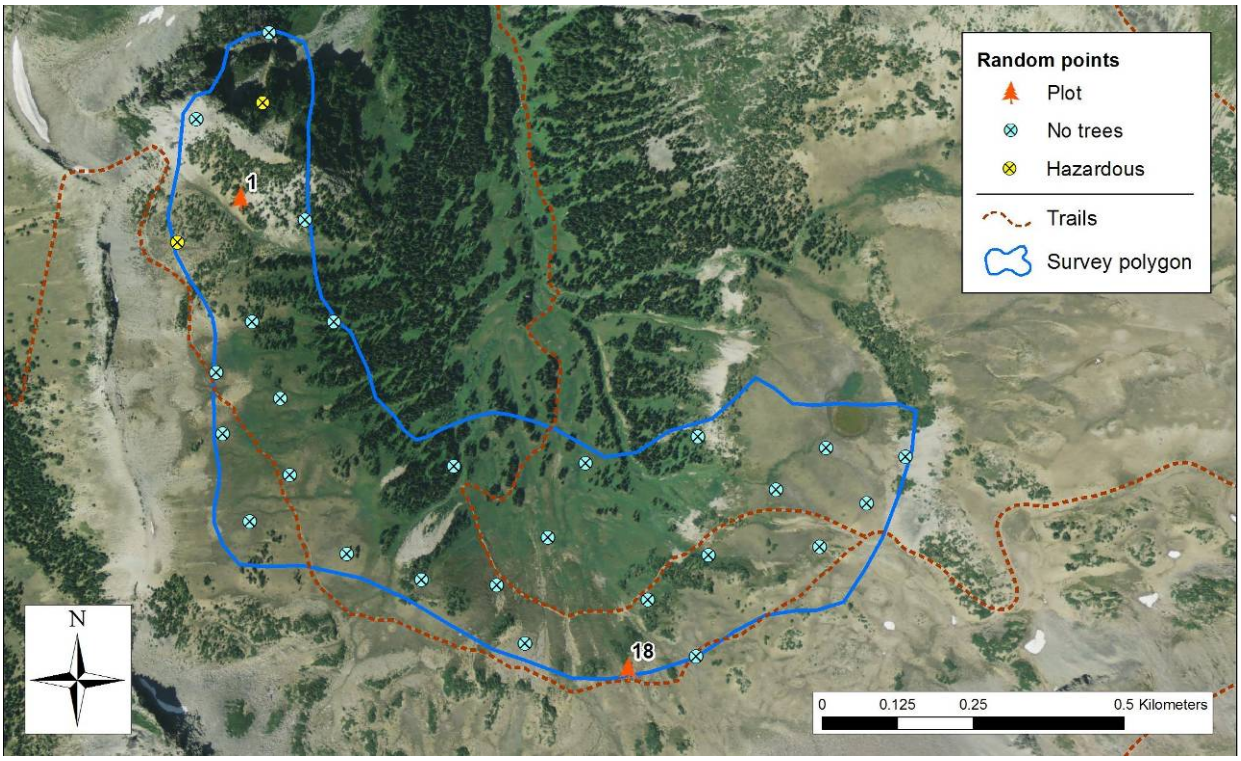


Figure B.9. Location of permanent plots in the Skyscraper (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

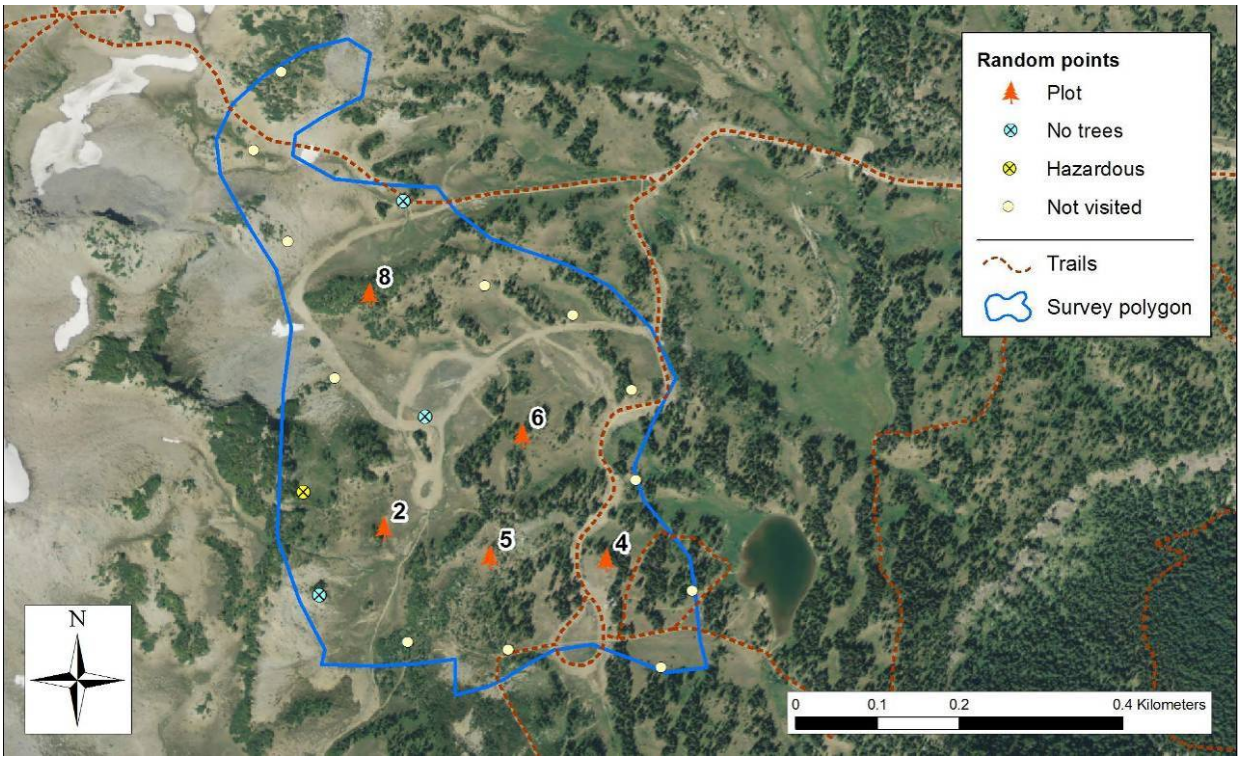


Figure B.10. Location of permanent plots in the Sunrise Campground (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

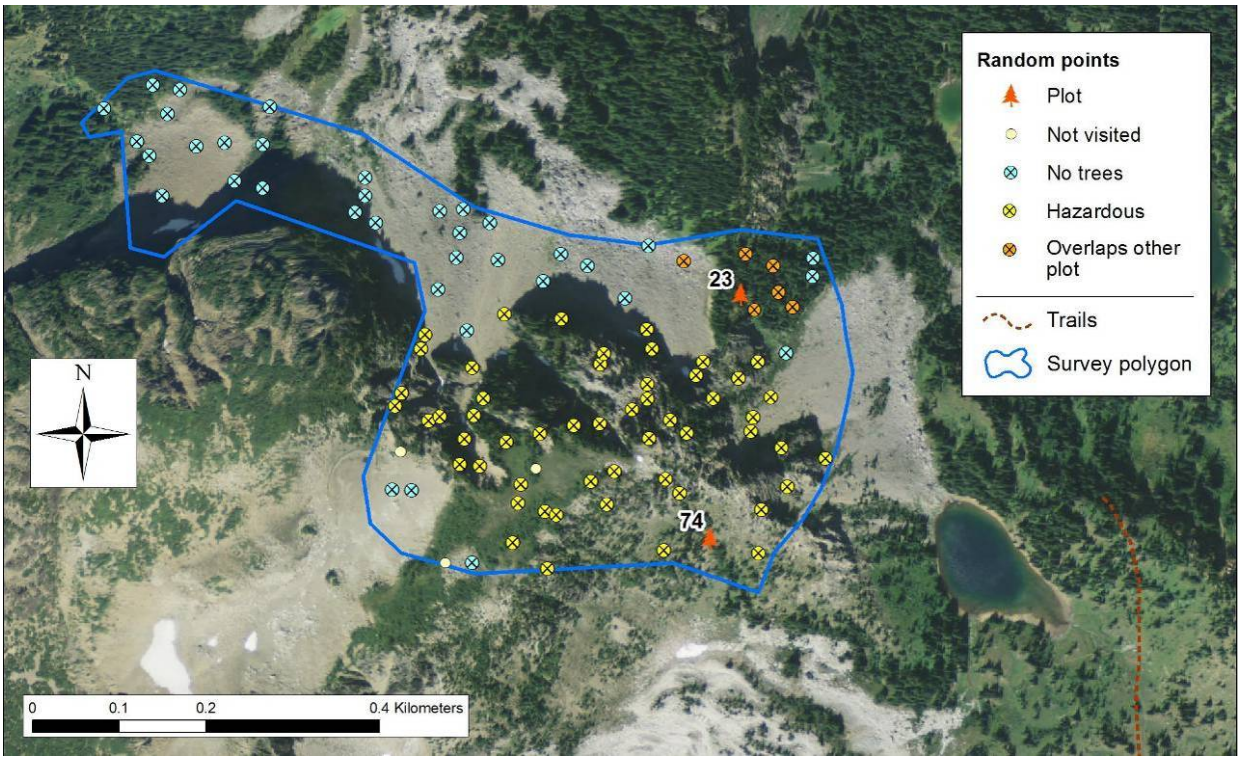


Figure B.11. Location of permanent plots in the Palisades (MORA) study area (polygon) and random points reviewed prior to sample site establishment.

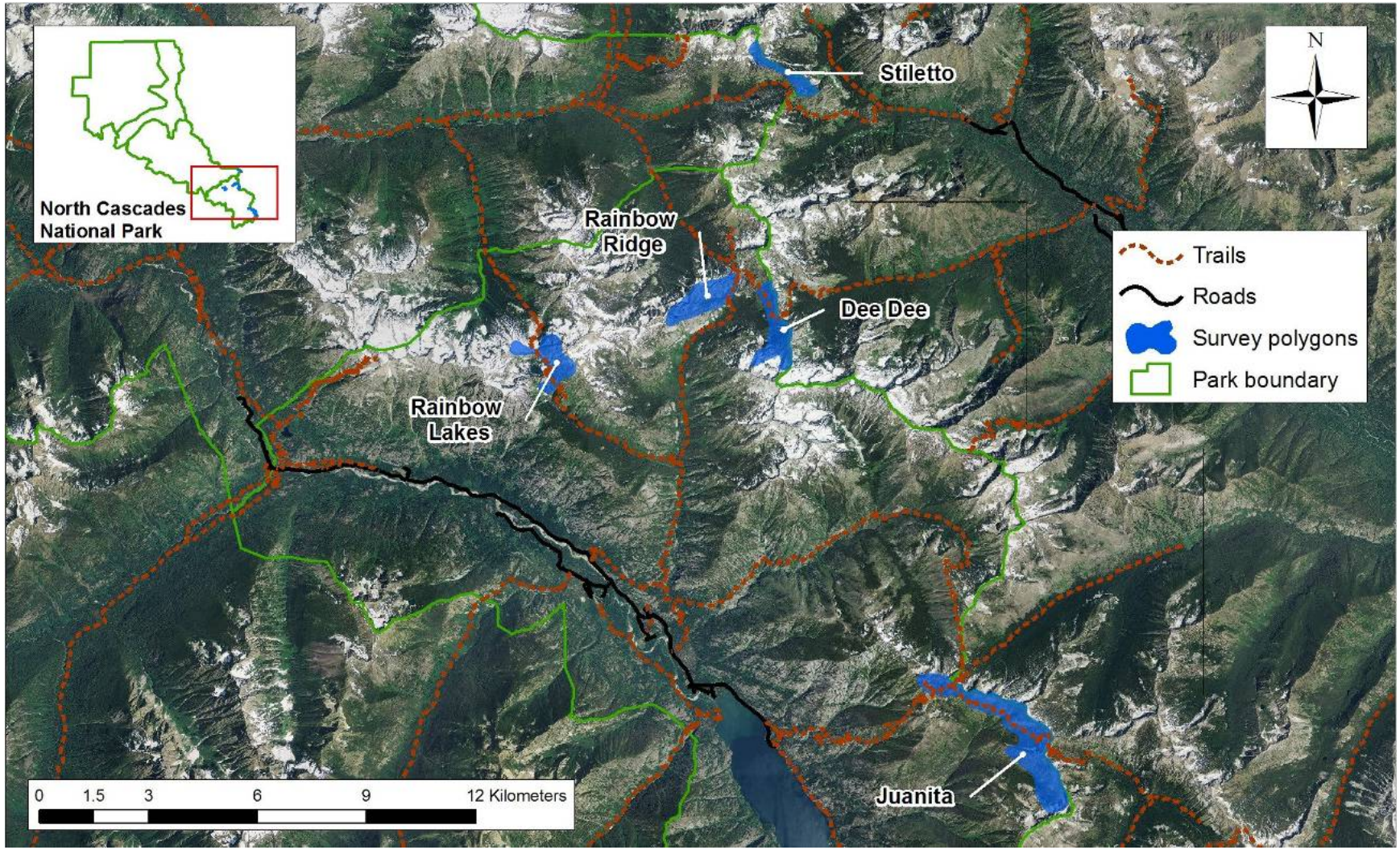


Figure B.12. Locations of legacy whitebark pine survey polygons in NOCA.

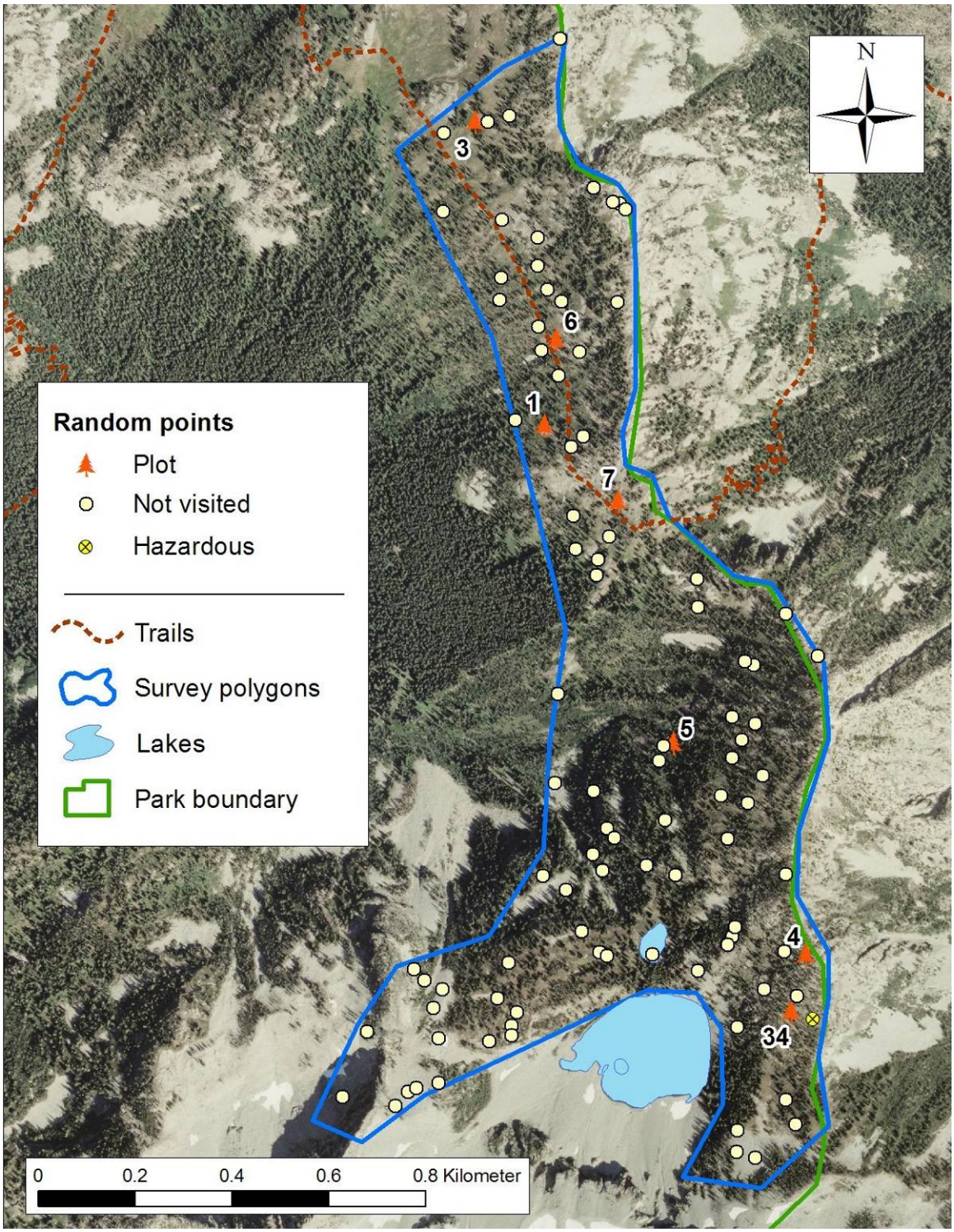


Figure B.13. Location of permanent plots in the DeeDee (NOCA) study area (polygon) and random points reviewed prior to sample site establishment.

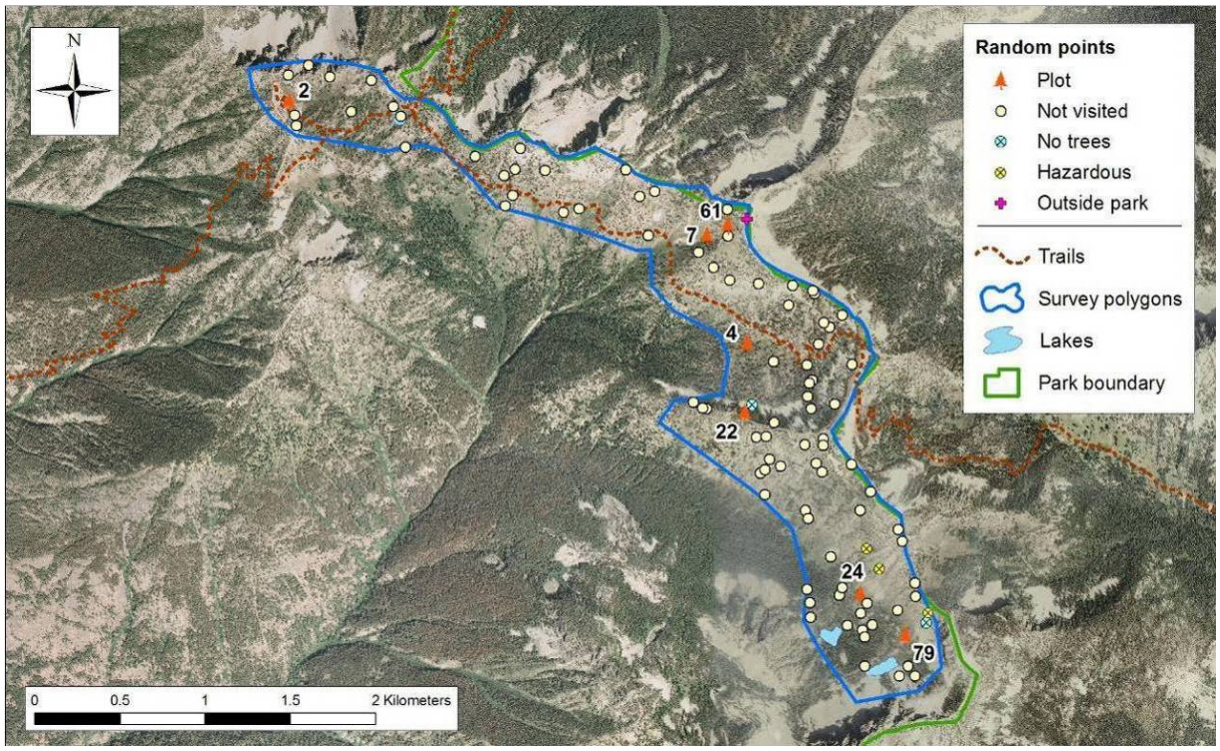


Figure B.14. Location of permanent plots in the Juanita Lake (NOCA) study area (polygon) and random points reviewed prior to sample site establishment.

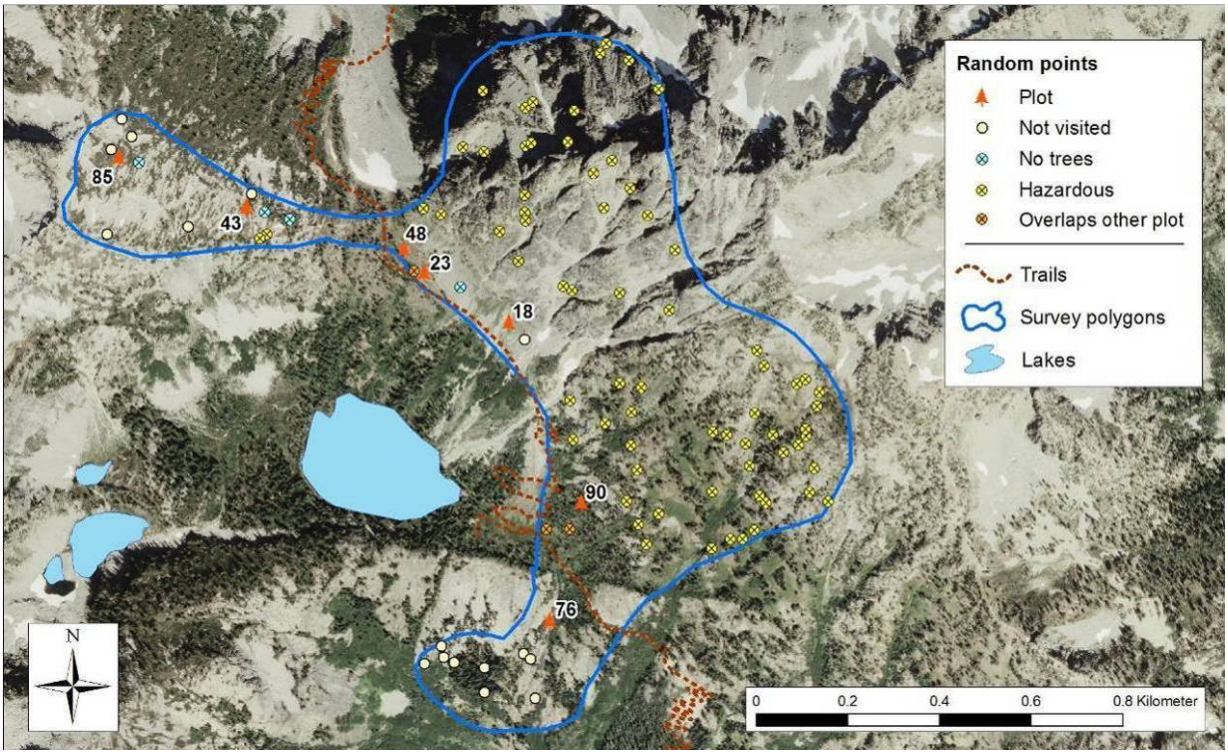


Figure B.15. Location of permanent plots in the Rainbow Lakes (NOCA) study area (polygon) and random points reviewed prior to sample site establishment.

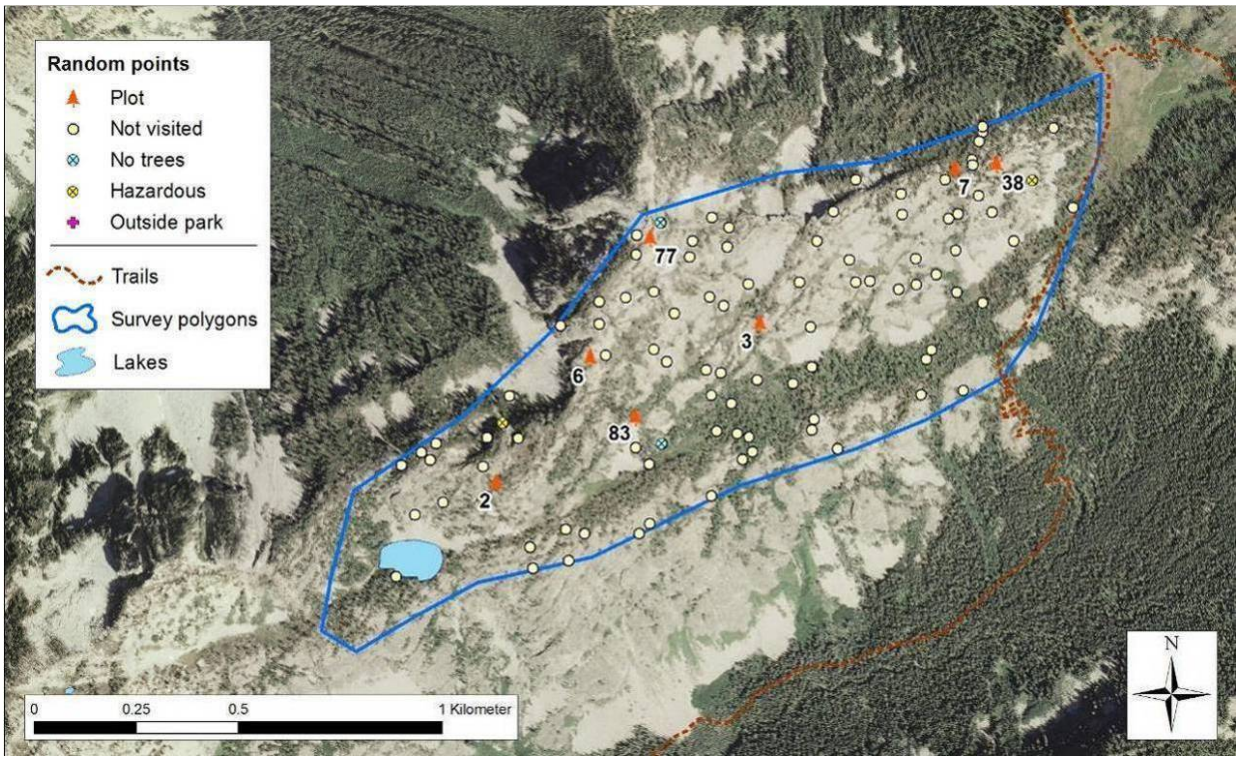


Figure B16. Location of permanent plots in the Rainbow Ridge (NOCA) study area (polygon) and random points reviewed prior to sample site establishment.

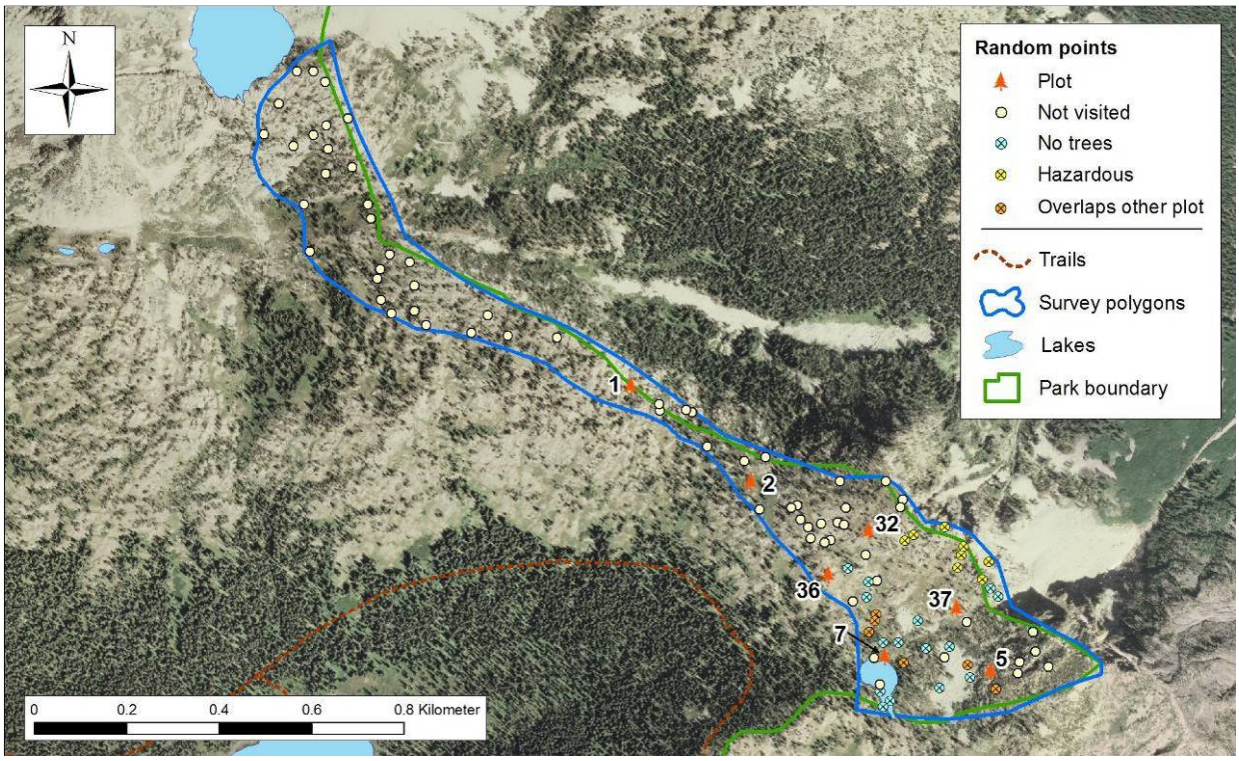


Figure B.17. Location of permanent plots in the Stiletto (NOCA) study area (polygon) and random points reviewed prior to sample site establishment.

Literature Cited

Agee, J. K., and J. Kertis. 1986. Vegetation cover types of the North Cascades. Report CPSU/US 86-2, National Park Service, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Seattle, WA.

ESRI, Environmental Research System Institute. 1999. ArcView GIS 3.2. Environmental Research System Institute, Redlands, CA.

Murray, M. P., and M. Rasmussen. 2000. Status of whitebark pine in Crater Lake National Park. Unpublished Final Report, Cooperative Cost-Share Agreement No. H9320000035. US Department of Interior, National Park Service, Crater Lake, OR.

Murray, M. P., and M. C. Rasmussen. 2003. Non-native blister rust disease on whitebark pine at Crater Lake National Park. Northwest Science 77:87-90.

National Park Service, Branch of Forestry. C.C.C.. 1936. Vegetation cover survey for Mount Rainier National Park. National Park Service, Branch of For., CCC. Published Report-132562.

Rochefort, R. M. 2008. The influence of white pine blister rust (*Cronartium rubicola*) on whitebark pine (*Pinus albicaulis*) in Mount Rainier National Park and North Cascades National Park Service Complex, Washington. Natural Areas Journal 28:290-298.

Appendix C. Yearly Project Task List

This table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution (Table C.1). Protocol sections and SOPs are referenced as appropriate.

Table C.1 Yearly project task list and responsibilities.

Project Stage	Task Description	Responsibility	Timing
Preparation (*Sections 3A, 3B and 4B*)	Initiate announcement for seasonal field crew positions	Project Lead	Nov 1
	Plan schedule and logistics, identify needed equipment and supplies	Project Lead	By Feb 15
	Ensure all project compliance needs are completed for the coming season	Park Plant Ecologists	Jan-Feb
	Inform GIS Specialist and Data Manager of specific needs for upcoming field season	Project Lead	By Mar 1
	Hire seasonal field crew positions	Project Lead and Park Plant Ecologists	By Mar 15
	Purchase equipment and supplies	Project Lead	By Jun 1
	Ensure that project workspace is ready for use (SOP 1)	Project Lead	By Apr 15
	Update and deploy database application for data entry	Data Manager	By May 1
	Update and load data dictionary, background maps, and target coordinates into GPS units. Make sure that GPS download software is available to field crews as needed.	GIS Specialist	By July 1
	Prepare and print field maps	GIS Specialist	By July 1
	Generate field visit reports and pre-printed data forms from database	Project Lead	By July 1
	Initiate computer access and key requests (may need park-specific dates)	Park Plant Ecologists	Apr 15
	Provide field crew email addresses and user logins to Data Manager. Grant modify access to project workspace once crew user logins are known.	Project Lead	May
	Provide database/GPS training as needed	Data Manager and GIS Specialist	May
	Train field crew in tree measurements, blister rust infection, Mt. pine beetle and other pathogen identification, plant species identification, use of equipment, field sampling protocols, safety, and backcountry travel	Project Lead	May-July
Data Acquisition (*Section 3C*)	Collect field data during field trips. Review data forms for completeness and accuracy after each field day.	Technicians	July-Sep
	Review field forms for completeness and accuracy	Field Crew Lead	Bi-weekly
	De-brief crew on operations, field methods, gear needs	Project Lead and Park Plant Ecologists	Monthly

Project Stage	Task Description	Responsibility	Timing
Data Entry & Processing (*Section 4C and 4D*)	Download GPS data and provide files to GIS Specialist for correction (SOP 6)	Technicians	After each field trip
	Download and process digital images (SOP 15)	Technicians	After each field trip
	Enter data into the database (SOP 16)	Technicians	After each field trip
	Verify accurate transcription from field forms to database as data are entered (SOP 17)	Technicians	After each field trip
	Correct GPS data and relate any problems to Field Crew Lead and Project Lead	GIS Specialist	After each field trip
	Review GPS location data and database entries for completeness and accuracy	Field Crew Lead and/or Project Lead	Monthly
	Scan all field forms and file in the project workspace	Field Crew Lead	By Sep 15
	Confirm that data entry and data verification is complete, and notify the Project Lead and Data Manager	Field Crew Lead	By Sep 15
	Complete field season report, send to Project Lead, Park Plant Ecologists, Data Manager, and GIS Specialist; submit to the NCCN Digital Library [1] when finalized (SOP 18)	Field Crew Lead	By Sep 15
	Merge, correct, and export GPS data. Upload processed and verified coordinates to database	GIS Specialist	Sep-Oct
Quality Review (*Section 4E*)	Complete data quality review and data validation using database tools (SOP 17)	Project Lead	Oct-Nov
	Determine best coordinates for subsequent mapping and field navigation	Project Lead and GIS Specialist	Oct-Nov
Metadata (*Section 4F and 4J*)	Identify any sensitive information contained in the data set (SOP 19)	Project Lead	By Nov 30
	Update project metadata interview form	Project Lead	By Nov 30
Data Certification & Delivery (*Section 4G*)	Certify the season's data and complete the certification report (SOP 17)	Project Lead	Nov
	Deliver certification report, certified data, and updated metadata to Data Manager (SOP 18)	Project Lead	By Nov 30
	Store certified data files in the project workspace	Data Manager	Dec-Jan
	Update project GIS data sets, layers and associated metadata records	GIS Specialist	Dec-Jan
	Finalize and parse metadata records, store in the project workspace	Data Manager and GIS Specialist	By Mar 15
Data Analysis (*Section 4H*)	Explore data in summary queries using database tools	Data Analyst	Feb-Mar
	Perform *ad hoc* queries as needed	Data Analyst and Data Manager	Feb-Mar
	Interpret results of automated and *ad hoc* queries	Data Analyst	Feb-Mar
Reporting & Product Development (*Section 4I*)	Export automated summary results and reports from database	Data Analyst	Feb-Mar
	Generate report-quality map output for reports	GIS Specialist	Feb-Mar

Project Stage	Task Description	Responsibility	Timing
	Acquire the proper report template from the NPS website (http://www.nature.nps.gov/publications/NRPM/index.cfm), draft annual report	Data Analyst and Project Lead	Feb-Apr
	Screen all reports and data products for sensitive information (SOP19)	Project Lead, Park Plant Ecologists, Data Analyst	Feb-Apr
	Prepare draft report and distribute to Park Plant Ecologists for preliminary review	Project Lead, Data Analyst	By Apr 15
Product Delivery (*Section 4K*)	Submit draft I&M report to Network Program Manager for review	Project Lead/Data Analyst	By Apr 30
	Review report for formatting and completeness, notify Project Lead of approval or need for changes	Network Program Manager	May
	Upload completed report to NCCN Digital Library [1], notify Data Manager (SOP 18)	Project Lead	Upon approval
	Deliver other products according to the delivery schedule and instructions (SOP 18)	Project Lead	Upon completion
	Product check-in	Data Manager	Upon receipt
Posting & Distribution (*Section 4K*)	Submit metadata to the NPS Data Store [2]	Data Manager	By Mar 15
	Create an online reference record and post reports to the NPS Data Store [2]	Data Manager	Upon receipt
	Update NPSpecies [4] records according to data observations	Data Manager	Dec-Mar
	Submit certified data and GIS data to the NPS Data Store [2]	Data Manager	Jun (after 2-year hold)
Archiving & Records Management (*Section 4L*)	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] (SOP 1)	Project Lead	Jan
	Move hard-copy data forms and voucher specimens to park collections collections after making sure that all forms have been scanned and all species records are entered into NPSpecies [3]	Project Lead	Jan
Season Close-out (*Section 3D and 4M*)	Inventory equipment and supplies	Field Crew Lead	By Sep 15
	De-brief field crew concerning safety, logistics, and data concerns	Project Lead, Technicians	By Sep 15
	Meet to discuss the recent field season, and document any needed changes to field sampling protocols or the database	Project Lead, Park Plant Ecologists, Data Analyst, Data Manager, and GIS Specialist	By Nov 30 of the same year
	Discuss and document needed changes to analysis and reporting procedures and plan for the coming field season	Project Lead, Data Analyst, Park Plant Ecologists, Data Manager, and GIS Specialist	By Apr 30

[1] The NCCN Digital Library is a document management system implemented in Microsoft SharePoint for maintaining important digital files (reports, protocol documents, and select 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 application 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://home.nps.gov/applications/npspolicy/DOrders.cfm.

Appendix D. Alpine and Subalpine Vegetation Monitoring Protocol 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_Strata	Stratification classes used during design and analysis
tbl_Locations	Sample locations - places where data collection occurs
tbl_Schedule	Schedule for monitoring sites
tbl_Target_Coords	Target coordinates for sample locations selected within GIS
tbl_Analysis_Notes	Sample location-specific comments related to data analysis
tbl_Events	Data collection event for a given location
tbl_Coordinates	Coordinate data collected during sampling events
tbl_GPS_Info	GPS information associated with sampling event coordinates
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_Task_List	Checklist of tasks to be completed at sampling locations
tbl_Images	Images associated with sampling events

The following are project-specific data tables:

tbl_Animal_Obs	Observations of certain diagnostic animals and birds
tbl_Data_Logger_Events	Information associated with data logger visits
tbl_Krummholz_Data	Observation data for krummholz species
tbl_Photopoints	Plot-wide photopoints used to document structural and compositional change over time
tbl_Photopoint_Distances	Information used to relocate plot-wide photopoints
tbl_Plot_Cover	Abiotic and biotic cover observations for whitebark pine plots
tbl_Plot_Desc	Plot description information
tbl_Plot_Logistics	Time and people required to complete plot sampling
tbl_Plot_Recon	Plot evaluation data from reconnaissance work
tbl_QA_Results	Quality assurance query results for the working data set
tbl_Quadrat_Cover	Abiotic and biotic cover observations in quadrats
tbl_Quadrat_Obs	Seedling observations in quadrats
tbl_Quadrat_Species	Species cover observations in quadrats
tbl_Recon_WBP	Whitebark pine stem tallies recorded during plot reconnaissance
tbl_Saplings_Other	Sapling tallies for non-whitebark pine species in whitebark pine plots
tbl_Saplings_WBP	Whitebark pine sapling tallies by condition
tbl_Seedlings	Seedling counts for whitebark pine plots

tbl_Species_Cover	Species cover data for whitebark pine plots
tbl_Trees	Trees associated with whitebark pine plots
tbl_Tree_Data_Entry	Temporary table for tree visit data from whitebark pine plots, to be appended to tbl_Trees and tbl_Tree_Visits at the end of the field season
tbl_Tree_Diameters	Tree diameter measurements by species
tbl_Tree_Visits	Tree observation data for whitebark pine plots
tbl_Veg_Events	Information associated with vegetation monitoring sampling events

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

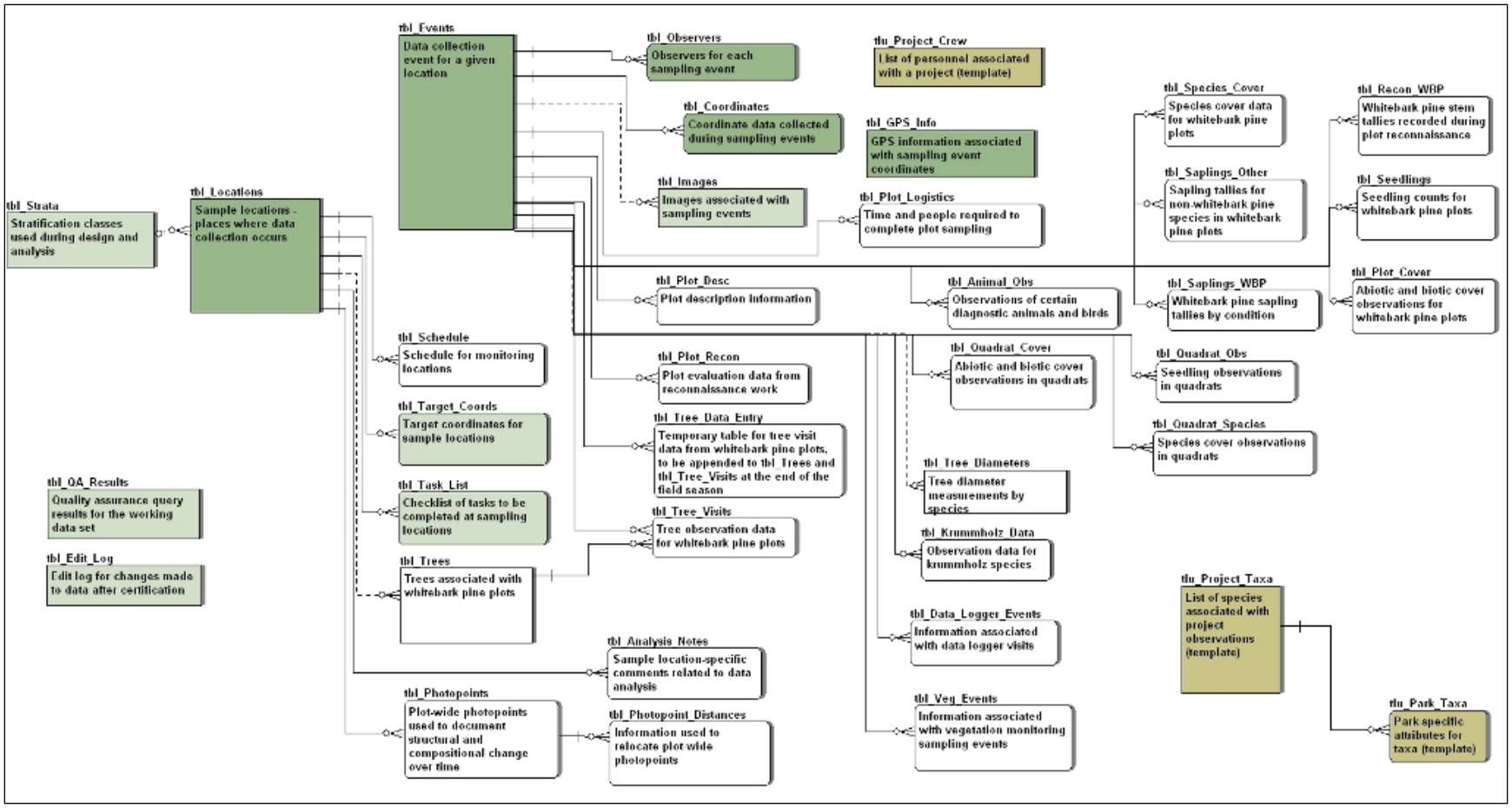


Figure D.1. Entity relationship diagram for the project database. Relationships between tables are represented by lines. Dark green tables represent core standard tables; light green represents extended standard tables; light brown are standard lookup tables. Project-specific tables are unshaded.

Data Dictionary

Required fields are denoted with an asterisk (*).

tbl_Analysis_Notes - Sample location-specific comments related to data analysis

Index	*Index columns*
Location_ID	Location_ID
pk_tbl_Analysis_Notes (primary)	Location_ID, Analysis_year

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sampling location
Analysis_year	primary *	text (4)	Analysis year (e.g., 2010)
Analysis_notes		memo	Comments about this sample location related to the specified analysis year

tbl_Animal_Obs - Observations of certain diagnostic animals and birds

Index	*Index columns*
Event_ID	Event_ID
Obs_result	Obs_result
pk_tbl_Animal_Obs (primary)	Event_ID, Species
Sort_order	Sort_order
Species	Species

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Species	primary *	text (25)	Animal species that was watched for
Obs_result	indexed *	text (15)	Observation outcome
Obs_time		datetime	If the species was observed, the time the species was first observed
Obs_notes		text (150)	Comments about the species observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Coordinates - Coordinate data collected during sampling events

Index	*Index columns*
Coord_label	Coord_label
Coord_type	Coord_type
Coord_updated	Coord_updated
Datum	Datum
Event_ID (unique)	Event_ID
Field_coord_source	Field_coord_source
pk_tbl_Coordinates (primary)	Coord_ID

Field name	*Index/key*	*Data type*	*Description*
Coord_ID	primary (FK)*	text (50)	Unique identifier for each coordinate record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	unique *	text (50)	Sampling event of coordinate data collection
Is_best		bit	Indicates whether this set of coordinates is the best available for this location
UTM_east		double	Final UTM easting (zone 10N, meters), including any offsets and corrections
UTM_north		double	Final UTM northing (zone 10N, meters), including any offsets and corrections
Coord_type	indexed	text (20)	Coordinate type stored in UTM_east and UTM_north: target, field, post-processed

Datum	indexed	text (5)	Datum of UTM_east and UTM_north
	Default: "NAD83"		
Est_horiz_error		double	Estimated horizontal error (meters) of UTM_east and UTM_north
Elevation_m		single	Elevation in meters, derived from GIS using final UTMs
Slope_deg		single	Slope steepness in degrees, derived from GIS using final UTMs
Aspect_deg		single	Slope aspect in degrees, derived from GIS using final UTMs
Coord_label	indexed	text (25)	Name of the coordinate feature (e.g., plot center, NW corner)
Field_UTME		double	UTM easting (zone 10N) as recorded in the field
Field_UTMN		double	UTM northing (zone 10N) as recorded in the field
Field_datum		text (5)	Datum of field coordinates
Field_horiz_error		double	Field coordinate horizontal error (m)
Field_offset_m		double	Distance (meters) from the field coordinates to the target
	Constraint: Is Null Or >=0		
Field_offset_azimuth		smallint	Azimuth (degrees, declination corrected) from the coordinates to the target
	Constraint: Is Null Or (>=0 And <=360)		
Field_coord_source	indexed	text (12)	Field coordinate data source
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
Source_citation		text (250)	Name, date and scale of the source map
Coordinate_notes		memo	Notes about this set of coordinates
Coord_created_date		datetime	Time stamp for record creation
	Default: Now()		
Coord_updated	indexed	datetime	Date of the last update to this record
Coord_updated_by		text (50)	Person who made the most recent edits

tbl_Data_Logger_Events - Information associated with data logger visits

Index	*Index columns*
Event_ID	Event_ID
Logger_type	Logger_code
Next_retrieval_date	Next_retrieval_date
pk_tbl_Data_Logger_Event (primary)	Event_ID, Logger_code

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Logger_code	primary *	text (10)	Type of data logger
Action_time		datetime	Time at which the data logger was installed and/or retrieved
Was_deployed	*	bit	Indicates whether a data logger was deployed during the visit
Next_retrieval_date	indexed	datetime	Date on which the newly-deployed logger must be removed or replaced
Was_retrieved	*	bit	Indicates whether a data logger was retrieved during the visit
Data_file		text (25)	Name of the data log file
Visit_notes		memo	Comments about the data logger visit

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: "VCa08"		
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 event for a given location

Index	*Index columns*
Certified_date	Certified_date
Entered_date	Entered_date
Location_ID	Location_ID
pk_tbl_Events (primary)	Event_ID
Start_date	Start_date
udx_tbl_Events (unique)	Location_ID, Start_date
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())		
Project_code	*	text (10)	Project code, for linking information with other data sets and applications
	Default: "VCa08"		
Start_date	unique *	datetime	Start date of the sampling event
End_date		datetime	End date of the sampling event (optional)
Start_time		datetime	Start time of the sampling event
Declination		text (25)	Declination correction factor for measurement of compass bearings
Logistics_notes		memo	Comments about logistics for reaching and sampling this location
Routine_visit	*	bit	Indicates whether this represents a routine visit
	Default: True		
Travel_notes		memo	Directions for relocating the sample location
Travel_notes_action		text (10)	Action to be taken to update the master copy of travel notes in tbl_Locations
Weather_cond		text (100)	Comments about weather conditions

Task_notes		text (255)	Explanation for tasks that were not completed
Tree_measurements	*	bit	Indicates whether tree measurements were completed
	Default: False		
Seedling_sapling_data	*	bit	Indicates whether seedling and sapling data were collected
	Default: False		
Mortality_data	*	bit	Indicates whether WBP infection and mortality data were collected
	Default: False		
Pine_beetle_data	*	bit	Indicates whether pine beetle infestation data were collected
	Default: False		
Tree_cover	*	bit	Indicates whether tree cover data were collected (alpine/subalpine plots)
	Default: False		
Understory_cover	*	bit	Indicates whether understory cover data were collected
	Default: False		
Quadrat_data	*	bit	Indicates whether quadrat monitoring data were collected
	Default: False		
Has_new_coordinates	*	bit	Indicates whether improved coordinates were collected
	Default: False		
GPS_file_name		text (50)	GPS rover file used for data downloads
Has_site_map	*	bit	Indicates whether a site map was drawn
	Default: False		
Site_map_file		text (100)	File name of the site map image
Tags_replaced	*	bit	Indicates whether any tree tags were replaced
	Default: False		
Replaced_tags		text (50)	Comments about the tags that were replaced
Tags_added	*	bit	Indicates whether any tree tags were added
	Default: False		
New_tags		text (50)	Comments about the tags that were added
Stakes_replaced	*	bit	Indicates whether any stakes were replaced
	Default: False		
Replaced_stakes		text (50)	Comments about the stakes that were replaced
Observed_changes		text (120)	Notes about observed changes to the plot
Animal_evidence		text (150)	Comments about animal evidence
Significant_events		text (120)	Significant events and observations (e.g., sightings of rare/exotic species, severe weather, etc.)
Disturbance_indicators		text (120)	Comments about disturbance indicators since the last visit
Transportation_notes		text (100)	Comments about special transportation needs
Accommodation_used		text (50)	Indicates the campsite, ranger station, or housing used
Accommodation_notes		text (100)	Comments about the overnight accommodations
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
Location_ID	unique *	text (50)	Sampling location for this event

tbl_GPS_Info - GPS information associated with sampling event coordinates

Index	*Index columns*
Coord_ID	Coord_ID
Corr_type	Corr_type
Datum	GPS_datum
Feat_name	Feat_name
Feat_type	Feat_type
GPS_date	GPS_date
GPS_file	GPS_file
Location_ID	Location_ID
pk_tbl_GPS_Info (primary)	GPS_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())		
Coord_ID	indexed	text (50)	Coordinate identifier
Location_ID	indexed	text (50)	Sample location, 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		

tbl_Images - Images associated with sampling events

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_Krummholz_Data - Observation data for krummholz species

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Quadrat_Species (primary)	Taxon_ID, Event_ID
Sort_order	Sort_order
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Taxon_ID	primary *	text (50)	Taxon identifier
N_patches	*	tinyint	Number of patches observed
	Constraint: >=0 And <=50		
N_stems	*	tinyint	Number of upright stems observed
	Constraint: >=0 And <=50		
Obs_notes		text (50)	Comments about the observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered
Event_ID	primary (FK)*	text (50)	Sampling event

tbl_Locations - Sample locations - places where data collection occurs

Index	*Index columns*
Evaluation_code	Evaluation_code
Field_evaluation	Field_evaluation
Firing_order	Firing_order
Loc_updated	Loc_updated
Location_code	Location_code
Location_status	Location_status
Location_type	Location_type
Office_evaluation	Office_evaluation
Panel_name	Panel_name
Panel_type	Panel_type
Park_code	Park_code
Park_region	Park_region
pk_tbl_Locations (primary)	Location_ID
Public_offset	Public_offset
Slope_class	Slope_class
Stratum_ID	Stratum_ID
Substratum	Substratum
udx_tbl_Locations (unique)	Location_code, Park_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	unique *	text (4)	Park in which the site is located
Location_code	unique *	text (10)	Alphanumeric code for the sample location
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)
Stratum_ID	indexed (FK)	text (50)	Stratum of the site
Park_region	indexed	text (25)	Region of the park in which the site is located
Slope_class	indexed	text (20)	Slope classification used for site selection
Substratum	indexed	text (20)	Additional criteria used for site selection
Panel_type	indexed	text (20)	Sampling panel for the site
Panel_name	indexed	text (10)	Name of the sampling panel, used to group data for analysis
Firing_order	indexed	int	Site selection and evaluation order
Office_evaluation	indexed	text (15)	Office evaluation: passed or failed criteria or evaluation not conducted
Field_evaluation	indexed	text (15)	Field evaluation: passed or failed criteria or evaluation not conducted
Evaluation_code	indexed	text (2)	Site evaluation status code
Evaluation_notes		text (100)	Brief comment about the site evaluation, rationale for not sampling, etc.
UTME_public		double	UTM easting (zone 10N, meters). Note: in addition to any measurement error, these coordinates may have been offset up to 2 km from their actual position.
UTMN_public		double	UTM northing (zone 10N, meters). Note: in addition to any measurement error, these coordinates may have been offset up to 2 km from their actual position.
Public_offset	indexed	text (50)	Type of processing performed to make coordinates publishable
Travel_notes		memo	Directions for relocating the sample location
Safety_notes		text (255)	Comments about safety considerations when accessing or working at the location
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
Elevation_m		smallint	Elevation in meters, derived from GIS using target UTMs (temporary field for stratification/review))
Slope_pct		smallint	Slope steepness in percent, derived from GIS using target UTMs (temporary field for stratification/review))
Aspect_deg		smallint	Slope aspect in degrees, derived from GIS using target UTMs (temporary field for stratification/review))

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

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event identifier
Contact_ID	primary *	text (50)	Observer identifier
Observer_role	primary *	text (25)	Role of the observer during data collection (optional)
Observer_notes		text (200)	Comments about the observer specific to this sampling event

tbl_Photopoints - Plot-wide photopoints used to document structural and compositional change over time

Index	*Index columns*
Location_ID	Location_ID
Photopoint_num	Photopoint_num
pk_tbl_Photopoints (primary)	Location_ID, Photopoint_num

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sampling location for this event
Photopoint_num	primary *	text (2)	Photopoint identifier
Perspective	*	text (10)	Perspective from which the photopoint was taken
Loc_desc		text (100)	Photopoint location description
UTME		int	Universal Transverse Mercator easting value, in meters (Zone 10N)
UTMN		int	Universal Transverse Mercator northing value, in meters (Zone 10N)
Updated_date		datetime	Date on which the record was updated

tbl_Photopoint_Distances - Information used to relocate plot-wide photopoints

Index	*Index columns*
Location_ID	Location_ID
Photopoint_num	Photopoint_num
pk_tbl_Photopoints (primary)	Location_ID, Photopoint_num, Ref_corner
Ref_corner	Ref_corner

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sampling location for this event
Photopoint_num	primary (FK)*	text (2)	Photopoint identifier
Ref_corner	primary *	text (2)	Plot corner for which the relocation information applies

Distance_m		single	Distance between the reference corner and the photopoint, in meters
Azimuth_deg		smallint	Azimuth from the photopoint to the plot reference corner, in degrees, corrected for declination
	Constraint: Is Null Or (>=-1 And <=360)		
Updated_date		datetime	Date on which the record was updated

tbl_Plot_Cover - Abiotic and biotic cover observations for whitebark pine plots

Index	*Index columns*
Cover_type	Cover_type
Event_ID	Event_ID
pk_tbl_Plot_Cover (primary)	Event_ID, Cover_type
Sort_order	Sort_order

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Cover_type	primary *	text (25)	Category of biotic and abiotic cover types
Cover_class	*	tinyint	Cover class
Obs_notes		text (100)	Comments about the observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Plot_Desc - Plot description information

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Field_elevation		double	Elevation of the location
	Constraint: Is Null Or (>=0 And <14500)		
Field_elev_units	*	text (2)	Units for elevation data
	Default: "m"		
Elev_source		text (20)	Source of elevation data
Field_slope_deg		smallint	Slope steepness, in degrees
	Constraint: Is Null Or (>=0 And <=90)		
Field_aspect_deg		smallint	Dominant slope aspect, in degrees, corrected for declination
	Constraint: Is Null Or (>=-1 And <=360)		
Microconfig		text (20)	Configuration of local terrain
Microtopog_position		text (20)	Position within the immediate landscape
Topog_position		text (20)	Position relative to large scale topographical features
Environment_notes		text (255)	Comments to clarify point description data

tbl_Plot_Logistics - Time and people required to complete plot sampling

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Plot_Logistics (primary)	Event_ID, Plot_task
Plot_task	Plot_task
Sort_order	Sort_order

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event identifier
Plot_task	primary *	text (50)	Sampling event task
Time_spent		double	Time required to complete the task
	Constraint: Is Null Or (>=0 And <=100)		
N_people		double	Number of people needed to complete the task
	Constraint: Is Null Or (>=0 And <=20)		
Task_notes		text (100)	Comments about the task
Sort_order	indexed *	int	Used to show records in the order in which they were entered

tbl_Plot_Recon - Plot evaluation data from reconnaissance work

Index	*Index columns*
Is_appropriate	Is_appropriate
pk_tbl_Plot_Recon (primary)	Event_ID
Veg_association	Veg_association

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Has_safe_access	*	bit	Whether or not safely accessible (unsafe=too steep, cliffs, major river or glacier crossing)
Access_notes		text (100)	Comments about safety of access
Avalanche_track	*	bit	Whether the plot occurs in an avalanche track
Avalanche_notes		text (100)	Comments about the avalanche track determination
Forest_opening	*	bit	Whether the plot occurs within a forest opening
Forest_notes		text (100)	Comments about the forest opening determination
Trees_above_threshold	*	bit	Whether the plot has more than 25 percent cover
Tree_cover_notes		text (100)	Comments about the tree cover determination
Water_cover		tinyint	Estimate of percent cover by water
	Constraint: Is Null Or (>=0 And <=100)		
Water_type		text (50)	Type of water observed
Water_notes		text (100)	Comments about the water cover estimate
Snow_cover		tinyint	Estimate of percent cover by permanent snow and ice
	Constraint: Is Null Or (>=0 And <=100)		
Snow_notes		text (100)	Comments about the snow cover estimate
Talus_cover		tinyint	Estimate of percent cover by talus
	Constraint: Is Null Or (>=0 And <=100)		
Talus_notes		text (100)	Comments about the talus cover estimate
Shrub_cover		tinyint	Estimate of percent cover by tall shrubs
	Constraint: Is Null Or (>=0 And <=100)		
Shrub_notes		text (100)	Comments about the shrub cover estimate
Veg_association	indexed	int	Plant association, determined within a 10x10 meter plot centered on the point
Krummholz_criteria	*	bit	Whether the site meets krummholz criteria (krummholz found at same elevation as or below plot center)
Tree_criteria	*	bit	Whether the site meets tree criteria (upright trees >2m found at same elevation as or below plot center)
Summit_criteria	*	bit	Whether the site meets summit criteria (summit within 5m)
Summit_dist_m		smallint	Distance from plot center to the nearest summit, in meters
	Constraint: Is Null Or (>=0 And <=1000)		
Summit_notes		text (100)	Notes about the summit determination and/or the nearest summit
Human_impact	*	bit	Whether there is any obvious sign of human impact
Impact_dist_m		tinyint	Distance from plot center to human impact, in meters
	Constraint: Is Null Or (>=0 And <=250)		
Impact_notes		text (50)	Comments about the human impact determination
Wildlife_sign	*	bit	Whether there is any obvious sign of wildlife use at the site
Wildlife_notes		text (50)	Comments about the wildlife use determination
Classification_notes		text (100)	Field comments about whether and why the plot could be classified as alpine or subalpine
Is_appropriate	indexed	text (10)	Determination of whether the site is appropriate for a permanent plot based on these criteria
Determination_notes		text (100)	Comments about the appropriateness of the site
Determined_by		text (50)	Person who made the most recent updates
Is_alpine	*	bit	Whether the plot qualifies as an alpine plot
Is_subalpine	*	bit	Whether the plot qualifies as a subalpine plot

Is_WBP	*	bit	Whether the plot qualifies as a whitebark pine plot
Route_description		memo	Description of route with special consideration for efficient and safe access

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_Quadrat_Cover - Abiotic and biotic cover observations in quadrats

Index	*Index columns*
Cover_type	Cover_type
Event_ID	Event_ID
pk_tbl_Quadrat_Cover (primary)	Event_ID, Quadrat, Cover_type
Quadrat	Quadrat
Sort_order	Sort_order

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Quadrat	primary *	tinyint	Quadrat number for cover observations
	Constraint: >0 And <=20		
Cover_type	primary *	text (25)	Category of biotic and abiotic cover types
Cover_perc	*	tinyint	Estimated cover to the nearest percent
	Constraint: >=0 And <=100		
Obs_notes		text (50)	Comments about the observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Quadrat_Obs - Seedling observations in quadrats

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Quadrat_Obs (primary)	Event_ID, Quadrat
Quadrat	Quadrat
Sort_order	Sort_order

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Quadrat	primary *	tinyint	Quadrat number for cover observations
	Constraint: >0 And <=20		
N_seedlings	*	smallint	Number of seedlings observed
	Constraint: >=0 And <=400		
Dist_m		single	Distance along the meter tape, in meters (legacy plots only)
	Constraint: Is Null Or (>=0 And <=100)		
Obs_notes		text (50)	Comments about the observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Quadrat_Species - Species cover observations in quadrats

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Quadrat_Species (primary)	Event_ID, Quadrat, Taxon_ID
Quadrat	Quadrat
Sort_order	Sort_order
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Quadrat	primary *	tinyint	Quadrat number for cover observations
	Constraint: >0 And <=20		
Taxon_ID	primary *	text (50)	Taxon identifier
Cover_perc	*	tinyint	Estimated cover to the nearest percent
	Constraint: >=0 And <=100		
Obs_notes		text (50)	Comments about the observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Recon_WBP - Whitebark pine stem tallies recorded during plot reconnaissance

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Recon_WBP (primary)	Event_ID, Subplot
Sort_order	Sort_order
Subplot	Subplot

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Subplot	primary *	text (5)	Subplot within which observations were made
N_live *	tinyint	Number of live whitebark pine stems above 2.54 cm dbh	
	Constraint: Is Null Or (>=0 And <=100)		
N_dead	*	tinyint	Number of dead whitebark pine stems above 2.54 cm dbh
	Constraint: Is Null Or (>=0 And <=100)		
Obs_notes		text (50)	Observation comments
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Saplings_Other - Sapling tallies for non-whitebark pine species in whitebark pine plots

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Saplings_Other (primary)	Event_ID, Subplot, Taxon_ID
Sort_order	Sort_order
Subplot	Subplot
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Subplot	primary *	text (5)	Subplot within which observations were made
Taxon_ID	primary *	text (50)	Taxon identifier
Tally	*	smallint	Number of saplings in the subplot of the indicated species
	Constraint: Is Null Or (>=0 And <=250)		
Obs_notes		text (50)	Comments about the species sapling observation.
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Saplings_WBP - Whitebark pine sapling tallies by condition

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Saplings_WBP (primary)	Event_ID, Subplot
Sort_order	Sort_order
Subplot	Subplot

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Subplot	primary *	text (5)	Subplot within which observations were made
Healthy		tinyint	Number of saplings that appear healthy
	Constraint: Is Null Or (>=0 And <=200)		
Cankers		tinyint	Number of saplings with blister rust cankers present
	Constraint: Is Null Or (>=0 And <=200)		
Browsed		tinyint	Number of saplings with browse wounds
	Constraint: Is Null Or (>=0 And <=200)		
Chlorotic		tinyint	Number with chlorotic or dead needles over a threshold proportion of the crown
	Constraint: Is Null Or (>=0 And <=200)		
Dead_BR		tinyint	Number that are dead with evidence of blister rust
	Constraint: Is Null Or (>=0 And <=200)		
Dead_other		tinyint	Number dead from other causes than blister rust
	Constraint: Is Null Or (>=0 And <=200)		
Sapling_notes		text (255)	Comments about whitebark pine sapling observations
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Schedule - Schedule for monitoring locations

Index	*Index columns*
Calendar_year	Calendar_year
Location_ID	Location_ID
pk_tbl_Schedule (primary)	Calendar_year, Location_ID

Field name	*Index/key*	*Data type*	*Description*
Calendar_year	primary *	text (10)	Calendar year for scheduled sampling (not necessarily actually sampled)
Location_ID	primary (FK)*	text (50)	Monitoring site

Schedule_notes	text (255)	Comments about this schedule item (especially for out-of-rotation sites)

tbl_Seedlings - Seedling counts for whitebark pine plots

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Seedlings (primary)	Event_ID, Subplot, Taxon_ID
Sort_order	Sort_order
Subplot	Subplot
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Subplot	primary *	text (5)	Subplot within which observations were made
Taxon_ID	primary *	text (50)	Taxon identifier
Tally	*	smallint	Number of seedlings in the subplot of the indicated species
Obs_notes		text (50)	Comments about the species seedling observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Species_Cover - Species cover data for whitebark pine plots

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Species_Cover (primary)	Event_ID, Taxon_ID, Stratum_code
Sort_order	Sort_order
Stratum_code	Stratum_code
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Taxon_ID	primary *	text (50)	Taxon identifier
Stratum_code	primary *	text (5)	Vegetation stratum
	Constraint: ="O" Or ="U"		
Cover_class	*	tinyint	Cover class
Obs_notes		text (50)	Comments about the species cover observation
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Strata - Stratification classes used during design and analysis

Index	*Index columns*
pk_tbl_Strata (primary)	Stratum_ID
Stratum_updated	Stratum_updated
udx_tbl_Strata (unique)	Park_code, Project_code, Stratification_date, Stratum_name

Field name	*Index/key*	*Data type*	*Description*
Stratum_ID	primary *	text (50)	Unique identifier for each stratum record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Park_code	unique *	text (4)	4-letter park code of the stratification
Project_code	unique *	text (10)	Project code, for linking information with other data sets and applications
Stratification_date	unique *	datetime	Date on which the stratification occurred, used for grouping strata
Stratum_name	unique *	text (25)	Name of the stratification class (e.g., low, medium, high)
Stratum_definition		text (250)	Brief text definition of the stratum (e.g., elevations below 1000 meters)
N_population		int	Total population in the stratum

Weight_factor		double	Weight factor to be used in analyses; inverse of inclusion probability
Stratum_notes		memo	Comments about the stratum
Stratum_created		datetime	Time stamp for record creation
	Default: Now()		
Stratum_updated	indexed	datetime	Date of the last update to this record
Stratum_updated_by		text (50)	Person who made the most recent edits

tbl_Target_Coords - Target coordinates for sample locations

Index	*Index columns*
pk_tbl_Target_Coords (primary)	Location_ID
Target_updated	Target_updated

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sample location
Target_UTME		double	Target UTM easting (zone 10N)
Target_UTMN		double	Target UTM northing (zone 10N)
Target_datum		text (5)	Target coordinate datum
	Default: "NAD83"		
Target_notes		memo	Notes about the target coordinates
Target_created_date		datetime	Time stamp for record creation
	Default: Now()		
Target_updated	indexed	datetime	Date of the last update to this record
Target_updated_by		text (50)	Person who made the most recent edits

tbl_Task_List - Checklist of tasks to be completed at sampling locations

Index	*Index columns*
Date_completed	Date_completed
pk_tbl_Task_List (primary)	Location_ID, Request_date, Task_desc
Task_status	Task_status

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sampling location
Request_date	primary *	datetime	Date of the task request
	Default: Now()		
Task_desc	primary *	text (100)	Brief description of the task
Requested_by		text (50)	Name of the person making the initial request
Task_status	indexed *	text (50)	Status of the task
	Default: "Active"		
Date_completed	indexed	datetime	Date the task was completed
Followup_by		text (50)	Name of the person following up on or completing the task
Task_notes		memo	Notes about the task
Followup_notes		memo	Comments regarding what was done to follow-up on or complete this task

tbl_Trees - Trees associated with whitebark pine plots

Index	*Index columns*
Clump_code	Clump_code
Location_ID	Location_ID
pk_tbl_Trees (primary)	Tree_ID
Taxon_ID	Taxon_ID
Tree_tag_num	Tree_tag_num
Tree_type	Tree_type
udx_tbl_Trees (unique)	Location_ID, Tree_tag_num

Field name	*Index/key*	*Data type*	*Description*
Tree_ID	primary *	text (50)	Unique identifier for each tree record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Location_ID	unique (FK)*	text (50)	Sampling location
Tree_tag_num	unique *	smallint	Tree tag number
Is_active	*	bit	Indicates whether the tree record is active for data collection and field form output
	Default: True		
Is_excluded	*	bit	Flag to exclude the tree from reported stem counts and basal area estimates (e.g., if recorded by mistake)
	Default: False		
Taxon_ID	indexed *	text (50)	Taxon observed
Tree_type	indexed *	text (2)	Indicates that the tree is for measurement, is a witness tree, or both
Clump_code	indexed	text (2)	Field code given to indicate the grouping of stems in to a clump likely originating from one root mass
Offset_azimuth		smallint	Azimuth (degrees, declination corrected) from the plot center to the tree
	Constraint: Is Null Or (>=0 And <=360)		
Offset_dist_m		double	Offset distance in meters
	Constraint: Is Null Or (>=0 And <200)		
In_plot	*	bit	Indicates whether the tree is inside the plot (legacy plots may have included some trees outside the 17.84m radius)
	Default: True		
Tree_rec_notes		memo	Comments about the tree record

tbl_Tree_Data_Entry - Temporary table for tree visit data from whitebark pine plots, to be appended to tbl_Trees and tbl_Tree_Visits at the end of the field season

Index	*Index columns*
pk_tbl_Tree_Data_Entry (primary)	Tree_ID, Event_ID
Taxon_ID	Taxon_ID
Tree_ID	Tree_ID
Tree_status	Tree_status
Tree_tag_num	Tree_tag_num
Tree_type	Tree_type
udx_tbl_Tree_Data_Entry (unique)	Event_ID, Tree_tag_num
Clump_code	Clump_code
Event_ID	Event_ID

Field name	*Index/key*	*Data type*	*Description*
Tree_ID	primary *	text (50)	Unique identifier for each tree record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	primary (FK)*	text (50)	Sampling event
Tree_tag_num	unique *	smallint	Tree tag number
Is_active	*	bit	Indicates whether the tree record is active for data collection and field form output
	Default: True		
Is_excluded	*	bit	Flag to exclude the tree from reported stem counts and basal area estimates (e.g., if recorded by mistake)
	Default: False		
Taxon_ID	indexed *	text (50)	Taxon observed
Tree_type	indexed *	text (2)	Indicates that the tree is for measurement, is a witness tree, or both
Clump_code	indexed	text (2)	Field code given to indicate the grouping of stems in to a clump likely originating from one root mass

Offset_azimuth		smallint	Azimuth (degrees, declination corrected) from the plot center to the tree
	Constraint: Is Null Or (>=0 And <=360)		
Offset_dist_m		double	Offset distance in meters
	Constraint: Is Null Or (>=0 And <200)		
In_plot	*	bit	Indicates whether the tree is inside the plot (legacy plots may have included some trees outside the 17.84m radius)
	Default: True		
Tree_status	indexed *	text (2)	Observed status of the tree
DBH_cm		double	Diameter at breast height, in centimeters
	Constraint: Is Null Or (>0 And <200)		
Height_m		double	Tree height, in meters
	Constraint: Is Null Or (>0 And <=120)		
Bole_cankers		text (50)	Status of cankers found along the main stem
Branch_cankers		text (50)	Status of cankers found on the branches
Crown_kill		tinyint	Proportion of the total tree height with dead foliage
Mature_cones		bit	Whether mature cones were present
First_yr_cones		bit	Whether first year cones were present
Pollen_cones		bit	Whether pollen cones were present
Pine_beetle		bit	Whether evidence of mountain pine beetle was present
Browsed		bit	Whether evidence of animal browsing was present
Fire_scars		bit	Whether fire scars were present
Mistletoe_present		bit	Whether mistletoe was present
Mistletoe_low		tinyint	Mistletoe rank for the bottom third of the tree
Mistletoe_mid		tinyint	Mistletoe rank for the middle third of the tree
Mistletoe_top		tinyint	Mistletoe rank for the top third of the tree
Collection_num		text (20)	Voucher specimen collection number
Tree_obs_notes		text (250)	Tree observation notes
Tree_rec_notes		memo	Comments about the tree record

tbl_Tree_Diameters - Tree diameter measurements by species

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Tree_Diameters (primary)	Record_ID
Sort_order	Record_ID
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Record_ID	primary *	int	Record ID; also sort order for displaying records in the order they were entered
Event_ID	indexed (FK)*	text (50)	Sampling event
Taxon_ID	indexed *	text (50)	Taxon identifier
DBH_cm	*	double	Diameter at breast height, in centimeters
	Constraint: Is Null Or (>0 And <200)		
Obs_notes		text (50)	Comments about the observation

tbl_Tree_Visits - Tree observation data for whitebark pine plots

Index	*Index columns*
Event_ID	Event_ID
pk_tbl_Tree_Visits (primary)	Event_ID, Tree_ID
Tree_ID	Tree_ID
Tree_status	Tree_status

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Tree_ID	primary (FK)*	text (50)	Unique identifier for each tree record

Tree_status	indexed *	text (2)	Observed status of the tree
DBH_cm		double	Diameter at breast height, in centimeters
	Constraint: Is Null Or (>0 And <200)		
Height_m		double	Tree height, in meters
	Constraint: Is Null Or (>0 And <=120)		
Bole_cankers		text (50)	Status of cankers found along the main stem
Branch_cankers		text (50)	Status of cankers found on the branches
Crown_kill		tinyint	Proportion of the total tree height with dead foliage
Mature_cones		bit	Whether mature cones were present
First_yr_cones		bit	Whether first year cones were present
Pollen_cones		bit	Whether pollen cones were present
Pine_beetle		bit	Whether evidence of mountain pine beetle was present
Browsed		bit	Whether evidence of animal browsing was present
Fire_scars		bit	Whether fire scars were present
Mistletoe_present		bit	Whether mistletoe was present
Mistletoe_low		tinyint	Mistletoe rank for the bottom third of the tree
Mistletoe_mid		tinyint	Mistletoe rank for the middle third of the tree
Mistletoe_top		tinyint	Mistletoe rank for the top third of the tree
Collection_num		text (20)	Voucher specimen collection number
Tree_obs_notes		text (250)	Tree observation notes

tbl_Veg_Events - Information associated with vegetation monitoring sampling events

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
Canopy_cover_class		smallint	Canopy cover class for whitebark pine plots
Species_obs_notes		memo	Species observation notes
Sampling_notes		memo	Other sampling comments

tlu_Animal_Obs_Code - List of animal observation codes

Field name	*Index/key*	*Data type*	*Description*
Obs_code	primary *	text (15)	
Obs_desc		text (100)	
Sort_order		tinyint	

tlu_Animal_Species - List of diagnostic animal species searched for during plot visits

Field name	*Index/key*	*Data type*	*Description*
Species_name	primary *	text (25)	
Is_active	*	bit	Indicates whether the record is active for data entry
	Default: True		
Sort_order		tinyint	

tlu_Canker_Code - List of canker infection classes

Index	*Index columns*
pk_tlu_Canker_Code (primary)	Canker_code
Sort_order	Sort_order

Field name	*Index/key*	*Data type*	*Description*
Canker_code	primary *	text (50)	
Canker_desc		text (50)	
Sort_order	indexed *	int	

tlu_Coord_Source - List of coordinate data sources (standard)

Field name	*Index/key*	*Data type*	*Description*
Coord_source	primary *	text (12)	
Coord_source_desc		text (100)	
Sort_order		tinyint	

tlu_Coord_Type - List of coordinate types (standard)

Field name	*Index/key*	*Data type*	*Description*
Coord_type	primary *	text (20)	
Coord_type_desc		text (100)	
Sort_order		tinyint	

tlu_Cover_Class - List of cover classes

Field name	*Index/key*	*Data type*	*Description*
Cover_class	primary *	tinyint	
Percent_cover	*	text (50)	

tlu_Cover_Type - List of abiotic and biotic cover type categories

Field name	*Index/key*	*Data type*	*Description*
Cover_type	primary *	text (25)	
Cover_desc		text (100)	
Is_active	*	bit	Indicates whether the record is active for data entry
	Default: True		
Sort_order		tinyint	

tlu_Crown_Kill - List of crown kill classes

Field name	*Index/key*	*Data type*	*Description*
Crown_kill_class	primary *	tinyint	
Percent_kill_desc	*	text (50)	

tlu_Current_Association - Cross-reference table of current interpretations of plant associations

Index	*Index columns*
Current_association	Current_association
pk_tlu_Current_Association (primary)	Veg_association

Field name	*Index/key*	*Data type*	*Description*
Veg_association	primary *	int	Vegetation association ID
Current_association	indexed *	int	Current interpretation of the association

tlu_Datum - List of coordinate datum codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Datumprimary *	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_Elevation_Source - List of elevation data source codes (template)

Field name	*Index/key*	*Data type*	*Description*
Elev_source	primary *	text (20)	
Elev_source_desc		text (100)	
Sort_order		tinyint	

tlu_Elevation_Unit - List of elevation measurement units (standard)

Field name	*Index/key*	*Data type*	*Description*
Elev_unit	primary *	text (2)	
Units_desc	*	text (25)	

Sort_order		tinyint	

tlu_Evaluation_Code - List of field and office evaluation codes used in site screening

Field name	*Index/key*	*Data type*	*Description*
Eval_code	primary *	text (15)	
Eval_code_desc		text (100)	
Sort_order		tinyint	

tlu_Evaluation_Status - List of evaluation codes for sample sites (template)

Field name	*Index/key*	*Data type*	*Description*
Eval_code	primary *	text (2)	
Eval_status	*	text (20)	
Eval_status_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_Code - List of project image codes

Field name	*Index/key*	*Data type*	*Description*
Image_code	primary *	text (20)	
Image_code_desc		text (100)	
Category		text (50)	
Is_active	*	bit	Indicates whether the record is active for data entry
	Default: True		
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_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_Microconfig - List of site microconfiguration codes

Field name	*Index/key*	*Data type*	*Description*
Microconfig_code	primary *	text (20)	
Microconfig_desc		text (100)	
Sort_order		tinyint	

tlu_Micro_Position - List of site microtopographic position codes

Field name	*Index/key*	*Data type*	*Description*
Microtopog_position	primary *	text (20)	
Micro_position_desc		text (200)	
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_Panel_Type - List of sampling panel types (template)

Field name	*Index/key*	*Data type*	*Description*
Panel_type	primary *	text (20)	
Panel_type_desc		text (200)	
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 *Default*: "Unknown"	text (16)	Status of the taxon in this park (from NPSpecies)
Park_origin	indexed *Default*: "Unspecified"	text (16)	Origin of the taxon in this park (from NPSpecies)
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_Plot_Tasks - List of logistics and sampling tasks for tracking time spent

Field name	*Index/key*	*Data type*	*Description*
Task_code	primary *	text (50)	
Task_units	*	text (10)	
Task_desc		text (100)	
Is_active		bit	Indicates whether the record is active for data entry
	Default: True		
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)
Contact_is_active		bit	Indicates that the contact record is currently available for data entry pick lists
	Default: True		
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

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
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_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_Subplot_Code - List of whitebark pine subplot codes

Field name	*Index/key*	*Data type*	*Description*
Subplot_code	primary *	text (5)	
Subplot_name	*	text (20)	
Subplot_desc		text (100)	
Is_active	*	bit	Indicates whether the record is active for data entry
	Default: True		
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_Topog_Position - List of site topographic position codes

Field name	*Index/key*	*Data type*	*Description*
Topog_position	primary *	text (20)	
Topog_position_desc		text (100)	
Sort_order		tinyint	

tlu_Tree_Status - List of tree status codes

Field name	*Index/key*	*Data type*	*Description*
Tree_status	primary *	text (2)	
Tree_status_desc		text (100)	
Sort_order		tinyint	

tlu_Tree_Type - List of tree types

Field name	*Index/key*	*Data type*	*Description*
Tree_type	primary *	text (2)	
Tree_type_description		text (255)	
Sort_order		tinyint	

tlu_Veg_Association - List of plant associations for North Coast and Cascades Network parks

Index	*Index columns*
Association_code (unique)	Association_code
pk_tlu_Veg_Association (primary)	Association_ID

Field name	*Index/key*	*Data type*	*Description*
Association_ID	primary *	int	Unique identifier for each association
Association_code	unique *	text (100)	Code for associations based on shortened version of name
Association_name	*	text (255)	Name of the association based on dominants and diagnostic species
Association_type		text (50)	Alliance level categories for associations
Association_notes		memo	Description of association
WNHP_ID		int	Washington Natural Heritage Program identifier

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 support, 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 E. Alpine and Subalpine Habitat Delineation Methods

Overview

The habitat delineation for the Alpine and Subalpine Vegetation Monitoring Protocol consisted of a GIS analysis of two existing land cover data sets and a suite of ancillary data layers to create a polygon GIS layer representing the largest potential 'universe' of subalpine and alpine habitats in NOCA, MORA, and OLYM. For the analysis, the Project Lead and NOCA GIS staff defined a set of criteria for the input land cover data sets and ancillary data to best characterize the subalpine and alpine zones in the NCCN. Criteria were also set for determining accessibility to potential habitat, based largely on feasibility and safety.

Input Data Sets

The land cover data included the vegetation classifications from Washington GAP Analysis v.5 (GAP) (Cassidy 1997) and the Pacific Meridian Resources (PMR) (NPS 1996). The GAP data were based on 1991 Landsat satellite imagery and were in vector (polygon) format. The PMR data were based on 1988 Landsat satellite imagery were in raster format. Ancillary data for each park included digital elevation models, lakes, roads, trails, and waytrails or social trails/climbers routes where available (Table E. 1).

Table E.1. Ancillary GIS data sets used in subalpine and alpine habitat delineation.

Park	DEM	Lakes	Roads	Trails	Other trails
NOCA	10 m elevation; 1524 m (5,000 ft.) contour; slope	Park lakes layer, 1:24,000	Park roads layer, 1:24,000	Park trails layer, 1:24,000	Social trails: Eldorado, Boston Basin, Mix-up Arm
OLYM	10 m elevation; 1219 m (4,000 ft.) contour; slope	Park lakes layer, 1:24,000	Park roads layer, 1:24,000	Park trails layer, 1:24,000	Some way trails (screened for sensitivity)
MORA	10 m elevation; 1524 m (5,000 ft.) contour; slope	Park lakes layer, 1:24,000	Park roads layer, 1:24,000	Park trails layer, 1:24,000	Park trails layer included waytrails

Criteria

The criteria for delineating the potential subalpine and alpine habitat for the three parks included the following:

- Cover/vegetation classes (defined by 'zone' and 'primary cover' in the GAP data and by 'species/cover' and 'crown closure' in the PMR data) to be included in the analysis were selected by the Project Lead and are presented in Tables E.2 – E.4. These were the inputs to a union cover class data set of the GAP and PMR data.
- Slope must be ≤35 degrees in the habitat areas.
- Habitat must be above 5,000 feet (1524 m) for NOCA and MORA and must be above 4,000 feet (1219 m) for OLYM
- Habitat cannot be in lakes, or on snow or ice.

- Habitat must be within 1.5 km of roads and trails. The roads and trails GIS layers were merged for each park and then a 1.5 km buffer was created around each of these merged layers.
    - NOCA trail data included the park's maintained trails GIS layer and the Eldorado, Boston Basin, and Mix-up Arm social trails from the park's social trails GIS layer. The social trails at Baker River, Thornton, Rainbow, and Easy Ridge were not included because previous field crews determined that these social trails were either unsafe to travel or not readily visible and difficult to follow.
    - MORA trail data included the park's maintained trails GIS layer, which included waytrails but not climbing routes.
    - OLYM trail data included the park's maintained trails GIS layer and select waytrails (screened by Steve Acker and Ruth Scott for sensitivity and accessibility).

Table E.2. GAP data: regions, zones, and primary cover types selected for NOCA, MORA, and OLYM.

Regions	
6	Outer Olympic Peninsula
12	East Central Cascades
15	Northeast Cascades
16	Northwest Cascades
17	Southwest Cascades
19	Inner Olympic Peninsula
Zones (Primary)	
81	Subalpine Fir
82	Mountain Hemlock
83	Whitebark Pine (incompletely delineated, and treated with Alpine/Parkland)
85	Alpine/Parkland
90	Permanent Ice/Snow
Cover (Primary)	
120	Bare ground, ice/snow, unknown/mixed form (e.g., cliffs)
600	Non-forested, unknown seral stage, unknown/mixed veg physiognomy
604	Non-forested, unknown seral stage, shrub-dominated (>25% shrub, <10% trees)
620	Non-forested, undisturbed/climax, unknown/mixed veg physiognomy
621	Non-forested, undisturbed/climax, sparse vegetation (10-30%)
622	Non-forested, undisturbed/climax, grass/forb-dominated (<10% trees)
624	Non-forested, undisturbed/climax, shrub-dominated (>25% shrub, <10% trees)
625	Non-forested, undisturbed/climax, tree savanna (10-25%)
901	Conifer forest, unknown/mixed seral stage, open canopy (25-60% overstory cover)
981	Conifer forest, late seral, open canopy (25-60% overstory cover)

Table E.3. GAP data: specific zone/primary cover type combinations present in NOCA, MORA, and OLYM.

Park	Region	Zone	Cover	Description
NOCA	12	81	604	Subalpine Fir zone: Non-forested; disturbance status unknown; usually subalpine shrubby meadows, slopes, avalanche chutes
	12	81	901	Subalpine Fir zone: Conifer forest; open, usually on steep slopes or at high elevations; usually Subalpine Fir/Lodgepole Pine/Whitebark Pine
	12	85	620	Alpine/Parkland zone: Non-forested; alpine and subalpine meadows and parkland
	15	81	604	Subalpine Fir zone: Non-forested; disturbance status unknown; usually subalpine shrubby meadows, slopes, avalanche chutes
	15	81	620	Subalpine Fir zone: Non-forested; apparently natural; subalpine meadows or parkland
	15	81	901	Subalpine Fir zone: Conifer forest; open; usually Subalpine Fir and/or Whitebark Pine
	15	83	620	Whitebark Pine zone: Non-forested; shrubby high meadow, avalanche chute, or parkland
	15	83	901	Whitebark Pine zone: Conifer forest; open, usually with Subalpine Fir or Whitebark Pine
	15	85	600	Alpine/Parkland zone: Non-forested; structure and disturbance status unknown; usually a variety of alpine and subalpine
	15	85	620	Alpine/Parkland zone: Non-forested; shrubby high meadow, avalanche chute, or parkland
	15	90	120	Permanent Ice/Snow zone: Permanent ice and snow
	16	81	620	Subalpine Fir zone: Non-forested; apparently natural; usually dry subalpine meadows, slopes, and parkland
	16	81	625	Subalpine Fir zone: Non-forested; apparently natural, subalpine parkland
	16	81	901	Subalpine Fir zone: Conifer forest; open; often on steep slope slopes or ridges, usually Subalpine Fir/Whitebark Pine
	16	81	981	Subalpine Fir zone: Conifer forest; open, often on steep slopes or dry ridges; usually Subalpine Fir/Whitebark Pine; late seral or no sign of recent disturbance
	16	82	620	Mountain Hemlock zone: Non-forested; apparently natural, subalpine meadow or parkland
	16	82	622	Mountain Hemlock zone: Non-forested; apparently natural, herbaceous subalpine meadow
	16	82	624	Mountain Hemlock zone: Non-forested; apparently natural, shrubby subalpine meadow, slope, or avalanche chute
	16	82	625	Mountain Hemlock zone: Non-forested; apparently natural; subalpine parkland
	16	82	901	Mountain Hemlock zone: Conifer forest; open; usually stands among subalpine meadows or on steep slopes; often Mountain Hemlock or Subalpine Fir
	16	85	620	Alpine/Parkland zone: Non-forested; subalpine or alpine meadow or parkland
	16	85	621	Alpine/Parkland zone: Non-forested; sparsely vegetated alpine meadow or steep slope
	16	85	625	Alpine/Parkland zone: Non-forested; subalpine parkland
	16	90	120	Permanent Ice/Snow zone: Permanent ice and snow

Table E.3. GAP data: specific zone/ primary cover type combinations present in NOCA, MORA, and OLYM (continued).

Park	Region	Zone	Cover	Description
MORA	12	81	620	Subalpine Fir zone: Non-forested; apparently natural; subalpine meadows or parkland
	17	81	622	Subalpine Fir zone: Non-forested; apparently natural, usually dry subalpine herbaceous slopes or meadows
	17	82	625	Mountain Hemlock zone: Non-forested; apparently natural; subalpine parkland
	17	85	120	Alpine/Parkland zone: Permanent ice and snow
	17	85	620	Alpine/Parkland zone: Non-forested; subalpine or alpine meadow or parkland
	17	85	621	Alpine/Parkland zone: Non-forested; sparsely vegetated alpine meadow or steep slope
	17	85	622	Alpine/Parkland zone: Non-forested; herbaceous subalpine or alpine meadow or parkland
	17	85	624	Alpine/Parkland zone: Non-forested; shrubby subalpine or alpine meadow, slope, or avalanche chute
	17	85	625	Alpine/Parkland zone: Non-forested; subalpine parkland
	17	90	120	Permanent Ice/Snow zone: Permanent ice and snow
OLYM	6	82	624	Mountain Hemlock zone: Non-forested; apparently natural, shrubby or lush high meadow, parkland, or avalanche chute
	6	82	625	Mountain Hemlock zone: Non-forested; apparently natural, parkland, meadows with scattered trees or trees in sheltered areas
	6	85	120	Alpine/Parkland zone: Permanent ice and snow
	6	85	622	Alpine/Parkland zone: Non-forested; apparently natural; herbaceous alpine or subalpine meadow or parkland
	6	85	624	Alpine/Parkland zone: Non-forested; apparently natural; shrubby alpine or subalpine meadow, slope, or avalanche chute
	6	85	625	Alpine/Parkland zone: Non-forested; apparently natural; parkland and high meadows with scattered trees or trees in sheltered areas
	6	90	120	Permanent Ice/Snow zone: Permanent ice and snow
	19	81	625	Subalpine Fir zone: Non-forested; apparently natural, subalpine parkland
	19	82	625	Mountain Hemlock zone: Non-forested; apparently natural subalpine parkland
	19	85	120	Alpine/Parkland zone: Permanent ice and snow
	19	85	620	Alpine/Parkland zone: Non-forested; subalpine or alpine meadow or parkland
	19	85	622	Alpine/Parkland zone: Non-forested; herbaceous subalpine or alpine meadow or parkland
	19	85	624	Alpine/Parkland zone: Non-forested; shrubby subalpine or alpine meadow, slope, or avalanche chute
	19	85	625	Alpine/Parkland zone: Non-forested; subalpine parkland

Table E.4. PMR species/cover data: classes present within NOCA, MORA, and OLYM.

Species/Cover class	NOCA	MORA	OLYM
Water	x	x	x
Rock / sparsely vegetated	x	x	x
Snow/ice*	x	x	x
Heather	x	x	x
Shrub	x	x	x
Herbaceous/sedge		x	
Meadow 1	x		x
Meadow 2	x		x
Meadow 3	x		x
Meadow 4	x		x
Meadow 5	x		x
Pacific silver fir	x	x	x
Subalpine fir	x	x	x
Red alder	x	x	x
Alaska yellow cedar	x	x	x
Douglas fir	x	x	x
Western redcedar	x	x	x
Western hemlock	x	x	x
Mountain hemlock	x	x	x
Noble fir		x	
Engelmann spruce	x		
Sitka spruce			x
Lodgepole pine	x		x
Ponderosa pine	x		
Subalpine larch	x		
Black cottonwood	x		
Quaking aspen	x		
Bigleaf maple	x		x
Douglas fir / western hemlock mix**		x	
Western redcedar / western hemlock			x
Conifer mix	x	x	x
Conifer / deciduous mix	x		
Hardwood mix	x		x
<25% any species	x	x	x

* NOCA had 'Snow/ice' but MORA and OLYM had 'Snow'

** This was eliminated by the 5,000 ft. (1524 m) elevation threshold

Data Processing Steps

The following GIS analysis procedures were conducted for each park:

GAP data:

- The Project Lead identified the relevant GAP zones and primary covers for the three parks (see Tables E.2 and E.3).
- The data were clipped to parks' boundaries.
- The data were clipped to the 5,000 ft. (1524 m) contour for NOCA and MORA and the 4,000 ft. (1219 m) contour for OLYM.

- The data were converted from shapefile polygons to raster grids.
- The data were reclassified to 3 classes: 0 = Background (No Data), 10 = Vegetation, 20 = Snow/ice.

PMR data:

- All PMR species/cover classes were selected for this analysis as it was determined that those considered not to be alpine or subalpine classes would largely be eliminated with the elevation thresholds and were mostly comprised of a smattering of pixels when present above those thresholds.
- The PMR crown closure data consisted of the following classes for all tree-dominated species/cover classes: 11-40%, 41-70%, and 71-100%. These crown closure data were reclassified to a binary grid where 0 = ≥40% canopy closure and 1 = all other values. The crown closure data were then clipped with the appropriate elevation contour for each park.
- The PMR species/cover data were clipped with the appropriate elevation contour for each park.
- We used 'map algebra' (multiplied reclassified crown closure grid by species/cover grid) to generate a new raster grid of species/cover in which tree-dominated covers only included those with <40% crown cover.
- We reclassified the grid resulting from previous step to 4 classes: 0 = Background (No Data), >40% crown cover, 1 = Water, 2 = Rock / sparsely vegetated, and all vegetation species classes, 3 = Snow/ice.

Merging GAP and PMR data:

- We used 'map algebra' (added final reclassified GAP and PMR grids from steps above together) to produce a union GAP/PMR grid of cover classes.
- We reclassified the union GAP/PMR grid into a binary grid of potential subalpine/alpine habitat and snow/ice, using the decision matrix presented in Table E.5.
- Because the GAP data could have reintroduced areas that in the PMR data were classified as >40% crown closure, this union GAP/PMR grid was multiplied again by the reclassified PMR crown closure data to eliminate them.
- The union GAP/PMR grid of cover classes was then clipped by the 1.5 km roads and trails buffer.
- Using 'map algebra,' all areas with slope >35 degrees were eliminated from the final GAP/PMR grid of cover classes.

Table E.5. Decision matrix for reclassifying union GAP/PMR grid of cover classes.

GAP		PMR		GAP-PMR union	
Value	**Class**	**Value**	**Class**	**Value**	**Class**
0	No Data	0	No Data	0	No Data + No Data = No Data
10	Vegetation	1	Water	1	No Data + Water = No Data
20	Snow/ice	2	Vegetation	2	No Data + Vegetation = Vegetation
		3	Snow/ice	3	No Data + Snow/ice = Snow/ice
				10	Vegetation + No Data = Vegetation
				11	Vegetation + Water = Vegetation
				12	Vegetation + Vegetation = Vegetation
				13	Vegetation + Snow/ice = Snow/ice[1]
				20	Snow/ice + No Data = Snow/ice[2]
				21	Snow/ice + Water = Snow/ice[2]
				22	Snow/ice + Vegetation = Vegetation
				23	Snow-ice + Snow/ice = Snow/ice

[1] Visual comparison of the PMR and GAP data to the NOCA glacier GIS layer, Digital Orthoquads, and aerial photographs revealed that the PMR data better represented Snow/ice in NOCA than the GAP did; the PMR assignment to 'Snow/ice' was likely a more accurate classification for these areas than the assignment to 'vegetation' by the GAP data. The same was assumed to be true for MORA and OLYM.

[2] Union class not present at MORA and OLYM

Clean-up of the union GAP/PMR cover class grid:

- We ran a 3x3 majority filter using '8 neighbors' to smooth small clusters of grid cells.
- We ran the Remove Noise filter (area = 4 cells) to eliminate clusters of grid cells smaller than 2500 m^2.
- The grid data set was converted to a polygon shapefile.
- The parks' lakes GIS layers were used to clip out all lakes.

The final polygon shapefile of potential subalpine/alpine habitat was sent to West, Inc. so that the statistician could then generate GRTS sample points within these areas for plot locations.

Literature Cited

Cassidy, K. M. 1997. Washington Gap Project 1991 Land Cover for Washington State. Washington Cooperative Fish and Wildlife Research Unit, University of Washington. Seattle, WA.

National Park Service. 1996. Vegetation and landform database development study final report. Pacific Meridian Resources. Portland, OR.

Appendix F. Job Hazard Analysis

The Job Hazard Analysis for the Alpine and Subalpine Vegetation Monitoring Protocol is presented in the following Figure F.1.

JOB HAZARD ANALYSIS (JHA)		Date: **January 6, 2011**	☒ New JHA ☐ Revised JHA
Park Unit: **North Cascades National Park Service Complex, Mount Rainier National Park and Olympic National Park**	Division: **Resource management**	Branch: **Resource Management**	Location: **Network wide**
TASK TITLE: **Alpine and subalpine vegetation monitoring**		JHA Number:	Page ___1___of __4____
Job Performed By: **OLYM, MORA and NOCA staff**	Analysis By: Mignonne Bivin	Supervisor: Jack Oelfke	Approved By:

Required Standards and General Notes:	
Required Training:	Good physical condition
Required Personal Protective Equipment:	Standard field apparel; long pants, long-sleeved shirts, boots with ankle support. Sun protection (sun screen, sun glasses, brimmed hat), rain gear, wind protection and warm clothing. Trekking poles and/or ice axes.
Tools and Equipment:	Plot frames, GPS units, meter tapes, notebooks, hand lens, flagging, handheld radios, spare batteries for radios, first aid kits.

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Travel to the site	Vehicle condition Weather Road Conditions Other Drivers Animals Backing vehicle	• Perform pre-trip inspection on vehicle. Conduct scheduled PM inspections. • Drive to avoid accident situations created by weather or road conditions. • Always wear your seat belt. • Reduce speed when driving on wet surfaces or rough roads. • To prevent accidents, make concessions to other drivers who are thoughtless, unskilled, or ignorant of the hazards they create. Alway use a person to serve as a guide for backing when available. Use chock blocks when parked. • Always drive defensively. Be aware. Do not drive when distracted, tired or ill.

Figure F.1. Job Hazard Analysis form.

JHA - CONTINUATION SHEET	JHA Number:	Page __2___of __4___
Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Hiking to and around field site	Traveling on rough uneven terrain, steep slopes, slippery slopes, and forested slopes	• Wear sturdy boots with good soles; dig in heels while descending. Use trees and solid rocks for handholds when they are available. Use trekking poles. Move slowly and deliberately across steep areas. • Be very cautious of the following slippery situations: 1) bare rock covered with small rocks, moss, or leaves, 2) stumps and branches, and 3) wet rocks or logs, use trekking poles when crossing streams • When walking on forested slopes, be cautious of foot placement. Be aware of branches at face level even when you are focusing on the ground. • When crossing rocky or talus slopes be very cautious of footing; be sure the rock you are stepping on is secure. • When crossing snow fields, use trekking poles or ice axes for stability, kick steps in the snow surface, plant feet deliberately, and move slowly. Use plunge steps when descending snowy slopes. Avoid traveling on snow in early morning or on a cold day when the surface may be frozen.
	Dehydration/Exhaustion	• Employees should be in good physical condition. Take breaks when hiking up steep slopes. Carry two quarts of water, and drink throughout the day.
	Hypothermia	• Layer your clothing such that it will be easy to regulate your body temperature by adding or subtracting layers. DO NOT wear cotton as a layer. Instead, wear clothing that stays warm when wet, such as wool or clothing made from synthetic material such as polypropylene. • Expect rain and carry appropriate gear. • Always carry a warm hat and gloves.

Figure F.1. Job Hazard Analysis form (continued).

JHA - CONTINUATION SHEET	JHA Number:	Page __3___of __4___
Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Hiking to and around field site	Lightning	• Check the forecast prior to fieldwork and watch the sky. If lightning is predicted, reschedule fieldwork. If lightning is approaching, seek shelter. • Get to a lower elevation, get off ridgelines and peaks. • Avoid single trees and metal objects. If in a forested area, do not touch or lean on trees. Spread out from crew members (lightning can travel between people). • Do not stay in gullies, under overhangs, or in caves. • As a last resort, assume a crouch position on the ground with your weight on the balls of the feet, your feet together, head lowered, and ears covered.
	Wildlife encounters	• When encountering a bear or cougar, make noise, raise arms (to appear larger), maintain eye contact, and back away. Do not run. Report incident to the park's wildlife biologist.
	Fatigue	• Field crews should be in good physical condition. Hydration and food are important to maintain stamina. Work brakes should be taken as necessary.
Data entry and office tasks	Repetitive motion injuries, eye strain	• Stretch often, change positions, and take brakes. • Ensure the work space is ergonomically correct. • Ensure the office space has proper lighting.

Figure F.1. Job Hazard Analysis form (continued).

JHA - CONTINUATION SHEET	JHA Number:	Page __4___of __4___
Text Description of Task When it is Done Safely		

Authorized Employee Information			
Employee ID	Last Name	First Name	Qualifications/Remarks

Figure F.1. Job Hazard Analysis form (continued).

INSTRUCTIONS FOR COMPLETING THE JOB HAZARD ANALYSIS FORM

Job Hazard Analysis (JHA) is an important accident prevention tool that works by finding hazards and eliminating or minimizing them *before* the job is performed, and *before* they have a chance to become accidents. Use your JSA for job clarification and hazard awareness, as a guide in new employee training, for periodic contacts and for retraining of senior employees, as a refresher on jobs which run infrequently, as an accident investigation tool, and for informing employees of specific job hazards and protective measures. Set priorities for doing JHA's: jobs that have a history of many incidents, jobs that have produced disabling injuries, jobs with high potential for disabling injury or death, and new jobs with no accident history. Here's how to do each of the three main parts of a Job Hazard Analysis:

SEQUENCE OF JOB STEPS

Break the job down into steps. Each of the steps of a job should accomplish some major task. The task will consist of a *set* of movements. Look at the first *set* of movements used to perform a task, and then determine the next logical *set* of movements. For example, the job might be to move a box from a conveyor in the receiving area to a shelf in the storage area. How does that break down into job steps? Picking up the box from the conveyor and putting it on a hand truck is one logical set of movements, so it is one job step. Everything is related to that one logical set of movements is part of that job step.

The next logical *set* of movements might be pushing the loaded hand truck to the storeroom. Removing the boxes from the truck and placing them on the shelf is another logical set of movements. And finally, returning the hand truck to the receiving area might be the final step in this type of job.

Be sure to list *all* the steps in a job. Some steps might not be done each time checking the casters on a hand truck, for example. However, that task is a part of the job as a whole, and should be listed and analyzed.

POTENTIAL HAZARDS

Identify the hazards associated with each step. Examine each step to find and identify hazards – actions, conditions, and possibilities that could lead to and accident.

It's not enough to look at the obvious hazards. It's also important to look at the entire environment and discover every conceivable hazard that might exist.

Be sure to list health hazards as well, even though the harmful effect may not be immediate. A good example is the harmful effect of inhaling a solvent or chemical dust over a long period of time.

It's important to list *all* hazards. Hazards contribute to accidents, injuries, and occupational illnesses.

In order to do part three of a JHA effectively, you must identify potential and existing *hazards*. That's why it's important to distinguish between a hazard, and accident and an injury. Each of these terms has a specific meaning:
HAZARDS – Potential danger. Oil on the floor is a hazard.
ACCIDENT – An unintended happening that may result in injury, loss or damage. Slipping on the oil is an accident.
INJURY – The result of an accident. A sprained wrist from the fall would be an injury.

Some people find it easier to identify possible accidents and illnesses and work back from them to the hazards. If you do that, you can list the accident and illness types in parentheses following the hazard. But be sure you focus on the *hazard* for developing recommended actions and safe work procedures.

SAFE ACTION OR PROCEDURE

Using the first two columns as a guide to decide what actions are necessary to eliminate or minimize the hazards that could lead to an accident, injury, or occupational illness.

Among the actions that can be taken are, 1) engineering the hazard out; 2) providing personal protective equipment; 3) job instruction training; 4) good housekeeping; and 5) good ergonomics (positioning the person in relation to the machine or other elements in the environment in such a way as to eliminate stresses and strains).

List recommended safe operating procedures on the form, and also list required or recommended personal protective equipment for each step of the job.

Be specific. Say *exactly* what needs to be done to correct the hazard, such as, "lift using your leg muscles." Avoid general statements like, "be careful."

Give a recommended action or procedure for *every* hazard.

If the hazard is a serious one, it should be corrected immediately. The JSA should then be changed to reflect the new conditions.

Figure F.1. Job Hazard Analysis form (continued).

Appendix G. Annual Report Template

The annual report should consist of the following information and sections:

Report

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Authors/Contacts

Introduction/Background

Boilerplate for each report covering the following:

- Importance of alpine and subalpine vegetation monitoring in the NCCN and our ecoregion
- Monitoring Objectives and connection to park management (Table G.1)

Methods

- Quick review of methods (i.e., plot establishment and monitoring)
- Study design – spatial and temporal aspects; target population for each combination of park and vegetation stratum
- Plot design and monitoring methods

Results

- Overview of Accomplishments of current year (i.e., office and field evaluation of GRTS points, which plots were established, monitored) (see Tables G.2, G.3)
- Maps of MORA, NOCA, and OLYM showing where plots were established and monitored
- Subalpine and alpine vegetation – during first 4 years, summary of status of vegetation in plots (e.g., elevation ranges of subalpine and alpine plots, patterns of species richness, summary of cover types, description of community types monitored) (see Tables G.4-G.5)
- Subalpine and alpine vegetation – list or table of data loggers deployed (i.e., number of data loggers deployed in each plot and date of deployment)
- Whitebark pine –review of GRTS points, status of monitoring of plots, trends in mortality and infection following repeat visits (see Tables G.6-G.8)
- Detection of change and trend, based on initiation of monitoring in 2011 and repeat visits beginning in 2016

Table G.1. Monitoring objectives, response variables, and link to management issues.

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
1. Composition and structure of alpine vegetation 2. Composition and structure of subalpine vegetation	Species cover organized by growth form: trees, shrubs, forbs, sedges, grasses, moss, lichen	• Individual park and organized by: - alpine - subalpine - alpine treeline ecotone (ate)[2] • Network and organized by: - alpine - subalpine - alpine treeline ecotone	• Proportion of each cover type by alpine or subalpine vegetation for each park • Proportions across alpine or subalpine vegetation in NCCN • Comparison of patterns between NCCN parks	• Change in proportions within alpine & subalpine vegetation by park • Change across alpine or subalpine in the NCCN • Comparison of rates of change across parks	• Identification of parks, or areas where rates of change are most rapid • Areas where recreational opportunities may be changing • Quality of wildlife habitat • Change in landscape connectivity patterns • Adaptation guidelines
	Native species richness Exotic species richness		• Locations of exotic species • Description of patterns of species richness by vegetation type, park, elevation, aspect	• Rate or magnitude of changes in species richness by park, vegetation type, elevation, or aspect	• Recommendations for exotic plant management • Estimate of ecological integrity of areas based on exotic species • Evaluation of Wilderness character
	Cover of individual species	• Plot • Species distribution • Park - alpine - subalpine - alpine treeline	• Average and variation in cover • Distribution by elevation or park	• Change in cover within park or between parks	• Development of adaptation guidelines • I33nforming desired future conditions • Informing wildlife studies

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
	Plot classification and elevation	ecotone • NCCN - alpine - subalpine - alpine treeline ecotone	• Average and range of elevation of plots classified as alpine or subalpine	• Change in number of plots that have succeeded to a different type (alpine or subalpine)	• indication of rate of change in alpine treeline ecotone: subalpine to forest or alpine to subalpine
3. Composition and structure of alpine legacy plots	Cover type: trees, shrubs, forbs, sedges, grasses, moss, lichen Native species richness Exotic species richness Species cover of individual species	• Plot	• Proportion of each cover type • Number of native and exotic species per vegetation plot • Cover of individual species	• Changes in proportion of cover types within each plot • Change in exotic and native species richness • Change in cover of individual species	• Provide a perspective on 30+ years of change in select alpine environments • Early warning of changes that may be expected in plots
4. Soil temperature and snow cover	Soil temperature	• Individual park and organized by: - alpine - subalpine - alpine treeline ecotone • Network and organized by: - alpine - subalpine - alpine treeline ecotone	• Patterns of soil temperature by day, month, growing season • Snow melt as estimated by soil temperature	• Change in average daily or monthly soil temperature • Change in snow melt date and growing season	• Change in snow cover patterns in alpine treeline ecotone – application to recreational opportunities, rates of vegetation change • Development of adaptive management strategies for natural resources

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
5. Whitebark pine	Whitebark pine tree status – infected, dead, uninfected Whitebark pine – diameter, height All other tree species- diameter, height	• Park • NCCN	• % live, dead, infected • Basal area/ha by species • Tree density/ha by species • Average and distribution of height by species	• Rate of change in mortality and infection rates • Changes in composition • Changes in structure	• Development of adaptive management or restoration strategies for whitebark pine in parks of NCCN • Compare status of whitebark pine with other parks and forests in Pacific West Region and Rocky Mountains • Identification of potentially resistant trees • Decisions on whether and where to control mountain pine beetles with pheromones
	Saplings, seedlings		• Sapling density/ha by species • % whitebark pine saplings infected with blister rust • Seedling density/ha by species	• Changes in structure and composition of saplings and seedlings • Rate of change in infection rates of whitebark pine saplings • Rates of recruitment by tree species	
	Evidence of Mountain pine beetles		• Incidence of mountain pine beetles by plot, park, elevation	• Trends in beetle occurrences in parks	
	Cankers		• Percent of trees with bole or branch cankers – severity of infection • Percent of trees with active or inactive cankers	• Changes in percent of trees with cankers • Progression of blister rust – change in % trees with bole cankers	
	Crown Kill on whitebark pine		• Average crown kill per tree	• Rate of change in crown kill	

Objective	Response Variable	Inference[1]	Status Estimates	Trends	Management Application
	Dwarf mistletoe		• Number of trees /ha with mistletoe • Pattern of mistletoe incidence in crown	• Change in proportion of trees with mistletoe • Change in distribution of mistletoe within crowns	
	Understory vegetation		• Average cover by species • Classification of whitebark pine communities	• Change in understory plant composition	

[1] Vegetation within the target population as described in Chapter 2,Section B.

[2] Alpine treeline ecotone calculations will be based on all plots within the alpine and subalpine zones to describe status or trends in all areas above closed canopy forests (i.e., forestline).

Table G.2. Schedule of vegetation monitoring activities.

	Year																			
Task	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A&S 1[1]	M[4]					M					M					M				
A&S 2[1]	R[5]	M					M					M					M			
WBpine[2]		R		M					M					M					M	
WB Legacy				M																
A&S 3[1]				R	M					M					M					M
Forest[3]	A	A	F	A	A	A	A	F	A	A	A	A	F	A	A	A	A	F	A	A
Alpine Legacy			M					M					M					M		

[1] A&S: indicates panel 1, 2, or 3 of alpine and subalpine monitoring plots.

[2] WBpine: indicates whitebark pine monitoring plots.

[3] Forest: Forest monitoring Annual mortality checks or Full census monitoring.

[4] M: indicates monitoring of plots and in initial year includes establishment.

[5] R: indicates site review of potential sample points for alpine & subalpine or whitebark pine monitoring.

Table G.3. Number of plots established by park and strata.

Park	**Alpine**		**Subalpine**		**Whitebark Pine**	
	Number of plots	Elevation range (m)	Number of plots	Elevation range (m)	Number of plots	Elevation range (m)
MORA						
NOCA						
OLYM						
Totals						

Table G.4. Summary of species richness in alpine plots established by park.

	MORA		**NOCA**		**OLYM**	
	Native (# species)	Exotic (# species)	Native (# species)	Exotic (# species)	Native (# species)	Exotic (# species)
Trees						
Shrubs						
Forbs						
Grasses						
Sedges						
Mosses						
Lichens						

Table G.5. Summary of species richness in subalpine plots established by park.

	MORA		**NOCA**		**OLYM**	
	Native (# species)	Exotic (# species)	Native (# species)	Exotic (# species)	Native (# species)	Exotic (# species)
Trees						
Shrubs						
Forbs						
Grasses						
Sedges						
Mosses						
Lichens						

Table G.6. Summary of whitebark pine trees status by park.

		Whitebark Pine (# trees/plot)				**Other Species (# trees/plot)**			
Park	**Plot Number**	**Infected**	**No blister rust**	**Dead**	**Mountain pine beetle[1]**	**ABLA**	**PICO**	**TSME**	**XXXX**
MORA									
NOCA									
OLYM									

[1] Recently dead, as indicated by presence of pitch tubes, frass, or galleries.

Table G.7. Summary of saplings in whitebark pine plots by species and park.

		Whitebark Pine (# saplings/plot)		**Other Species (# saplings/plot)**			
Park	**Plot Number**	**Infected**	**No blister rust**	**ABLA**	**PICO**	**TSME**	**XXXX**
MORA							
NOCA							
OLYM							

Table G.8. Summary of seedlings in whitebark pine plots by species and park.

		Whitebark Pine (# seedlings/plot)		Other Species (# seedlings/plot)			
Park	**Plot Number**	**Infected**	**No blister rust**	**ABLA**	**PICO**	**TSME**	**XXXX**
MORA							
NOCA							
OLYM							

Summary/Conclusions

- Summary of accomplishments in past year
- Discussion of challenges to developed methods and revisions to any methods
- Discussion of patterns in physiognomic cover types, species richness, or vegetation composition across subalpine and alpine zones and within and among parks
- Description of differences among plots, zones, parks over time (when available) in species composition
- Recommendations for changes to methods
- Summary of questions raised by monitoring observations or data and recommendations for research to complement or expand upon the monitoring effort

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

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