National Park Service
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Natural Resource Program Center

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Natural Resource Report NPS/KLMN/NRR—2010/227

ON THE COVER
Scotch broom (*Cytisus scoparius*) growing in ponderosa pine woodland in the Klamath Region.
Photograph by: Dennis Odion

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Dennis C. Odion
Department of Biology
Southern Oregon University
Ashland, OR 97520

Daniel A. Sarr
Klamath Network
Southern Oregon University
Ashland, OR 97520

Sean R. Mohren
Klamath Network
Southern Oregon University
Ashland, OR 97520

Rob C. Klinger
USGS-BRD
Yosemite Field Station
Bishop Office RR2
14 Utah Street
Bishop, CA 93514

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1.0 Background and Objectives

1.1 Rationale for Early Detection Monitoring of Invasive Plants

Non-native, invasive species are a paramount concern in virtually all natural areas and, not surprisingly, ranked as the top vital sign for monitoring within the Klamath Network. Impacts of invasives threaten the core goals of the National Park Service. Invasive species are second only to habitat loss as a threat to native biodiversity (Wilcove et al. 1998). Impacts from invasives that can severely degrade native ecosystems include the replacement of native vegetation (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure (Mack and D'Antonio 1998), alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), changes in water availability (D'Antonio and Mahall 1991), and alteration of disturbance regimes (Mack and D'Antonio 1998). Invasive species having these effects are ecosystem transformers. Invasive species capable of transforming ecosystems are the focus of this protocol.

Invasive plant species also negatively affect park resources in non-ecological ways that are a threat to National Park Service goals. Visitor enjoyment can be impaired in several ways, including altering landscapes and historic viewsheds, encroaching upon trails, and acting as a form of visual pollution. Invasives may hinder trail work by diverting resources or increasing trail maintenance needs.

Despite much appreciation for the potential negative effects of invasives, our understanding of their full consequences and manifestations is far from complete. Monitoring can play a key role in filling this void and help with managing to limit the consequences of invasives.

Although a variety of invasive plants, animals, and pathogens are of concern in the Klamath Network, invasive plants are the most pervasive problem. Therefore, the Network's monitoring under this protocol will concentrate on early detection of invasive plants. Early detection is cost-effective, in that it can identify populations for removal, control, or eradication before they become entrenched within a park (OTA 1993, Myers et al. 2000, Harris et al. 2001, Rejmanek and Pitcairn 2002, Timmins and Braithwaite 2002). In addition to saving money, early detection and rapid response efforts minimize ecological damage caused by control efforts, which may become futile if not done early in the invasion process (Rejmanek and Pitcairn 2002). Given the limited resources of the Network, early detection is an especially pragmatic approach. A more complete discussion of the merits of early detection is presented in Appendix A and in the USGS/NPS Early Detection of Invasive Species Handbook (http://www.pwrc.usgs.gov/brd/invasiveHandbook.cfm).

This protocol will focus on species that are not yet well established and are along roads and trails. Part of the reason this protocol focuses on early detection along the roads and trails is because the vegetation monitoring protocol the Network is developing proposes to broadly sample invasive plants, both spatially and taxonomically. The invasive species early detection protocol described here and the vegetation protocol complement one another to provide a broader picture of invasive species' status and trends than either would alone.

1.2 Link to National Strategy

Early detection of invasive species is a nation-wide issue. Many parks and networks are working on early detection protocols collaboratively and individually. In 2002, the National Research Council thoroughly reviewed the state of knowledge on invasive species invasions (non-indigenous species). Their key recommendations for furthering knowledge and preventing invasions include the following:

"…Careful recording of the circumstances of arrival, persistence, and invasion of non-indigenous species in the United States would substantially improve prediction and risk assessment."

"Information on the structure and composition of natural ecosystems in North America (and the disturbance regimes within them) should be reinterpreted by the scientific community to analyze these ecosystems' vulnerability to biotic invasion. Attention should be paid to identifying groups of native species that could be vulnerable or could facilitate the establishment of non-indigenous species."

"A central repository of information relevant to immigrant species would accelerate efforts to strengthen the scientific basis of predicting invasion. Information collected by federal, state, and international agencies; academic researchers; and others should be brought together in a single information facility or service so that it can be evaluated collectively, to permit the construction of needed datasets and the design of appropriate experiments, and to document the circumstances surrounding invasions."

Through the implementation of this and other invasive species monitoring protocols, the National Park Service will be building on these important recommendations as a contribution to the greater body of knowledge regarding the threat of invasive species in the United States.

This protocol will also serve to meet invasive species goals that were mandated by the National Park Service as part of the Natural Resource Challenge that established 32 Inventory & Monitoring (I&M) networks across the United States (National Parks Omnibus Management Act of 1998 [P.I. 105-391]). In 2002, the NPS I&M program held a workshop to recommend guidelines and tools for developing protocols for inventory and monitoring of invasive plants. One of the four adopted goals is to "prevent and detect new alien plant invasions, and eradicate new invasives" (Hiebert 2002, Benjamin and Hiebert 2004). This protocol meets the goal established in 2002 and follows standards that have been recently developed through the USGS-NPS Early Detection of Invasive Plants Handbook (http://www.pwrc.usgs.gov/brd/invasiveHandbook.cfm).

The NPS Invasive Species Action Plan (NPS 2006b) includes specific, recommended actions ranging from leadership and coordination to restoration. This protocol meets or helps to meet the guidelines and suggestions of the following actions from the plan:

- 1A.2: Develop NPS capability at a regional or multi-park level.
- 1B.1: Expand partnerships to maximize results.
- 1C.3: Rank invasive species for each park unit.

3A.3: Contribute to the development of national standards for all aspects of invasive species management.
6A.2: Improve the quality of the invasive species data in the NPSpecies database.

The protocol is linked to the action plan by being Network-wide, partnering with parks, ranking invasives by park, and providing knowledge on the management and distribution of invasives.

1.3 Monitoring History

Managing invasive species has been an important component of resource protection in the parks in the Network for decades. There are various informal monitoring efforts associated with management of invasives, but no formal early detection program. There are maps of invasive species occurrences that have been produced, known locations of management treatments, and substantial knowledge among resource staff. There are data from fire management Fire Monitoring Handbook (FMH) plots in burns, fuelbreaks, etc., and other vegetation sampling that has documented invasive species. At Lava Beds, Youth Conservation Corps volunteers produce a database of invasive species locations annually from surveys throughout much of the park. Nonetheless, there is no standardized, repeatable monitoring being done that can rigorously assess the status and trends in invasive plants in the Network, nor are existing efforts focused on early detection.

The Network undertook an inventory of invasive plant species in five of the six parks during Fiscal Year 2003 to build a base of knowledge about invasive species distribution and abundance in landscapes of the parks. Three primary survey methods, singly or in combination, were employed: (1) site profile surveys of known disturbed areas, (2) targeted mapping of invasive species, and (3) establishment of quantitative belt plots for non-native vegetation. Belt plots were installed on randomly selected linear road and trail segments, and encompassed different elevations and vegetation types in each park. Complete methods and results are described in Sarr et al. (2004).

Across the Network, the most striking pattern observed in the inventory was that mean richness of non-native species in the 1 ha belt subplots declined sharply from low elevations of Whiskeytown to the higher elevations at Lassen Volcanic (Figure 1). At low elevations, richness declined with belt distance from the road or trail, but this pattern was not evident at mid and high elevation sites, at least within the 100 m distance selected for the belt transect.

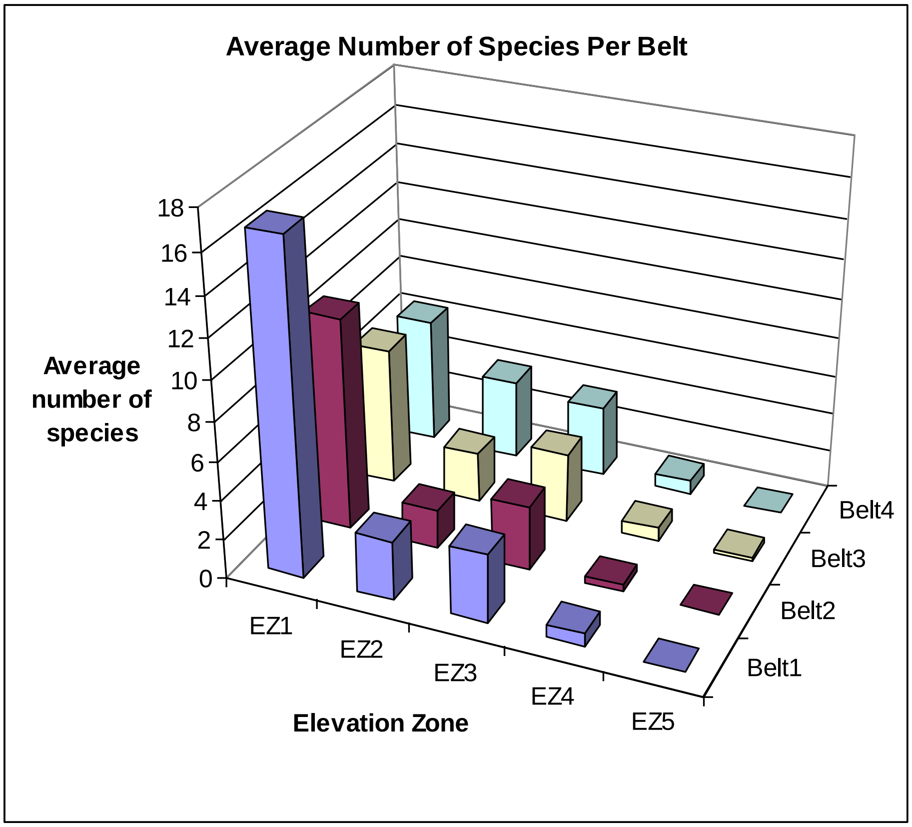

Figure 1. Average non-native species richness in 24 (1 ha) quantitative belt plots grouped by elevation zone (EZ1 = 0-500 m, EZ2 = 500-1000 m, EZ3 = 1000-1500 m, EZ4 = 1500-2000 m, EZ 5 = 2000-2500 m) and belt distance from a road or trail (Belt 1 = 0-25 m, Belt 2 = 25-50 m, Belt 3 = 50-75 m, Belt 4 = 75-100 m).

The monitoring history in the Network also includes a pilot study conducted to test this invasive species early detection protocol. The pilot study was conducted in fall 2007. Two researchers spent 5 weeks sampling in Redwood National and State Parks. Findings from the pilot study have been incorporated as improvements to the original sampling design as described in the relevant sections of this protocol. A report on the pilot study and its findings is presented in Appendix B.

1.4 Network Invasive Species Early Detection Conceptual Models

In the development of this protocol, the Network has considered a number of interacting factors relating to the invasion process and monitoring. These are summarized conceptually in Figure 2. Park management, the susceptibility of park landscapes to invasion, and species environmental tolerances directly affect the invasion process.

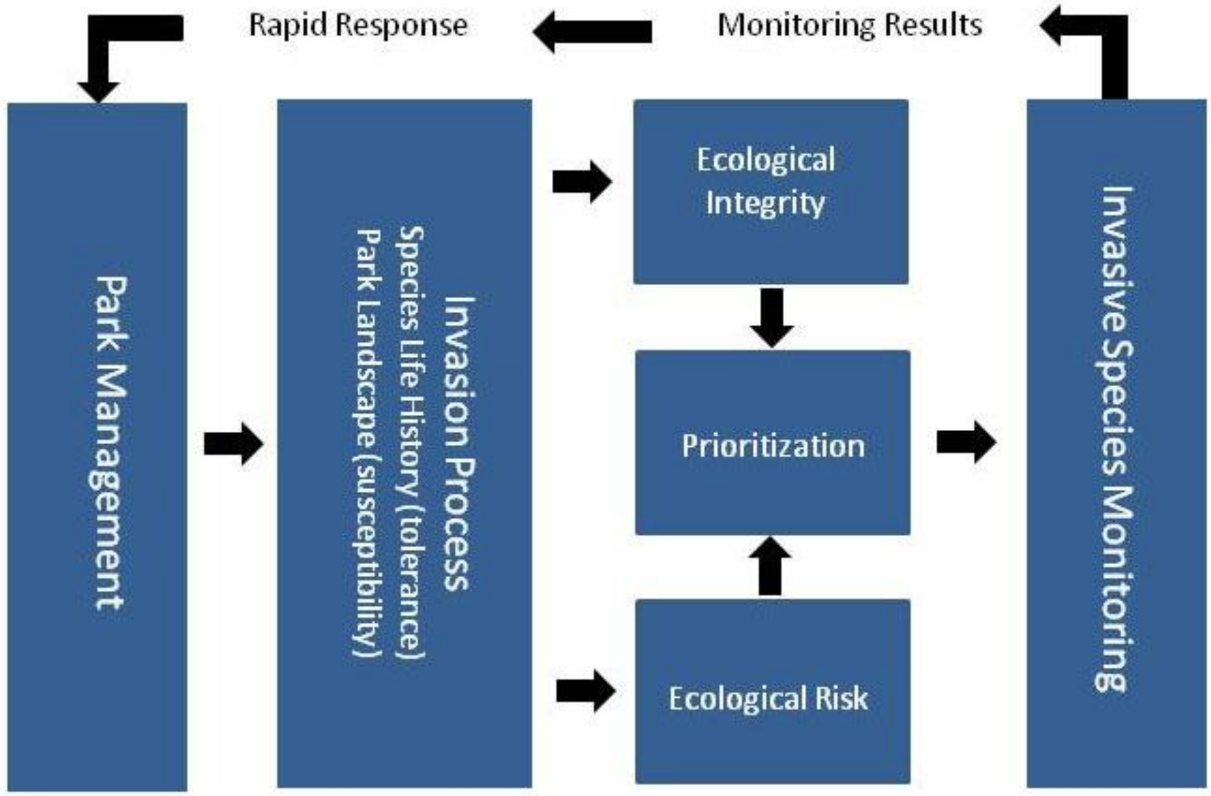

Figure 2. Conceptual model of the Klamath Network's invasive species early detection monitoring protocol. Park management and invasive control efforts affect the invasion process. This process places differential ecological risks across the park landscape, affecting ecological integrity. These effects determine the prioritization of species and locations to sample in the invasive species monitoring protocol. The results of this monitoring feed directly into rapid response, a component of park management of invasives.

The invasion process in turn affects the ecological integrity of parks and the risk of degradation. These are key factors in prioritizing which species to monitor. Also key is feedback from monitoring to support rapid response by park managers. We explore these interrelated aspects of the invasion process further with conceptual modeling.

1.4.1 Susceptibility of Park Landscapes

Past inventories and park-wide species lists strongly suggest that vulnerability to invasive plants varies considerably among parks in the Klamath Network. Although the number of non-native species present generally increases with park area, many more invasive species are present at parks with lower elevations (Figure 3). Thus, at both of the parks with the lowest elevations, Whiskeytown and Redwood, far more invasives may be found in a given-sized area than the higher elevation parks. Non-climate factors promoting invasion at Whiskeytown appear to be mechanical and soil disturbances associated with fuelbreak construction and maintenance, vegetation mastication, prescribed burning (particularly where mastication slash resides), wildfires, and vegetation management under a powerline corridor traversing the park. Redwood has a major highway running through it, high levels of visitor use, and past anthropogenic and natural disturbances, as well as coastal processes that may be linked to invasions. The shrubsteppe ecosystems at Lava Beds are also vulnerable to invasives, due to relatively open vegetation and an abundant source of invasive propagules from surrounding agricultural lands and various disturbances, such a fire. Most of Crater Lake and Lassen Volcanic National Parks is high enough in elevation that the numbers of invasive species are comparatively low for their sizes.

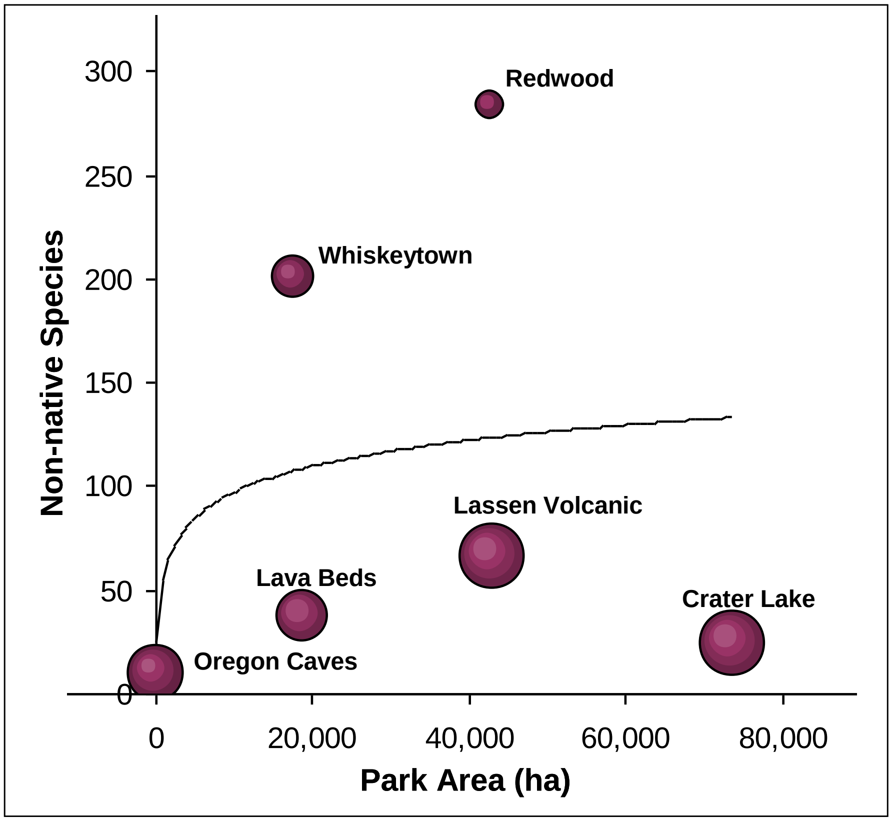

Figure 3. Non-native species richness as a function of park area in National Park system units in the Klamath Network. A logarithmic line is provided to illustrate the expected species / area relationship across park sizes; bubble size is proportional to mean park elevation. The lower elevation parks have more non-native species than expected for their size, whereas higher elevation parks have fewer recorded species.

Based on these general patterns of invasive plant species richness, the lower elevation parks will have a much wider range of species of potential concern and efforts there could easily outstrip the resources available. Prioritization of which species to monitor, therefore, will be essential to assuring that we can allocate monitoring efforts to locate the most pressing concerns in these parks.

1.4.2 Species Tolerances

As an initial step in predicting the abiotic conditions favoring species invasion, we have developed a semi-quantitative conceptual model to link species' physiological tolerances with potentially invasible park habitats. To develop this model, we undertook the following research and analysis of the species that were included in the prioritization described in Appendix A.

For each species, a number of sources were checked for habitat preferences and elevation limits. Sources included the Jepson Manual (Hickman 1993, D'Antonio et al. 2004) for elevations and habitat preferences. In addition, numerous online sources such as the California Invasive Plant Council's web page (http://www.cal-ipc.org/) and expert opinion of park resource managers as described in SOP #1: Invasive Species Prioritization. The following attributes were coded for each species to create a species/attribute matrix.

A. Cold Tolerance:
- 1 = Intolerant. Occurs only at or near sea level.
- 2 = Somewhat tolerant. Occurs below 1,000 m elevation.
- 3 = Fairly tolerant. Can occur from 1,000 – 2,000 m elevation.
- 4 = Tolerant. Occurs above 2,000 m.

B. Shade Tolerance:
- 1 = Intolerant. A light-demanding species, found almost exclusively in full sun.
- 2 = Somewhat intolerant. Can handle some shade.
- 3 = Somewhat tolerant. Can grow in understory of open forest or shrubland.
- 4 = Very tolerant. Can grow in the understory of a closed forest or shrubland.

C. Moisture Requirements or Drought Tolerance:
- 1 = Aquatic.
- 2 = High moisture requirement, not drought tolerant.
- 3 = Moderate moisture requirement, somewhat drought tolerant.
- 4 = Low moisture requirement, drought tolerant, or annual species.

D. Soil Nutrients:
- 1 = Intolerant of low nutrient soils or substrata.
- 2 = Fairly tolerant of low nutrient soils or substrata.
- 3 = Tolerant of low nutrient soils or substrata.

E. Salt Tolerance:
- 1 = Not known to occur on salt affected substrata.
- 2 = Can grow on salt-affected substrata.

Species were classified into three groups using cluster analysis in the software package PC Ord. The species were then ordinated by their tolerance values using Principal Components Analysis in PC Ord. The result is a diagram visually illustrating patterns of species' tolerances. In the diagram, species with similar attributes cluster together in ordination space (Figure 4). Tolerances variables are overlaid as vectors to create a biplot.

The ordination in Figure 4 shows that the most variation among species (43%) is explained along a primary environmental gradient (Axis 1) relating to cold tolerance. This reflects effects of elevation and/or continentality at one extreme and mild and humid coastal conditions at the other. The second gradient, Axis 2, explains 31% of the variance. Axis 2 is closely related to a combination of drought tolerance and shade intolerance on one extreme, and shade tolerance and drought intolerance on the other. Drought tolerance is positively correlated with tolerance of low soil nutrients.

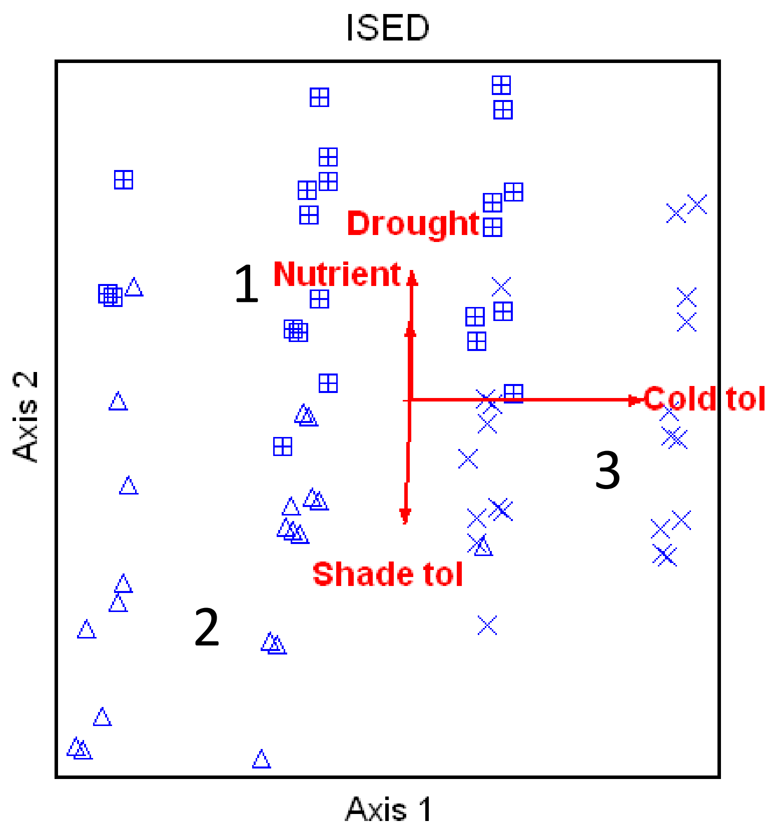

Figure 4. Ordination biplot of invasive species in the Klamath Network based on physiological tolerances. The first axis explains 43% of the variation in tolerance values among 166 species, while the second axis explains 31%. Some labels represent the locations of more than one species in the ordination space. Group 1 are squares, Group 2 are triangles, and group 3 are X's.

Cluster analysis identified three general groups of species with distinctive combinations of drought/nutrient, shade and cold tolerance. Group 1 consists of invasives species that are tolerant of drought and low soil nutrients but intolerant of deep shade or cold temperature extremes. Such species are capable of primarily invading low elevation, open environments. Of the 166 total species in the ordination, group 1 contains 55. Eighteen of these species were ranked as early detection priorities (SOP #1: Invasive Species Prioritization). Some were ranked in more than one park, leading to a total of 27 times that a species from group 1 was prioritized for monitoring among the six park lists. Of these, one species, Scotch broom (*Cytisus scoparius*), was prioritized in four parks and another, cheatgrass (*Bromus tectorum*) was prioritized in three parks.

Group two consists of species that are relatively shade tolerant and drought intolerant. Consistent with general observations that there are fewer shade tolerant invasives in general, this group has fewer species (48) and occurrences of species prioritized for monitoring among the six park-specific lists (22). Moreover, only one of these species, dyer's woad (*Isatis tinctoria*) was prioritized for monitoring in more than one park, and this species may be among the least shade tolerant in this group. Although there are fewer species in this group, there is much habitat in the Klamath Network where species in this group can invade, for example, most of Redwood and Oregon Caves. Moreover, the group includes species that are shade tolerant enough to invade the understory of intact redwood forests, for example, holly (*Ilex aquifolium*) and Robert's geranium (*Geranium robertianum*).

Given that high elevation environments are generally the least invaded in the Network, it is surprising that group 3, characterized by moderate cold tolerance, contains the most species (69) and the greatest number of total occurrences of species prioritized for monitoring among park lists (52). In group 3, species are not only cold tolerant, but they are also able to tolerate drought and shade, as long at these are not extreme. Thus, group 3 species are characterized by particularly broad ecological amplitudes. They are species with classic ruderal characteristics. Group 3 contains Canada thistle (*Cirsium canadensis*), yellow starthistle (*Centaurea solstitialis*), knapweed (*Centaurea maculata*), and dalmation toadflax (*Linaria genistifolia*), all ranked among top early detection invasives in four or five parks (SOP #1: Invasive Species Prioritization). Members of group 3 should be considered as potential invaders of middle, and in some cases, upper elevations in the Klamath parks.

1.4.3 Landscape Susceptibility to Plant Invasion

As we have seen, it will be important to detect invasive species in all habitats throughout the Network. However, resources are too limited to monitor everywhere. Most invasive species cannot tolerate shady environments. In addition, the Klamath Network's invasive species inventory found a strong association between invasives and roads in the five Network parks that were sampled. Moreover, in the pilot study for this protocol, road and trail density were the most important predictors of the distribution of the most commonly encountered early detection species, Klamath weed (*Hypericum perforatum*). This is an invasion profile that likely fits many, if not most, invasive species. There are numerous studies of vegetation that have documented a very strong local association between roads and trails and invasive species (Trombulak and Frissell 2000, Douglas and Matlack 2006). The occurrence of invasive plants has been found to predictably decline with distance from roads and trails (Reed et al. 1996, Greenberg et al. 1997, Parendes and Jones 2000, Silveri et al. 2001, Watkins et al. 2003). The increased abundance of invasives alongside roads has been related to road surface materials (Greenberg et al. 1997, Silveri et al. 2001), light (Parendes and Jones 2000), and higher frequency of disturbance (e.g., Parendes and Jones 2000). Gelbard and Belknap (2003) found much greater numbers of invasives along paved road verges than on 4-wheel drive tracks. Other transportation, utility, and riparian corridors, along with fuelbreaks (Merriam et al. 2006), have many of the same features as roads (disturbance and propagule pressure), making them also suited to invasion. With a conceptual linkage between transportation and utility corridors and invasives, we have identified these corridors as the locations for our invasive species early detection monitoring.

As data are collected, we can refine our conceptual understanding of the relationships between invasive species and the environments in which they are found using spatial modeling (SOP #10: Reporting and Analyses of Data). Figure 5 shows one type of output from this modeling from data collected at Redwood. Models will provide a conceptual basis for predicting beyond the current known range of invasives to new areas in the parks. This modeling will also use data from the vegetation monitoring protocol so that predictive modeling is not as strictly limited to road and trailside environments.

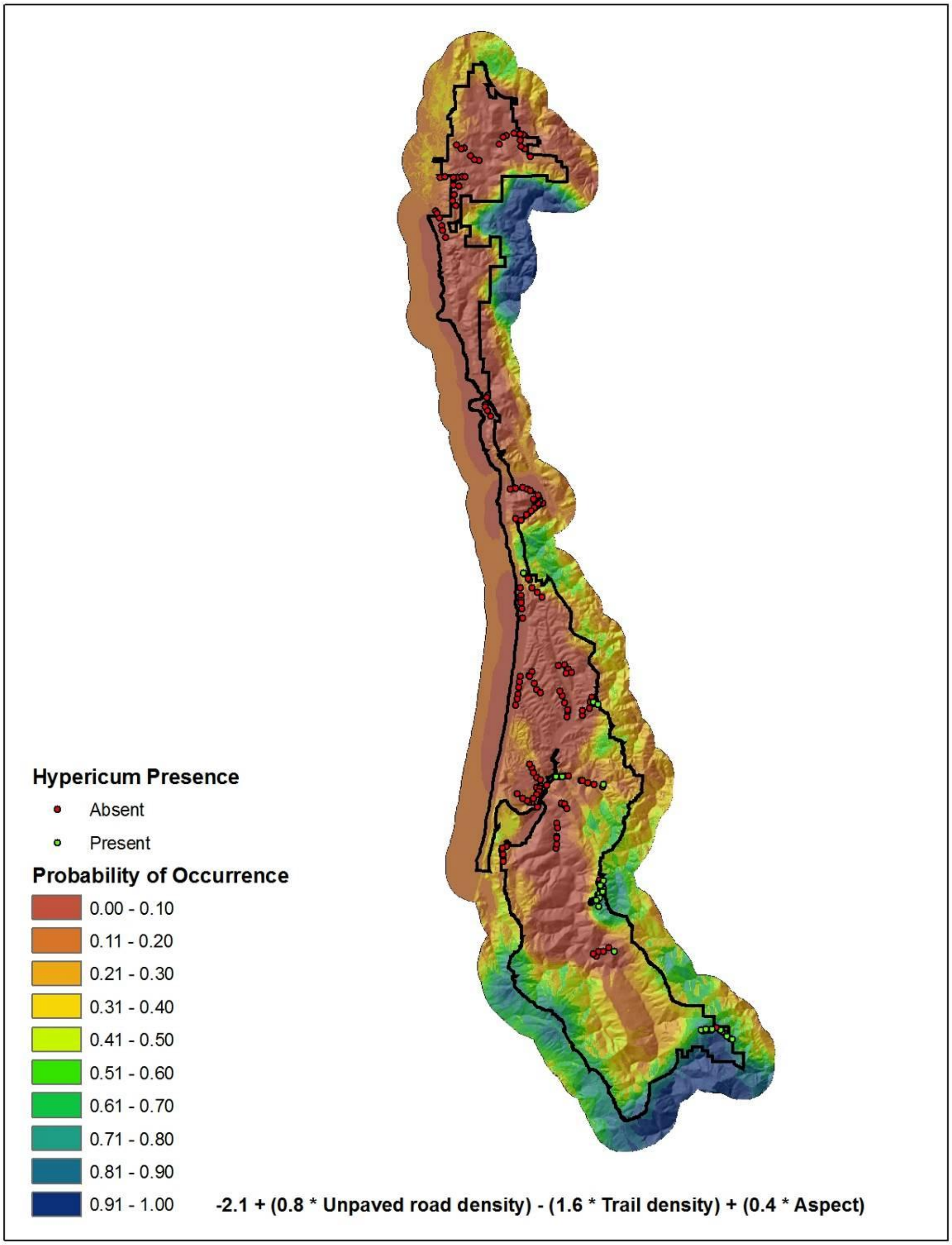

Figure 5. Interpolated surface showing the probability of occurrence of Klamath weed (*Hypericum perforatum*), at Redwood National Park. Data used in the modeling were collected during the pilot study, described in Appendix B.

1.4.3 Ecological Integrity and Risk and Species Prioritization

Ecological integrity is based on the level to which an ecosystem has been degraded as a result of human activities. We use this concept to modify our prioritization of invasives for early detection. The risk of degradation due to a non-native species invasion is proportional to the ecological integrity of the habitat invaded. Some species, which may be prioritized as well established from a park-wide perspective, and thus not monitored, may be important to consider from an early detection standpoint in remote parts of a park with high ecological integrity. Conversely, where ecological integrity is very low, it may not make sense to monitor invasives at all. Thus, it is difficult to apply a uniform species prioritization across heterogeneous landscapes. The general relationship between ecological integrity and the ranking of species via prioritization is shown conceptually in Figure 6. We incorporate the concepts shown in Figure 4 in this protocol by including equilibrium species in the monitoring where they are currently not found, as determined by park resource specialists (SOP #1: Invasive Species Prioritization).

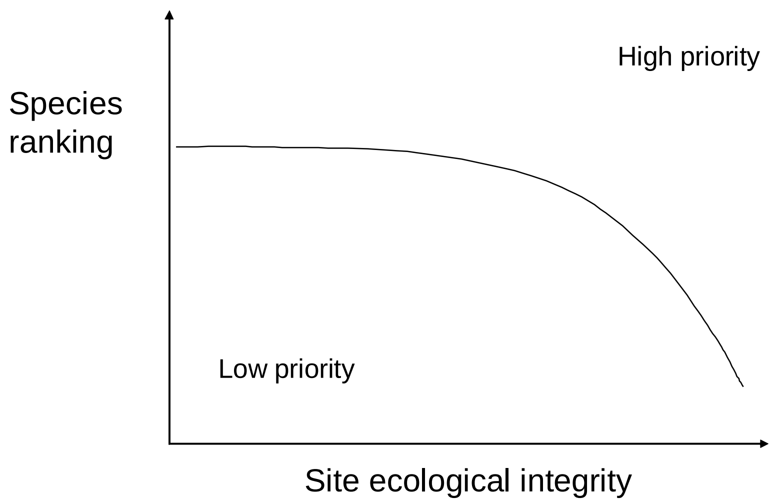

Figure 6. Conceptual model of how invasive species priorities may change as a function of the ecological integrity of sites where they are found.

1.4.4 Rapid Response

A key element of early detection monitoring that is recognized in the Network's overall concept of the role of invasive species monitoring is rapid response. This is the link between monitoring and management (Figure 2). This protocol recognizes the need to link monitoring and rapid response, and we have designed a reporting scheme using briefings to quickly communicate the most urgent findings to park managers (SOP #10: Reporting and Analyses of Data).

Currently, managers in Klamath Network parks attempt to respond to invasive species threats to the extent possible given existing resources. Three of the California parks, Lassen Volcanic, Redwood, and Whiskeytown, get Exotic Plant Management Team (EPMT) support, which can help with rapid response needs. These teams will be on the distribution list for the different reports produced by this protocol. However, the EPMT crews in California are stretched thin trying to provide for numerous parks, so their ability to provide rapid response is limited. Ultimately, an early detection monitoring protocol, however well designed, will fail to support park management goals unless specific arrangements are made to fully integrate the scientific findings with management actions on the ground. A complete vision of early detection and rapid response will require that additional fiscal and staffing resources are made available to support rapid response. Fortunately, there is regional support for more network level collaboration on exotic plant control within the parks. Park staff within the Network are very supportive of this idea. While parks would still maintain their own exotic plant control programs, a network approach would offer the Klamath parks the opportunity to collaborate more on control techniques, exchange expertise, coordinate on weed data management, maximize training opportunities, and create a flexible approach to exotic plant control over the season. All of these, in concert with the Network's monitoring efforts, would facilitate rapid response to early detection of invasives. The network of parks is in the early stages of conceiving such an integrated program; we will be exploring ways to make it a reality in the next few years.

1.5 Relationship to Other Vital Signs Monitoring by the Network

Invasive species were part of the reason vegetation, land cover, whitebark pine, cave entrance, aquatic communities, and intertidal communities were selected as vital signs. Useful and complementary information on status and trends of invasive species will come from monitoring these other vital signs, and this helped us refine the invasive species monitored in this protocol. For example, as mentioned above, the vegetation protocol will monitor the status and trends of invasives present in broad vegetation types and will help detect new occurrences. Since the sampling design for the vegetation protocol is probabilistic, and representative of all park habitats (Sarr et al. 2007), the data may be useful for modeling of invasive species habitat relations. Secondly, monitoring of blister rust should be adequate to determine trends in the invasion of this non-native pathogen in whitebark pine. Third, severe infestations or vegetation change to non-native species (e.g., type conversion to cheatgrass) may be monitored under the land cover protocol. Lastly, aquatic community and marine intertidal monitoring will add different ecosystem types in which invasive species will be tracked and potentially managed should they become problematic.

1.6 Protocol Objectives

1.6.1 Management Objectives

In considering the invasive species protocol, the Network also had to recognize that the vital signs scoping and ranking process did not specifically identify early detection among its broader monitoring questions and goals. The Network therefore met with park resource staff who have been intimately involved in managing invasive species. The purpose of this was to weigh early detection along with other non-native species monitoring objectives on a park-by-park basis. Some parks, such as Lava Beds, have already been conducting their own early detection monitoring or feel that early detection is handled very well by *de facto* monitoring by resource staff. It is important to recognize that this is not the same as a peer-reviewed, repeatable, science-based monitoring program with regular data analysis and reporting requirements, as developed under the NPS Inventory and Monitoring Program. Other parks have a need for monitoring that is broader than early detection alone. Staff from large parks ranked the invasive species management needs in their parks (Table 1), making no assumptions about the degree to which these needs can and should be met by network funding.

Table 1. Park ranking of needed components of an invasive species monitoring program for management in each large park. Components could be integrated to varying degrees with the Klamath Network's monitoring. Priorities are: 1= high, 2 = medium, 3 = low, 0 = not needed.

Program Item Needed	Crater Lake	Lava Beds	Lassen Volcanic	Redwood	Whiskeytown
Baseline mapping/inventory of invasive plants in park	0	3	2	3	1
Invasive Species Early Detection (ISED)	2	3	1	1	1
Status and trends monitoring	1	0	1	2	1-2
Technical Assistance					
GIS/Data management	3	3	1	2	2
Botanical expertise	3	1	0	0	2
Control methods	1	1	0	0	0
Prioritization (for ISED, not existing species)	2	2	3	0	0
Outreach and coordination of volunteers, staff, etc.	1	1	2	2	2
Curatorial assistance	3	1	3	0	2
Control	1	0	1	1	1

Based on these rankings, the Network developed the following *management* objectives:

1. Provide early detection of invasive plant species to assist managers in controlling or preventing new populations of high priority invasives from establishing.
2. Provide some outreach and education to help increase the potential for invasives to be detected in parks. Examples include illustrated invasive species identification guides to be produced and made available to support and inform park-based staff, visitors, and volunteer programs.
3. Provide taxonomic expertise to allow rapid identification and associated research to determine possible control methods for new species. This is most important for Lava Beds.

1.6.2 Monitoring Objectives

With other invasive species needs covered by other protocols, the Network recognized that the monitoring objectives for its ISED protocol could emphasize vascular plants.

1. Detect populations of selected invasive plants by sampling along roads, trails, and powerline corridors, and in campgrounds, where introduction is most likely.
2. Provide the early detection information to park management on a timely basis to allow effective management responses.
3. Develop and maintain a list of priority invasive plant species with greatest potential for spread and impact to park resources for monitoring in each park.
4. Adapt spatial sampling as knowledge improves through monitoring.
5. Use monitoring data collected from this protocol and the vegetation protocol to estimate possible trends and develop and refine models of invasive species habitat requirements and of the most susceptible habitats (both along roads and trails as well as elsewhere).

1.6.3 Sampling Objectives

1. Every 2 years, sample road and trail segments (generally 3 km) in each park, as many as possible, using a probabilistic sampling design to maximize detection of priority species.

2. Every 2 years, sample plots in infested and uninfested areas in an unbiased manner to provide data for species habitat modeling.

1.7 Protocol Standards

The Klamath Network ISED Protocol will be evaluated by the following broad management and scientific standards:

1) The protocol provides accurate, timely, and actionable information for invasive plant management in parks of the Klamath Network.

2) The protocol provides quantitative information about invasive plant species that supports spatial and temporal models of invasion risk in the Klamath Network parks.

3) The protocol contributes to a broader scientific understanding of invasive species ecology and management in the Klamath Network parks and in invasive species science in general.

The performance of the protocol in meeting these standards will be evaluated in Analysis and Synthesis Reports 1-3 (SOP #10: Reporting and Analysis of Data).

2.0 Sampling Design

2.1 Rationale for Selection of Species

Species prioritization was conducted on a park-by-park basis and the results are summarized in SOP #1: Invasive Species Prioritization. The full prioritization report is presented in Appendix A. Robert Klinger and Matt Brooks (USGS) undertook the Network's park-level prioritization process, with input from park and Network staff. Species prioritization was done differently among Klamath Network parks according to the information available. The prioritization was completed with existing quantitative data for Lava Beds and Whiskeytown, where the most data were available on invasive species' distribution and abundance. For other parks, expert opinion in concert with existing literature was used to prioritize species.

For each park, a list of invasive species present, with additional species that could invade based on the literature, was finalized. Then these species were classified into the invasion stage in which they are found in each park: colonization, spread, or equilibrium or not an invasive that transforms ecosystems. This was based on expert opinion of park staff, and invasiveness rankings by CAL-IPPC and other literature. Only species that were a consensus to be non-threats were excluded from the ranking. If there was any question, the species was included.

Colonization and spread species are the focus of early detection in this protocol. Depending on the park and species' ranking score, most or all of the colonization and spread species were selected as the priority species to monitor throughout a park (SOP #1: Invasive Species Prioritization). Equilibrium species whose locations will also be recorded in portions of the park with high ecological integrity are also listed in SOP #1.

Prior to the start of the sampling season, after the road and trail segments are selected for monitoring, the Crew Lead will consult with the Park Contact to discuss the segments and campgrounds that will be sampled that year. Those segments or campgrounds in which particular equilibrium species will also be will be identified if they have not already been. These roads and trails are currently defined for most parks based on elevation or wilderness areas (SOP #1: Invasive Species Prioritization).

The procedure for updating the prioritization lists and how the Network will research new invasive species threats to add to the lists for future re-prioritizations is also described in SOP #1: Invasive Plant Prioritization. With new invasions, control of existing invasions, changes in species' abundance, and new understanding of the threats particular species pose, prioritizations may need to be adjusted. This will be done in a comprehensive way every 5 years with the issuance of Analysis and Synthesis Reports (SOP #10: Reporting and Analyses of Data).

2.2 Rationale for Sampling Design

As described above in section 1.5, there is a strong association between invasive species and roads, trails, campgrounds, utility corridors, and fuelbreaks. In order to maximize efficiency in finding invasive species, these locations will be the target of monitoring efforts by the Network, except fuelbreaks, which are monitored under the auspices of fire management.

2.2.1 Sample Design

The spatial sampling design for each park is shown in Figure 7 and described in SOP #5: Field Survey Methods. The sampling frame will consist of roads and trails that are not closed for safety reasons. Powerline corridors that can be traversed and campgrounds (as part of the road network) will be included in parks where applicable.

The road, trail, and powerline network will be broken into 3 km target segments. Figure 8 shows an example from Lava Beds. A random sample of segments will be surveyed every 2 years as shown in Figure 9. The revisit frequency for any particular segment will vary from park to park and segment to segment. Since we are making park-wide inference, we will select a subset from all segments in each park at the beginning of the field season, rather than trying to revisit as many segments as possible or trying to include as many as possible that were not previously sampled.

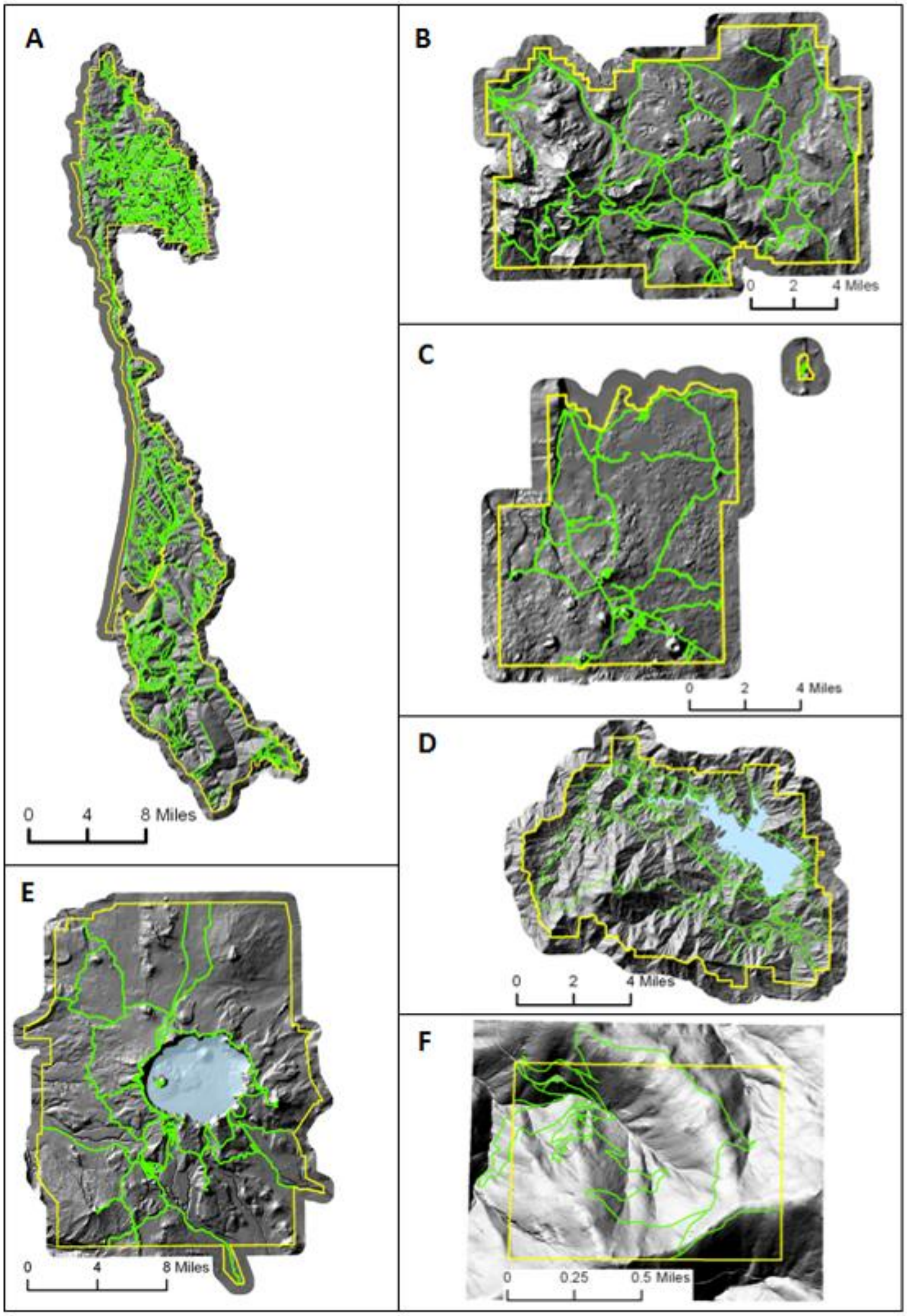

Figure 7. Sampling frames (green features) for (A) Redwood NSP, (B) Whiskeytown NRA, (C) Crater Lake NP, (D) Lassen Volcanic NP, (E) Lava Beds NM, and (F) Oregon Caves NM, include roads, trails, campgrounds, and powerline corridors. Park boundaries are outlined in yellow.

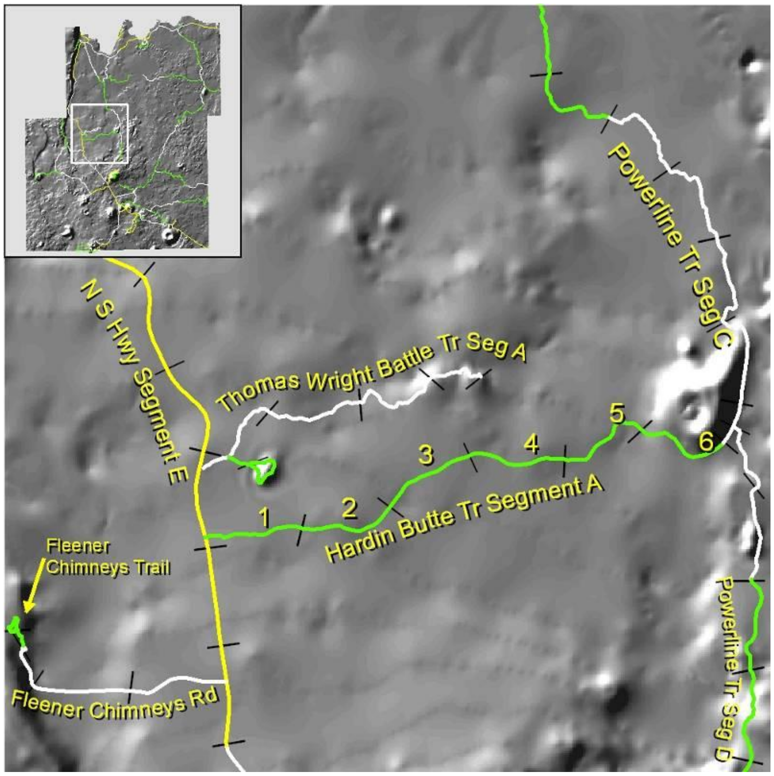

Figure 8. Close-up showing 3 km segments and 500 m subsegments (black lines). Hardin Butte Trail's 500 m subsegments at Lava Beds are labeled 1-6.

One end of a section of road, trail, or powerline corridor will serve as a starting point (Figure 9). Field crews will traverse the selected segment. A GPS coordinate of all prioritized species visible from the feature and an estimate of the infestation size will be recorded. Based on findings during the 2009 field season, we included in the sampling protocol instructions for mapping continuous populations and a maximum number of individual infestations (4) to be mapped per segment (SOP #5: Field Survey Methods).

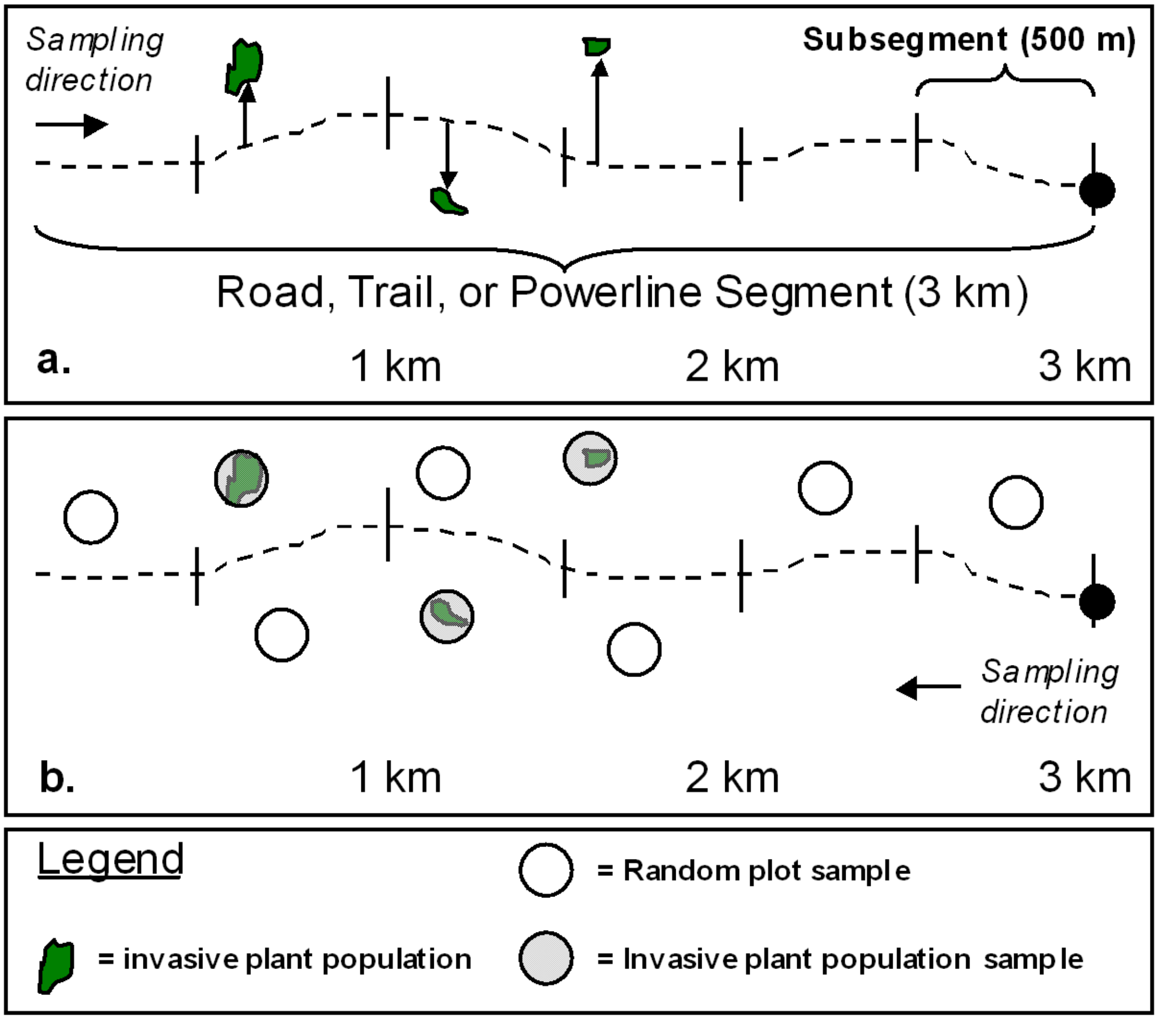

Figure 9 a and b. Illustration of the invasive species early detection response design to be completed at each randomly selected road, trail, or powerline segment in a park: a) location mapping and sampling of invasive plant populations; and b) plot sampling of random locations and the invasive plant populations located.

Crews will also place six 100 m^2 plots within each 3 km section of road, trail, or powerline corridor (one per 500 m). In these plots, they will sample the presence and abundance of invasive species and selected environmental variables (e.g., percent cover, soil disturbance, elevation, habitat type, etc., described in SOP #6: Data Collection and Entry). These samples will be supplemented by up to three opportunistic samples (if there are that many or more infestations found) for each invasive species detected along the road, trail, or powerline segment. These plots will be spread along the segment and selected at random when possible from multiple infestations, as described in SOP #5: Field Survey Methods. The methodology for locating and completing these plots was field tested in fall 2007 and summer 2009, and found to perform well. In general, two segments can be done in a day, but this depends on the number of infestations found.

2.3 Rationale for Selection of Parameters

The minimum parameters that will be measured for all prioritized species are presence/absence, location coordinates, and estimated infestation size. In addition, randomly selected infestations will be locations for plot sampling where numerous environmental variables (e.g., slope, aspect, tree cover, etc.) will be measured (SOP #5: Field Survey Methods). These same variables will be measured in randomly selected non-infestation plots. In general, this protocol emphasizes the quick collection of location and abundance data for invasive plants of greatest concern from an early detection perspective in the most likely places to find them. The data are likely to be immediately relevant to resource managers for planning control strategies, reporting on GPRA land health goals, and in some cases assessing effectiveness of control. The design is not optimized to assess the effectiveness of management treatments applied at small scales or to compare the effectiveness of control treatments. While this is an important goal for invasive species management, replicated experiments are the best approach to answering effectiveness questions. Nonetheless, the monitoring may provide information or abundance data to help address effectiveness questions, such as plot data that may serve as controls for comparison with experimental manipulations. In addition, questions such as whether management is keeping roadside infestations in check may be addressed using the monitoring data.

The design is also not suited to modeling distributions of invasives park-wide because inference cannot be extended from the roads, trails, and powerline corridors to the park as a whole. However, the habitat types and elevations of road and trail networks are quite representative of the parks as a whole (see analysis in the Network's monitoring plan [Sarr et al. 2007]). In addition, plot data up to 1 km away from roads and trails will be obtained from vegetation sampling under its separate protocol. The combined monitoring efforts should yield some important predictions about susceptibility of various park environments to invasive species that are found among the plots, except those that are still rare.

2.4 Site Selection

All trails in all parks are included in the sampling frame. Road segments that are unsafe to sample will not be included in the sampling frame. In addition, all drive-in campgrounds in each park will be sampled. Powerline corridors will be sampled.

2.5 Frequency and Timing of Sampling

Field sampling will occur every other year starting in 2009. Figure 10 shows the target times for field monitoring in each of the parks. Klamath Network-based crews will visit low elevations at Whiskeytown first, during early May. They will then visit Lava Beds and Redwood in May and June, and Oregon Caves and high elevations of Whiskeytown in June and into July. The two high elevation parks, Crater Lake and Lassen Volcanic, will be sampled from mid- to late July through early September. Unfinished work at Redwood can be completed any time during the second half of the field season. Actual times of each visit may need to be adjusted slightly in a given season based on logistical concerns, weather, or due to changes in the phenology of the target species. All such changes will be verified with the Park Contacts as early as feasible.

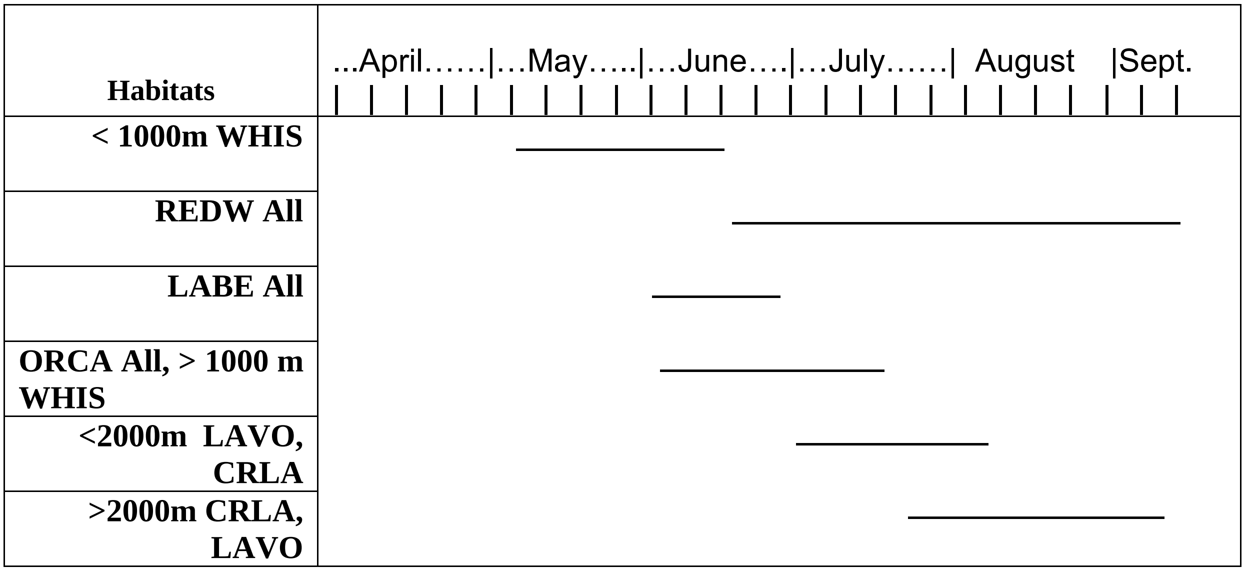

Figure 10. Timing for invasive species sampling in different elevation zones in different parks of the Klamath Network.

2.6 Sampling Effort in Parks

Sampling effort will be apportioned to allow a probabilistic sample of road, trail, or powerline segment in all five of the larger parks, with a complete census at ORCA (at least until the likely expansion occurs). Generally, the larger parks in the Network have between 160-500 miles of roads, trails, or powerline segments, with the exception of Redwood, which has nearly 900 km. Based on guidance in the Klamath Network Vital Signs Monitoring Plan (Sarr et al. 2007), we set a minimum sample size of 25 segments in each park. For Redwood, which has an exceptionally large road and trail network, we set the minimum at 35 segments (Table 2). This level of sampling should be feasible. Based on our pilot sampling work, we have determined that field crews can sample an average of two to three segments per day. Assuming a 6 month field season working on an 8 day on / 6 off schedule, 96 work days are available. With 2 weeks (8 days) of training, about 88 days are available for field work, travel, and data entry. Our conservative seasonal sampling target is, therefore, approximately 179 segments across the six parks (Table 2). Therefore, we should be able to exceed our statistical sampling standard and also provide some additional management-specific data in each sampling season.

2.7 Co-location of Other Vital Signs

Based on current planning, no other vital signs will be specifically co-located with invasive species early detection. There are no apparent opportunities for cost savings by co-locating the early detection monitoring described in this protocol with other vital signs monitoring. Other protocols will provide important information for the broader goal of invasive monitoring that will be used in concert with the invasive species early detection data. In particular, the vegetation monitoring protocol will help monitor invasive species that occur away from roads and trails.

Table 2. Total road, trail, and powerline distances (km) in the parks of the Network, and the sum and percent of the total for the Network. Also shown is the number of days out of 115 that each park's percent equates to, and then the number of days that will be allotted to each park after considering practical concerns.

Sample Unit/Effort		Crater Lake	Lava Beds	Lassen Volcanic	Oregon Caves	Redwood	Whiskeytown	Total
Roads	highway	111.9	50	55.2	1.1	128.4	53.5	400
	non-highway	35.6	21.1	14.8		517.1	168.9	686
Trails		234.9	63.9	282.9	8.7	220.2	84.7	1086
Powerline		0	0	0	0.3	7.3	34.7	42.3
Sum		382.3	135	517.3	9	873	341.8	2258.3
Minimum Sample Size		25	25	25	11	35	25	146
Allotted Sampling Weeks		4	4	4	1	5	4	22
Allotted Sampling Days		16	16	16	4	20	16	88
Projected Sample Size @ 2 segments/ Day		32	32	32	11	40	32	179

3.0 Field Methods

3.1 Field Season Preparation and Equipment Setup

Preparations for field work must begin several weeks before the season. Details for the preseason preparation are included in SOP #2: Field Work Preparation, while details on observer training are provided in SOP #3: Observer Training. In general, it is the Crew Lead's responsibility to work with the Park Contacts to set up permits and to ensure availability of housing, keys, vehicles, radios, and computers when applicable. Sampling trips by Network crews will be scheduled and organized by the Crew Lead prior to the start of each field season. It is the Crew Lead's responsibility to create a detailed work plan for each sampling trip prior to going into the field. The Crew Lead will ensure that the field crew is properly trained and has all the required gear and the most up-to-date field forms. It is also the Crew Lead's responsibility to make certain all databases (handheld and desktop applications) and field equipment (e.g., laser rangefinders, GPS units, etc.) are calibrated and properly set up prior to heading into the field (SOP #4: Setting up the Electronic Field Equipment). The Crew Lead will work with the field crew to make sure it is clear where everyone is going, what is expected to be completed, and what the timelines are for when the work should be finished.

Prior to working in the field, each member of the field crew must review the job hazard assessment for this project and the entire protocol. With the Crew Lead, observers will review how to identify invasive plant species that have been prioritized using the outreach materials developed by the Network, and where appropriate, herbarium specimens, taxonomic keys, and photographs. The Crew Leader will also provide training on GPS navigation and field methods for recording data. All equipment and supplies, especially GPS units, shall be organized, prepared, and tested prior to the field season. All files needed for navigation will be loaded on to a GPS unit and on to a laptop, which will be taken to the park. SOP #4: Setting up the Electronic Field Equipment explains how to use the GPS.

At least 1 month prior to when Network crews expect to visit the field sites, the Park Contact at each park will be contacted to assure all logistical needs are addressed and on schedule. Each day, the Crew Leader shall provide a briefing regarding any safety, plant identification, and park navigation issues of concern for the day. The Crew Leader will also assign crew members to the search units for the day. Crew members will navigate to their units using the GPS unit, compass, and maps. Crews will be locating random plots while in the field following SOP #5: Field Survey Methods.

3.2 Collecting and Recording Data in the Field

Data are collected using field computers (Trimble GeoExplorer) with ArcPad and GPS units (Garmin 60/76 CSx). Instructions for using the hardware and software are provided in SOP #4: Setting up the Electronic Field Equipment. The data will also be recorded on standardized datasheets for the first few years to act as a backup for the electronic devices. A description of how to enter the data is provided in SOP #6: Data Collection and Entry. Hardcopy and electronic datasheets should be reviewed before leaving the monitoring segment to make certain they are complete. At the end of the field day, data are transferred electronically from the GPS to a laptop computer. At the end of a park-specific sampling trip, data forms are submitted to the Crew Lead and electronic data are transferred to the Network database.

3.3 Post Field Season

After the field season, a number of activities need to occur to finalize the year's sampling efforts and help ensure smooth start-up for the next field season (SOP #13: Post Field Season). Equipment is to be cleaned, inventoried, and stored. Any equipment that is found to be in need of repair or replacement will be identified to the Crew Lead. A short report about the year's sampling shall be prepared. Findings that are urgent for managers will be described in a written briefing to be sent to parks by December 1 (SOP #10: Reporting and Analyses of Data).

Data will be reviewed by the Project Lead, who has the authority to delegate this task to the Crew Leader. Once the data have been reviewed and corrected, automated processes are enacted by the Data Manager to upload the data into a master database that stores all the data for this project.

4.0 Data Management, Analysis, and Reporting

This section will focus on all aspects of managing, storing, analyzing, and reporting monitoring data according to the Network's Data Management Plan (Mohren 2007) and the reporting schedule in the Klamath Network Monitoring Plan (Sarr et al. 2007). Methodological details are located in these plans and the SOPs referenced herein. It is crucial to successful monitoring that project personnel understand all necessary data management methodologies. This includes who is responsible for implementing the methods and the timelines they are expected to follow when conducting data management.

4.1 Data Management

Data management begins with preparation for field work (SOP #2: Field Work Preparation); includes data collection and entry in the field (SOP #6: Data Collection and Entry); addresses data storage, analysis, and archiving at the end of the field season (SOP #8: Data Transfer, Storage, and Archiving); and includes data analysis and reporting (SOP #10: Data Analysis and Reporting). The data management cycle for the sampling year ends with a review of the yearly project activities. It is the responsibility of the Project Lead and Crew Leader to make sure all crew members are trained in proper data management protocols and procedures. It is also the responsibility of the Crew Lead to transfer all completed data to the Data Manager. However, at least one of the crew members will be trained in data transfer to act as a backup. Data entry will be completed using electronic and paper formats for the initial years of the project. Unless stated otherwise, data entry will be uploaded from the field computers to the desktop database and backed up on a nightly basis. Data will be transferred from the field PC to the master database at the end of the field season after all quality control and quality assurance process have been followed. It is the responsibility of the Project Lead or Crew Lead to make sure all electronic data collected during the field visit are transferred to the Data Manager, and that hardcopy datasheets are scanned and archived according to procedures detailed in SOP #8: Data Collection and Entry.

4.2 Metadata Procedures

Details on the process to develop, update, distribute, and archive metadata are provided in SOP #11: Metadata Guidelines. In general, metadata will be completed at the onset of implementing the Invasive Species Early Detection Protocol. Metadata will be created using Environmental Systems Research Institute (ESRI) tools, the NPS Metadata tools and Editor, and the NPS Database Metadata Extractor. Metadata will be to Federal Geographic Data Committee (FGDC) and NPS standards where applicable. Metadata will be created for the master database and priority species list. It is the responsibility of the Crew Lead to complete the Metadata Interview form at the end of each field season to document changes to the metadata. If changes have occurred, it is the Data Manager's responsibility to archive and update the metadata for each database.

4.3 Overview of Database Design

The invasive plant monitoring protocol requires two databases: 1) the invasive plant prioritization database, to be periodically updated as described in SOP #1: Invasive Plant Prioritization, and 2) the invasive plant location information database. Microsoft Access is the primary software environment used for these databases. The database utilizes the Natural

Resource Database Template (NRDT), developed by the NPS, and incorporates tools from the Nature Conservancy database called WIMS (Weed Information Management System) that are used to collect, view, manipulate, and report data and information.

Invasive plant prioritization database – There are separate Excel files for each park. Multiple worksheets are in each spreadsheet, with species lists, raw scores, and the final ranking (with graphs) for species in each of the three phases of invasion (SOP #1: Invasive Plant Prioritization has definitions of invasion phases). The spreadsheets are formatted so that the data feed directly into the ranking software. The software Criterium Decision Plus 3 http://www.infoharvest.com/ihroot/index.asp will be used to rerun the calculations when reprioritizations are done after the first sampling season and every 5 years thereafter. Final species lists are uploaded into the invasive plant information database described below.

The invasive plant information database – Development of a national, standardized invasive plant database is essential to the effective collection, dissemination, and consistent interpretation of invasive plant data. This is particularly true for early detection and rapid response efforts, which rely on predictable and transparent communication tools to engage an appropriate management response. At this time, an NPS national invasive plant database is still in the planning stages while the NPS Natural Resource Program Center (NRPC) transitions data systems to a Service Oriented Architecture and Extendible Markup Language (XML), web-based services development approach for data management and delivery. Therefore, the Network began to research the availability of other invasive species databases.

After examining existing invasive plant databases, we decided that we could utilize the NRDT, and then incorporate some of the tools that are available in the WIMS database. The Nature Conservancy's Weed Information Management System (WIMS) in its current state would meet 80% of the needs outlined in this protocol and provide an affordable and adaptable platform for customizing to our specific needs. This free database gives us the opportunity to use mobile mapping technologies; is very well documented with user guides, metadata, and setup instructions; incorporates the North American Weed Management Area standards; and is simple enough that it could easily be altered to meet all the needs of this project. In addition, discussion with staff at the national level have assured us that the national NPS database will have tools designed to upload data being collected using The Nature Conservancy's Weed Information Management System (WIMS). We decided to utilize the NRDT format instead of solely using WIMS to ensure the data collected as part of this protocol are stored in a format that is compatible with the database from other KLMN protocols and data management databases (e.g., image database, project database).

This protocol will use a database that integrates a suite of hardware and software elements to simplify the collection and management of invasive plant data. The central piece of the database is the relational MS Access database ("the database") that works to keep track of all invasive species' occurrences (documenting presence), assessments (monitoring), and all management treatments for invasives in a defined area. This database can be used in combination with ArcPad (the handheld version of ArcGIS) and a personal digital assistant with an attached GPS or a Windows-compatible GPS unit, like the Trimble GeoXT or Thales Mobile Mapper CE. If technical difficulties arise, data can also be collected on paper and manually entered into the database. Once a national database has been completed, we will reassess the database methods of this protocol to see if converting to the national database is necessary. Addition details about this database are provided in SOP #9: Databases.

4.4 Data Dictionary

The data dictionary for field data entry meets the standards set by the North American Weed Management Association. This data dictionary and the one for the invasive species prioritization are to be finalized at the onset of implementing the Invasive Species Protocol. It is the Crew Lead's responsibility to update the data dictionary (if needed) at the end of each field season. In addition, the Metadata Interview form, which will be submitted at the end of each field season, will be used by the Data Manager to indicate if changes have occurred to the metadata or data dictionary. The current data dictionary and relationship diagram for the main tables of the database is provided in Appendix D.

4.5 Data Entry, Verification, Validation, and Editing

Data entry will consist of transferring data from field collection devices (currently Trimble GeoXH) to a desktop computer located in a stable environment. Forms have been created to be used in conjunction with the electronic collection devices that incorporate pick list, domain values, and automated, populated fields. In addition, for the initial years of data collection, hardcopy datasheets will be completed to help with verification process described below. Details on the data entry process are described in SOP #6: Data Collection and Entry.

Data verification is the process of ensuring the data entered into a database correspond with the data recorded on the hardcopy field forms and data loggers. After collecting the field data, but prior to leaving the sample segment or site, the field crew will review all hardcopy and electronic data forms to make sure they are complete. After the end of the sampling period in a park, the Crew Lead will review the data to make sure everything has been entered properly. In addition, the Crew Lead should examine the data after collection has occurred for 1 week, to ensure field crews are following collection and data entry methods properly. At the end of the field season, a field crew member should cross-check the hardcopy field forms with the electronic data (SOP #6: Data Collection and Entry).

Data validation is the process of reviewing the finalized data to make sure the information presented is logical and accurate. Data validation requires a reviewer to have extensive knowledge of what the data mean and how they were collected. At the end of the season, the Crew Lead will compile data from all field surveys. This person should examine the data using general tools built into the database and his/her personal knowledge to ensure the data are accurate.

Once all validation and verification methods have been implemented, the databases will be transferred to the Klamath Network Data Manager, who will upload the data to the master database. While uploading the data into the database, the data will be subjected to an automated data quality process that will flag potential missing sites and invalid or improperly formatted data.

4.6 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; and (3) they are appropriately documented and in a condition for archiving, posting, and distributing. Certification does not necessarily mean that the data are completely free of errors or inconsistencies. Rather, it describes a formal and standardized process to track and minimize errors.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all data. The Crew Lead is primarily responsible for completing the Data Certification form, available on the KLMN web sites. This brief form is to be submitted with the certified data according to the timeline in SOP #6: Data Collection and Entry.

4.7 Product Distribution

It will be the Klamath Network Data Manager's responsibility to utilize the season's certified raw data, along with the materials presented in the biennial report, Analysis and Synthesis Report, data dictionary, and Metadata Interview form to populate or update the NPS I&M databases including NPSpecies, NatureBib, and the NPS Data Store. Details on distribution can be found in SOP #8: Data Transfer, Storage, and Archive. In general:

- All reports will be posted on the NPS Data Store and KLMN Internet and Intranet web pages.
- The full report will be sent to the Resource Chiefs of each park and to any park staff that are associated with the project.
- A short, one-page summary of the report will be sent to all park staff.
- One record will be created in NatureBib for each annual report, comprehensive report, and third year Analysis and Synthesis Report and linked to the corresponding species in NPSpecies.
- Metadata for each database will be created and updated based on the Metadata Interview form and data dictionary provided by the Crew Lead each year. Metadata for the project database will be posted at the NPS Data Store.
- Photographs and metadata provided for photographs will be stored in the project folder located on the Klamath Network shared drive. Images will be uploaded to the KLMN Image database (SOP #7: Photo Management).
- Three GIS shapefiles will be created documenting transects sampled, species locations, and vegetation plots. These files will be created by the Crew Lead, working with the GIS Specialist, and stored on the KLMN GIS Server.
- Upon completion of a deliverable, the Crew Lead will notify the Data Manager and Program Assistant, who will work together to update the KLMN Project Database and web sites.

4.7.1 Holding Period

To permit sufficient time for the Network to have the first priority to publish data, when the park staff or the public requests data, it will be understood that these data are not to be used for publication without contacting the Project Lead. After each 5-year survey cycle, all certified, non-sensitive data will be posted to the NPS Data Store. Note that this hold only applies to raw data and not to metadata, reports, or other products that are posted to NPS clearinghouses immediately after being received and processed.

4.7.2 Sensitive Information

Certain project information related to the specific locations of rare or threatened taxa may meet criteria for sensitive data and, as such, should not be shared outside NPS, except where a written confidentiality agreement is in place. Before preparing data in any format for sharing outside NPS, including presentations, reports, and publications, the Project Lead should refer to the guidance in SOP #8: Data Transfer, Storage, and Archive. Certain information that may convey specific locations of sensitive resources or treatments may need to be screened or redacted from public versions of products prior to release. All official Freedom of Information Act (FOIA) requests will be handled according to NPS policy. The NPS Lead will work with the Data Manager and the FOIA representative(s) of the park(s) for which the request applies.

4.8 Data Summaries and Analyses

Data summary routines that will be undertaken include: 1) maps for invasive plant distribution and infestation sizes in portions of each park sampled; 2) summary statistics and correlation analyses from plot-based sampling; and 3) changes in invasive species distribution and abundance over time in resampled units, which then may be linked to management actions, disturbances, etc. Additional analyses that will be undertaken with the data include spatial interpolation and other modeling to help predict habitats prone to invasion. Data from the vegetation monitoring protocol will also be useful for these analyses. Details on data analyses and the reporting schedule are provided in SOP #10: Reporting and Analyses of Data.

4.9 Schedule and Contents of Reports

A primary objective of this protocol is to provide monitoring information to park management on a timely basis to allow effective management responses. Therefore, a one-page briefing paper will be developed that summarizes the findings in the field immediately following the field season. This paper is not meant to convey all the efforts of the year but to act as an interest document that provides limited information and points readers to the more detailed document, if necessary.

More detailed, formal reports will be prepared in years alternating with field seasons. These biennial reports will document all findings including number of occurrences by road, trail, and powerline; by species; and management recommendations to be implemented during the alternate years. Biennial reports will also include the time spent surveying and miles covered. Maps of locations and presence/absence of species along survey routes will also be prepared for the reports.

Analysis and Synthesis reports will be prepared every sixth year (SOP #10: Reporting and Analysis of Data). The first Analysis and Synthesis Report will also include an assessment of whether the protocol is meeting objectives and any updates needed to the invasive species prioritization. The protocol will be adapted accordingly. The second Analysis and Synthesis Report will assess the invasion process using spatial modeling aimed at predicting the environments in which select invasives are most likely to invade. Appendix C provides a detailed description of the modeling methodology. The third Analysis and Synthesis report will investigate dynamics in invasive species abundance, which will be reported in terms of density, area occupied, overlap in area occupied, and persistence of infestations. Management actions will be evaluated as a covariable.

Formal reports will be prepared and distributed by May 1st of the year following monitoring. These reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word template document based on current NPS formatting. Biennial reports will be formatted using the Natural Resource Technical Report template located at the NPS Natural Resource Publications web site (NPS 2006a).

Reports will be posted in NatureBib, KLMN Internet and Intranet web sites, and SOU's bioregional electronic archive collection. Reports will also be sent to the Technical Advisory Committee and to park staff who have invested interest in this project. Reports will also be used to update NPSpecies.

In addition to formal reports, field crews will meet with park resource staff upon completing their seasonal field work. The purpose of these meetings will be to convey the most urgent findings verbally so that park managers can schedule more immediate treatments if appropriate and feasible. GIS layers showing data collected during each year will also be provided to the parks no later then December 1st of the year of a survey.

4.10 Data Storage and Archiving Procedures

File structure, version control, and regular back-ups are carefully controlled to preserve the integrity of network datasets (KLMN Network Data Management Plan [Mohren 2007]). As described above, all data are transferred to the Network Data Manager, who places them on a Network server that is subject to regular archiving and backup processes, as described in the Network's Data Management Plan.

During the field season, field forms will be submitted to the Project Lead and stored in cabinets at the end of each sampling trip. At the end of the field season, these datasheets will be scanned into PDF documents and stored in the Invasive Species Early Detection project folder located on the Klamath Network server.

Prior to the start of a new field season, all products from the prior field season should have been transferred to the Project Lead (SOP #8: Data Transfer, Storage, and Archive). The Project Lead will work with the Data Manager to make certain that products are stored in their proper location on the KLMN server and posted to the proper distribution locations.

5.0 Personnel Requirements and Training

5.1 Roles and Responsibilities

Roles and responsibilities under this protocol are summarized in Table 3. The Klamath Network Coordinator serves as the Project Lead, with ultimate responsibility for executing the protocol. The Network will hire a botanist or plant ecologist to serves as the Crew Leader to guide field operations for invasive plant monitoring. The Network Coordinator supervises the Crew Leader. The data management aspects of the monitoring effort are the shared responsibility of the Crew Leader and the Data Manager. The Crew Leader oversees data collection; data entry; data verification and validation; and data summary, analysis, and reporting. The Network Data Manager designs and maintains the database and oversees data security, archiving, and dissemination. The person in this position, in collaboration with the Crew Leader, also develops data entry forms and other database features to assure data quality and to automate report generation. The Network Data Manager is responsible for building adequate quality assurance/quality control procedures into the database management system and for following appropriate data handling procedures.

Table 3. Roles and responsibilities for implementing the Klamath Network Vegetation Monitoring Protocol.

Role	Responsibilities	Position
Project Lead	Project oversight	Klamath Network Coordinator
	Administration and budget	
	Consultant on all phases of protocol review	
	Evaluates progress toward meeting objectives	
	Facilitates communications between NPS and parks	
	Conducts periodic research on invasion ecology	
	Analyzes and interprets monitoring results	
	Leads report preparation	
	Leads protocol revision (SOP #12: Revising the Protocol)	
Data Manager	Oversees all data management activities	Klamath Network Data Manager
	Makes certain data are posted	
	Makes certain all products and deliverables are reviewed, submitted, stored, and archived	
	Maintains and updates database application	
	Provides database and data management training as needed	
	Consultant on GPS/GIS use	
	Works with Project Lead to prepare and analyze data	
	Ensures metadata have been developed for appropriate project deliverables (e.g., databases, GIS/GPS documents, images, etc.)	
	Primary steward of Access database and GIS data and products	
GIS Specialist (Data Manager and/or Project Lead in future)	Provides spatial data analysis that may be needed (e.g., GRTS)	Klamath Network GIS Specialist
	Develops metadata for spatial data products	
	Maintains GPS units	
	Helps train crew members on GPS use	
	Prepares maps for field crews	
	Prepares maps and graphics for reports	

Table 3. Roles and responsibilities for implementing the Klamath Network Vegetation Monitoring Protocol. (continued).

Role	Responsibilities	Position
Crew Leader	Suggests changes to protocol	GS-7 Term Botanist
	Maintains research permits	
	Coordinates hiring of field crews	
	Coordinates scheduling, travel, and accommodations	
	Acquires and maintains field equipment	
	Trains field teams on vegetation sampling techniques, plant identification, and any other aspects of the protocol	
	Performs data summaries, analyses and provide text for reports	
	Maintains and manages voucher specimens	
	Maintains and archives project records	
	Certifies each season's data for quality and completeness	
	Creates metadata for products in GIS, GPS, image, and document format	
	Maintains research permits	
Field Crew	Collects, records, enters, and verifies data	Seasonal Network staff
	Provides recommendations to improve protocol operational efficiency	
Administrative contact	Arranges vehicles	Klamath Network Program Assistant
	Coordinates timesheets, purchasing, and reimbursements	
	Performs copy editing and report production	
	Manages equipment checkout	
Park Contact	Consultant on protocol implementation	Park botanist, plant ecologist, or Resource Chief
	Facilitates logistics planning and coordination	
	Helps interpret management implications of results	
	Reviews reports, data and other project deliverables	

The Project Lead is responsible for representing the Klamath Network in all issues related to this protocol. The Project Lead should be in constant communication with Crew Lead and park staff to make certain the protocol is being properly implemented. It is the responsibility of the Project Lead to be familiar with all aspects of the protocol and to provide assistance to the Network and parks when necessary.

Each park within the KLMN has designated a Park Contact for the invasive species protocol. It is the responsibility of the Project Lead to contact the Park Contact when necessary. Park Contacts will help support the Invasive Species Monitoring, when necessary, by participating in meetings, helping with logistical planning at their associated parks, and providing assistance with other miscellaneous tasks to ensure that the crew can perform the work efficiently in their park.

The field work, seasonal data management, and data entry activity to be completed under this protocol will be conducted primarily by two GS-5 level seasonal employees at the GS-5 pay scale in a single 6 month field season every other year. They will work under the direct supervision of the Crew Lead. When and where feasible, we will explore means to supplement this core staffing with park-based employees or volunteers, or assistance from the Project Lead during critical periods, but ultimately the scope and complexity of the field monitoring will be designed specifically for the capabilities of the assigned seasonal employees.

5.2 Qualifications and Training

Competent, observant, and detail-oriented observers are essential for collecting credible, high-quality invasive plant data. The Crew Leader must have strong botanical, organizational, and leadership skills to ensure the crew is well outfitted, scheduled, adequately trained, and motivated do their best work. The crew members must take initiative to read and understand the protocol elements for which they will be responsible and to ask for clarification from the Crew Lead, when questions arise. All field observers must possess sufficient botanical skill to accurately recognize the prioritized invasive plants and note other potentially important species that they encounter. Field observers must also be competent with GPS navigation, compass use, estimating plant cover, and data collection. All crew members should be well organized, function well as a team member, be comfortable in the field, and work methodically under difficult conditions. They must also be willing to work flexible schedules that may include long work days and inclement weather.

Training is essential for developing competent observers, both at the initiation of the field season and thereafter. At the start of the season, observers will review invasive plant identification using interpretive materials developed by the Network, as well as herbarium specimens, keys, and photographs. The Crew Leader will ensure that training is adequate and provide a refresher on invasive plant identification, GPS navigation, etc. at the start of the season (SOP #2: Field Work Preparation). The Crew Lead should work closely with the Data Manager to train field crews on all data collection devices. As data are recorded or uploaded, additional training will ensure that data are recorded accurately, errors identified in a timely fashion, and all data are backed up in the most efficient and secure way in each park.

5.3 Training Volunteers

Youth Conservation Corps volunteers are trained to identify the prioritized invasives and to do the monitoring by resource management staff at Lava Beds. This monitoring supplements the Network monitoring program. It is also possible that parks or the I&M Program will obtain occasional supplementary funding to support Student Conservation Association interns to assist with field efforts. For volunteers to function as auxiliary observers for this protocol, they will be trained on or demonstrate competency in field observation, data collection, and data management comparable to paid field crew members.

5.4 Safety

The field crew will be working in some remote areas; it is therefore essential that everyone, to the extent possible, be prepared for emergency situations. The Klamath Network has developed job hazard assessment documents specific to each park, to which crew members will strictly adhere while working at the parks (Appendix E). The safety protocol addresses known hazards (e.g., poison oak, rocky terrain, etc.), wildlife issues, communications, first aid, and an emergency response plan. Prior to going into the field, as part of observer training (SOP #3: Observer Training), the Crew Lead shall review safety procedures and job hazard analyses (Appendix E) with all field crew personnel.

6.0 Operational Requirements

6.1 Annual Workload and Implementation Schedule

The annual schedule for implementing the protocol is shown in Table 4.

Table 4. Annual schedule of major tasks and events for the Klamath Network vegetation monitoring protocol.

Month	Administration	Field	Data Management/Reporting
January	Briefings and data delivery to parks complete Begin recruiting and hiring seasonal personnel	Hire seasonal staff and schedule field visits, reserve campgrounds, and vehicles	Finish data analysis from previous year. Prepare Biennial Report and/or Analysis and Synthesis report from previous season
February	Administer and modify existing agreements, if necessary		Prepare biennial or analysis and synthesis report
March	Final protocol modifications (if any)	Inventory field equipment and resupply where needed	Prepare biennial or analysis and synthesis report
April		Prepare field and GPS/electronic equipment. Train field crew	Finish biennial or analysis and synthesis report
May		Begin field work	Turn in biennial report. Finish analysis and synthesis report
June		Field work	Turn in analysis and synthesis report
July			
August	Prepare budget for new fiscal year		
September	Close out of fiscal year	Finish field work. Field season closeout and briefing report	Metadata production
October	Network Annual Report and Workplan drafted	Data verification	Data certification and archival
November			Data analysis
December			

Monitoring will require one two-person crew each year. Approximately 6 months or 240 person-days per crew member will be required annually to complete training, field data collection, and seasonal data management activities for this protocol. This level of effort may be supplemented by splitting the crew and adding volunteers during “crunch” times when vegetation in multiple parks is ready for monitoring (typically late May/early June in WHIS, LAVO, and REDW and late July/August in LAVO and CRLA). The number of person-days may change slightly depending on the abundance of invasive species, logistics, weather, and other factors. Positions will be announced during the winter prior to a field season. Crews will be hired during early spring to enable training by mid-spring and sampling by late spring (Figure 10).

6.2 Facility and Equipment Needs

Equipment and facility requirements for this protocol are modest. The crew will typically require housing or camping facilities in each park for 1 to 6 weeks. The Project Lead or Crew Lead will need to contact the Park Contact the winter before field work begins so arrangements can be made. The invasive plant monitoring requires a 4-wheel drive vehicle, computers, GPS units, hand-held computers, a laser rangefinder, a densiometer, taxonomic guides, tape measures, hand lenses, identification material, and a digital camera. For safety purposes, crews will also carry radios and/or cellphones to communicate, if necessary, with park staff in the event of emergency (SOP #2: Field Work Preparations). During the off-season, equipment will be kept and maintained at the Klamath Network office.

6.3 Startup Costs and Budget Considerations

Startup costs include the purchase of equipment and supplies, as well as maintenance and/or replacement of equipment shared among multiple projects (e.g., GPS units, cameras, vehicles) (Table 5). All equipment that needs to be purchased has been acquired prior to the implementation of this protocol. Additional monies ($4,000) are budgeted each year of data collection to cover equipment repair or replacement for this specific protocol.

This protocol will have an alternating budget appropriation starting out at just over $83,000 per year during field sampling (odd years). Of this, nearly $32,000 is base funding for core staff. During even years, just over $24,000 will be spent, all from base funding. This staggered allocation supports an intensive 6 month field season, whereby crews visit all the parks in the Network, while the budget also provides additional monies for analysis and reporting in alternate years. During the alternate years, the Project Lead and Crew Lead will conduct the analysis and reporting and prepare biennial reports. During every sixth year, the effort spent on reporting will increase. The Network expects to work with academic or USGS researchers to help with the spatial modeling and trend analyses. The decision to only conduct field monitoring every other year was made because alternate year monies will support cave monitoring efforts. We anticipate that control efforts for invasive species would be modified during each year following the field work to allow rapid application of monitoring results on the ground. We expect that the budget allocation will increase modestly due to inflation of general costs and cost of living increases for salaried staff. These increases will be addressed in part by scheduled cost of living increases for the KLMN monitoring budget based upon agency staff employed.

Table 5. Estimated startup costs and annual budget for KLMN invasive plant monitoring for A. 2011, B. 2012, and C. 2013, representing two field sampling years and one reporting year.

A. 2011

	Expense Item	Person-Months	Salary	Benefits	Total
Personnel	Network Program Manager	1.5	$6,416.00	$2,406.00	$13,233.00
	Network Data Manager	1.0	$5,200.00	$1,950.00	$7,150.00
	Crew Leader, GS-7	2.0	$4,172.00		$11,431.28
Subtotal (Base-funded Office Staff)					$31,814.28
	Field Crew, GS-5	12.0	$2,704.00		$35,043.84
Other	Equipment/Supplies				$4,000.00
	Travel				$4,000.00
	Vehicles				$9,000.00
Subtotal (Fieldwork Only)					$52,163.84
	Total				$83,558.12

B. 2012

	Expense Item	Person-Months	Salary	Benefits	Total
Personnel	Network Program Manager	1.0	$6,416.00	$2,406.00	$8,822.00
	Network Data Manager	1.0	$5,200.00	$1,950.00	$7,150.00
	Crew Leader, GS-7	1.5	$3,973.15		$8,164.82
Subtotal (Base-funded Office Staff)					$24,136.82
	Total				$24,136.82

C. 2013

	Expense Item	Person-Months	Salary	Benefits	Total
Personnel	Network Program Manager	1.5	$6,416.00	$2,406.00	$13,233.00
	Network Data Manager	1.0	$5,200.00	$1,950.00	$7,150.00
	Crew Leader, GS-7	2.0	$3,973.15		$10,886.43
Subtotal (Base-funded Office Staff)					$31,269.43
	Field Crew, GS-5	12.0	$2,626.00		$34,032.96
Other	Equipment Supplies				$4,000.00
	Travel				$4,300.00
	Vehicles				$9,500.00
Subtotal (Fieldwork Only)					$51,832.96
	Total				$83,102.39

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Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #1: Invasive Species Prioritization

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP summarizes the prioritization of invasive species to be monitored under the invasive species protocol. Nomenclature follows the Jepson Manual of California Vegetation (1993, University of California Press). The prioritization of species addresses the desire to focus management efforts on a subset of the total species pool where these efforts will be most effective. A detailed report explaining the prioritization process is presented in Appendix A. Therefore, only a brief summary of these methods is provided in this SOP. The prioritization process ranked numerous species for potential monitoring. The list of species to be monitored was developed using this ranking. In parks with a large number of ranked species (Redwood and Whiskeytown), the number of species selected for monitoring is much less than the potential number of invasives, as explained below.

In the future, new invasives will arrive in parks, while the status of existing invasives may change. These new invasives will need to be considered for prioritization or re-prioritized according to the process described at the end of this SOP.

Prioritization Process

The Network's prioritization process was undertaken by Robert Klinger, USGS, with input from park and Network staff. Species prioritization was done differently among Klamath Network parks according to the information available at each park. The prioritization was completed with the benefit of existing quantitative data and expert opinion for Lava Beds and Whiskeytown, where the most data were available. For other parks, expert opinion in concert with existing literature was used to prioritize species. For each park, a list of invasive species in the park, with additional species that could invade based on the literature, was finalized. Then the following steps were taken for prioritization:

1. The park list of non-native species was divided into invasive and non-invasive species. Non-invasive species were those that, based on experience of park managers CAL-IPPC ratings, would not become ecosystem transformers. We erred on the side of including species in the ranking, especially the many species for which invasiveness is not yet known.
2. The Analytical Hierarchy Process (Saaty 1977), was used to rank species based on the relative importance of four criteria and 20 subcriteria for species in different phases of the invasion process: 1) colonization, 2) establishment, 3) spread/equilibrium. These are defined briefly as follows. Species in the colonization phase were in areas adjacent to or near the NPS units but not yet within its boundaries, or they could have just recently colonized a small portion of the unit. Species in the establishment phase had multiple, relatively small, localized populations within the boundaries of a unit. Species in the spread/equilibrium phase were more widely distributed than those in the establishment phase. See Appendix A, Prioritization of Non-native Plants in the National Park Service Klamath Network using Weighted Criteria and Measures of Uncertainty, by R. Klinger and M. Brooks for more detailed definitions.
3. The criteria and subcriteria are based on Randall et al. (in press), described in Appendix A.
4. Pre-existing data and expert opinion were used to determine the phase of the invasion process for individual species.
5. The California Invasive Plant Council (Cal IPC) system, pre-existing data, and expert opinion were used to assign scores to species in different phases of the invasion process: colonization, establishment, and equilibrium.
6. Uncertainty scores in terms of a species' invasion, spread and management potential, and other factors were assigned at two levels in the Randall-based scheme: criteria and subcriteria.
7. Analytical hierarchy software was used to generate the scores and to evaluate the rankings (Appendix A). The software used was Criterium Decision Plus 3 http://www.infoharvest.com/ihroot/index.asp.
7. Comparisons were made with rankings for Randall et al. (in press) scores generated without division into phases of invasion or use of the Analytical Hierarchy Process.
8. Comparisons were made with expert opinions about what species to monitor for early detection and other monitoring goals.

With new invasions, control of existing invasions, changes in species' abundance, and new understanding of the threats particular species pose, prioritizations may need to be adjusted in the future. Another consideration is the difficulty of applying the prioritization across heterogeneous landscapes. One of the most important values of an early detection program is to alert managers to the presence of species that they would likely manage, in areas where they are not known to be. While the prioritization helps considerably by identifying species that fit this description park-wide, there are some species that may be classified into the equilibrium phase (and thus not prioritized for early detection monitoring park-wide), which are best regarded as colonizers in remote parts of the park. In order to address the potential need to document such equilibrium species in some areas, the Crew Lead will consult with the Park Contact for invasive species, but will make the final decision on sampling for equilibrium species. Those sample units in which particular equilibrium species should be searched for along with colonization and establishment species will be identified (the full monitoring protocol will not be done for equilibrium species; only their location and the size of the infestation will be recorded via GPS).

The classification of species into three phases of invasion and their rankings within the classes were put to the test at Redwood National and State Parks. An experienced botanist and invasive species specialist, Dr. Ayzik Solomeshch, along with a less experienced field assistant, spent 6 weeks monitoring to test this invasive species early detection protocol. They covered over 100 km of trails and roads. Dr. Solomeshch recommended a few changes, as discussed in Appendix A, the pilot study report. The initial species list at each park will require refinement. Therefore, the first reprioritization should occur after the first field season, and thereafter in association with Analysis and Synthesis Reports at 6 year intervals.

The prioritization of species at each park was sent for review to park staff expert in invasive plants. Changes suggested by park staff, or Dr. Solomeshch, have been incorporated into the lists below. Equilibrium species that warrant monitoring in backcountry areas are also listed. Backcountry areas are defined differently for each park as described below.

Priority Species for Crater Lake

At Crater Lake, prioritization relied heavily on the expert opinion of park Terrestrial Ecologist Michael Murray. Thirteen of the sixty non-native plant species were classified into the colonization phase, nine into the establishment phase, and seven into the spread/equilibrium phase. The remaining species were not considered invasive and were not ranked. Because of the relatively small number of species in the colonization and establishment phases of invasion, all but one were selected for park-wide monitoring (Table 1). The species not selected, perennial ryegrass (*Lolium perenne*), had a particularly low score of 1.98. The six equilibrium species are listed in Table 2. For many of these, all locations of existing infestation locations are believed known. The park will therefore be interested in any new locations for any of these species. Therefore, backcountry areas at Crater Lake include the entire park that will be monitored.

Table 1. Prioritized invasive species list for park-wide monitoring at Crater Lake National Park.

Scientific Name	Common Name	Invasion Phase	Ranking Score
Cytisus scoparius	Scotch Broom	Colonization	0.875
Centaurea solstitialis	Yellow Starthistle	Colonization	0.873
Centaurea maculata	Spotted Knapweed	Colonization	0.854
Bromus tectorum	Cheatgrass	Establishment	0.827
Holcus lanatus	Velvet Grass	Colonization	0.769
Centaurea diffusa	Diffuse Knapweed	Colonization	0.750
Linaria genistifolia ssp. dalmatica	Yellow Toad Flax	Colonization	0.744
Leucanthemum vulgare	Ox-eye Daisy	Colonization	0.740
Cirsium arvense	Canada Thistle	Establishment	0.642

Table 1. Prioritized invasive species list for park-wide monitoring at Crater Lake National Park (continued).

Scientific Name	Common Name	Invasion Phase	Ranking Score
Brassica rapa	Mustard	Colonization	0.610
Melilotus albus	White sweet clover	Colonization	0.591
Hypochaeris radicata	Rough Cat's Ear	Establishment	0.564
Poa bulbosa	Bulbous Bluegrass	Colonization	0.556
Festuca arundinacea	Tall Fescue	Establishment	0.538
Melilotus officinalis	Sweet Clover	Colonization	0.532
Bromus inermis	Smooth Brome	Establishment	0.507
Dactylis glomerata	Orchard grass	Establishment	*0.499*
Lactuca serriola	Wild Lettuce	Establishment	0.477
Tragopogon dubius	Goat's Beard	Establishment	0.401
Agrostis gigantea	Bentgrass	Establishment	0.393
Senecio sylvaticus	Ragweed	Colonization	0.322

Table 2. Equilibrium species in Crater Lake National Park and status of which species will be monitored in the backcountry, and which will not be, for the reason given.

Scientific Name	Common Name	Ranking Score	Monitor in Backcountry?
Hypericum perforatum	Klamath Weed	0.673	Y
Cirsium vulgare	Bull Thistle	0.667	Y
Verbascum thapsus	Common Mullein	0.657	Y
Rumex acetosella	Sheep Sorrel	0.545	N(control infeasible)
Poa pratensis	Kentucky Bluegrass	0.532	N(control infeasible)
Taraxacum officinale	Dandelion	0.517	N(control infeasible)

Priority Species for Lassen Volcanic National Monument

Prioritization at Lassen was based on expert opinion, and benefited greatly from Park Ecologist Michelle Cox. Of the 83 non-native plants considered for ranking at Lassen, 23 were classified as being in the colonization and establishment phases. With relatively few colonization and establishment species, all having relatively high ranking scores, all were included in park-wide monitoring for early detection (Table 3). An additional 10 species were placed in the equilibrium phase whose infestations may be documented in backcountry portions of the park (Table 4). Backcountry areas at Lassen have been defined as the existing wilderness areas.

Table 3. Prioritized invasive species list for park-wide monitoring at Lassen Volcanic National Park.

Scientific Name	Common Name	Invasion Phase	Ranking Score
Taeniatherum caput-medusae	Medusahead	Colonization	0.920
Lythrum salicaria	Purple Loosestrife	Colonization	0.901
Genista monspessulana	French Broom	Colonization	0.895
Cytisus scoparius	Scotch Broom	Colonization	0.875
Centaurea solstitialis	Yellow Starthistle	Colonization	0.873
Euphorbia esula	Leafy Spurge	Colonization	0.866
Centaurea maculosa	Spotted Knapweed	Colonization	0.854
Onopordum acanthium	Scotch Thistle	Colonization	0.848
Bromus tectorum	Cheatgrass	Establishment	0.827
Rubus armeniacus	Himalaya Berry	Establishment	0.823
Lepidium latifolium	Broadleaved Pepperweed	Establishment	0.812

Table 3. Prioritized invasive species list for park-wide monitoring at Lassen Volcanic National Park (continued).

Scientific Name	Common Name	Invasion Phase	Ranking Score
Phalaris arundinacea	Giant Reed Grass	Establishment	0.798
Halogeton glomeratus	Halogeton	Colonization	0.789
Isatis tinctoria	Dyer's Woad	Colonization	0.770
Carduus pycnocephalus	Italian Thistle	Colonization	0.769
Hirschfeldia incana	Mediterranean Mustard	Colonization	0.755
Centaurea diffusa	Diffuse Knapweed	Colonization	0.750
Acroptilon repens	Russian Knapweed	Colonization	0.749
Carduus nutans	Musk Thistle	Colonization	0.748
Chondrilla juncea	Skeleton Weed	Colonization	0.748
Centaurea virgata	Squarrose Knapweed	Colonization	0.744
Cardaria draba	Hoary Cress	Colonization	0.741
Linaria genistifolia ssp. dalmatica	Dalmation Toadflax	Establishment	0.713
Holcus lanatus	Velvet Grass	Establishment	0.650
Cirsium arvense	Canada Thistle	Establishment	0.634
Poa bulbosa	Bulbous Bluegrass	Establishment	0.619
Phleum pratense	Timothy	Establishment	0.607

Table 4. Equilibrium species in Lassen Volcanic National Park and status of which species will be monitored in the backcountry, and which will not be, for the reason given.

Scientific Name	Common Name	Ranking Score	Monitor in Backcountry?
Cirsium vulgare	Bull Thistle	0.679	Y
Verbascum thapsus	Common Mullein	0.655	Y
Tragopogon dubius	Goat's Beard	0.595	Y
Vulpia myuros	Vulpia	0.550	N(control infeasible)
Poa pratensis	Kentucky Bluegrass	0.530	N(control infeasible)
Lactuca serriola	Wild Lettuce	0.496	N(control infeasible)
Taraxacum officinale	Dandelion	0.494	N(control infeasible)
Poa annua	Annual Bluegrass	0.421	N(control infeasible)
Plantago lanceolata	English Plantain	0.414	N(control infeasible)
Plantago major	Common Plantain	0.404	N(control infeasible)

Priority Species for Lava Beds

A combination of plot sampling data and expert opinion was used to develop the prioritization for Lava Beds. Dave Hays, who conducts invasive species monitoring throughout the summers in the park, provided expert opinion. A total of 44 non-native plant species were considered for ranking. Of these, three were classified as being in the colonization phase, 14 in the establishment phase, and 13 species classified into the spread/equilibrium phase. With relatively few colonization and establishment species, all can be included in park-wide monitoring for early detection (Table 5). Spread/equilibrium species are shown in Table 6. Some of these species are too ubiquitous to monitor in backcountry area, as indicated. Backcountry areas of Lava Beds are defined as existing wilderness.

Table 5. Prioritized invasive species list for park-wide monitoring at Lava Beds National Monument.

Scientific Name	Common Name	Invasion Phase	Ranking Score
Lepidium latifolium	Broad-leaved pepperweed	Colonization	0.917
Centaurea solstitialis	Yellow Starthistle	Establishment	0.776
Linaria genistifolia ssp. dalmatica	Dalmation Toadflax	Establishment	0.712
Taeniatherum caput-medusae	Medusahead	Establishment	0.696
Thlaspi arvense	Penny-Cress	Colonization	0.622
Cirsium arvense	Canada Thistle	Establishment	0.612
Melilotus officianalis (and albus)s	Yellow Sweetclover	Colonization	0.591
Isatis tinctoria	Dyer's Woad	Establishment	0.532
Torilis arvensis	Hedge Parsley	Establishment	0.530
Salsola tragus	Russian Thistle	Establishment	0.527
Kochia scoparia	Kochia	Establishment	0.461

Table 6. Equilibrium species in Lava Beds National Monument and status of which species will be monitored in the backcountry, and which will not be, for the reason given.

Scientific Name	Common Name	Ranking Score	Monitor in Backcountry?
Bromus tectorum	Cheatgrass	0.618	N (ubiquitous)
Descurainia sophia	Pinnate Tansymustard	0.611	Y
Cirsium vulgare	Bull Thistle	0.609	Y
Verbascum thapsus	Common Mullein	0.584	Y
Tragopogon dubius	Goat's Beard	0.582	Y
Marrubium vulgare	Horehound	0.508	Y
Poa bulbosa	Bulbous Bluegrass	0.495	N(control infeasible)
Lepidium perfoliatum	Clasping Pepperweed	0.491	Y
Lactuca serriola	Wild Lettuce	0.479	N(control infeasible)
Urtica diocia	Nettle	0.418	N(potentially native)
Vulpia bromoides	Vulpia	0.404	N(ubiquitous)
Erodium cicutarium	Filaree	0.388	N(control infeasible)
Holosteum umbellatum	Jagged Chickweed	0.341	N(control infeasible)
Sisymbrium altissimum	Tumble Mustard	0.306	N(control infeasible)
Galium aparine	Bedstraw	0.259	N(possibly native)

Priority Species for Oregon Caves

Habitats at Oregon Caves overlap with those at Crater Lake, Redwood, and Whiskeytown. Therefore, all invasives were included for ranking if they occurred at these parks as well as Oregon Caves (Table 7). There was also one non-native plant species that has been documented at Oregon Caves but not at Whiskeytown, Redwood, or Crater Lake. This species, Mexican daisy (*Erigeron karvinskianus*), is not considered invasive by the California Invasive Pest Plant Council, nor other sources. Therefore, it was not prioritized.

Table 7. Prioritized invasive species list for park-wide monitoring at Oregon Caves National Monument.

Scientific Name	**Common Name**
Bromus tectorum	Cheatgrass
Cirsium vulgare	Bull Thistle
Dactylis glomerata	Orchardgrass
Festuca arundinacea	Tall Fescue
Holcus lanatus	Velvet Grass
Hypericum perforatum	Klamath Weed

Priority Species for Redwood

At Redwood, expert opinion of park managers, particularly Stassia Samuels, was a key to developing the prioritization. Of the 275 non-native plant species considered for ranking at Redwood NP, 226 were determined not to pose serious threats or be in need of monitoring. Thirteen of the remaining species were then classified as being in the colonizing phase, 22 in the establishment phase, and 19 in the equilibrium phase. In both the colonization and establishment rankings, scores decreased gradually with rank to 0.45-0.50. Scores decreased rapidly thereafter for the remaining species, indicating they are much less of an ecological threat. Therefore, all colonization and establishment species with a score of greater than .45 were selected for park-wide monitoring. Table 8 lists these species. A number of equilibrium species may also be considered for documenting in select, remote areas of the park (Table 9). These areas have not yet been defined.

Based on the pilot study and expert opinion of park staff who reviewed the rankings and classification *post hoc*, two equilibrium species should be considered to be in the establishment phase of invasion, and monitored park-wide: Scotch broom (*Cytisus scoparius*) and holly (*Ilex aquifolium*). Two species in the establishment phase of invasion are no longer considered important ecological threats, and do not need to be monitored: common mullein (*Verbascum thapsus*) and one seed hawthorne (*Crataegus monogyna*). Conversely, two species now appear to be greater threats than at the time of the ranking and should be monitored: Three-cornered leek (*Allium triquetrum*) and herb Robert (*Geranium robertianum*).

Table 8. Prioritized invasive species list for park-wide monitoring at Redwood National Park.

Scientific Name	*Common Name*	**Invasion Phase**	**Ranking Score**
Ulex europaeus	Gorse	Colonization	.85
Cortaderia spp.	Pampas Grass	Colonization	.83
Centaurea solstitialis	Yellow Starthistle	Colonization	.80
Hypericum perforatum	St. Johnswort	Establishment	.76
Delairea odorata	Cape Ivy	Establishment	.75
Lupinus arboreus	Yellow Bush Lupine	Colonization	.75
Cytisus scoparius	Scotch Broom	Establishment	.70
Cirsium arvense	Canada Thistle	Establishment	.67
Linaria genistifolia ssp. dalmatica	Dalmation Toadflax	Establishment	.67
Carpobrotus chilensis	Sea Fig	Establishment	.66
Polygonum cuspidatum-and *P. polystachyum*	Japanese Knotweed	Colonization	.65
Foeniculum vulgare	Fennel	Establishment	.64
Centaurea maculosa	Spotted Knapweed	Establishment	.61

Table 8. Prioritized invasive species list for park-wide monitoring at Redwood National Park (continued).

Scientific Name	*Common Name*	Invasion Phase	Ranking Score
Verbascum thapsus	Common Mullein	Colonization	.61
Crataegus monogyna	Oneseed Hawthorn	Colonization	.58
Acacia dealbata	Mimosa	Establishment	.56
Rubus laciniatus	Cut Leaved Blackberry	Establishment	.54
Ilex aquifolium	Holly	Equilibrium	.53
Polygonum sachalinense	Giant Knotweed	Establishment	.52
Erica lusitanica	Spanish Heath	Establishment	.50
Prunus avium	Sweet Cherry	Establishment	.49
Robinia pseudoacacia	Black Locust	Establishment	.46
Park Additions			
*Allium triquetrum***	Three-cornered Leek		
*Geranium robertianum***	Herb Robert		

*Pampas grasses *(Cortaderia selloana* and *C. jubata)* are nearly identical, and both species are managed identically by the park. Therefore, we combined then for monitoring.
**The latest information suggests that this ranked species may be more of a threat than recognized at the time of prioritization.

Table 9. Equilibrium species at Redwood National Park and status of which species will be monitored in the backcountry, and which will not be, for the reason given.

Scientific Name	Common Name	Ranking Score	Monitor in Backcountry?
Pinus radiata	Monterey Pine	0.789	Y
Ammophila arenaria	European Beach Grass	0.788	N(found on all dunes)
Rubus discolor	Himalaya Berry	0.757	Y
Genista monspessulana	French Broom	0.691	Y
Cirsium vulgare	Bull Thistle	0.667	Y
Hedera helix-	English Ivy	0.667	Y
Senecio jacobaea	Tansy Ragwort	0.601	Y
Phalaris aquatica	Harding Grass	0.598	Y
Silybum marianum	Milk Thistle	0.557	Y
Phalaris arundinacea	Reed Canary Grass	0.535	Y
Vinca major	Periwinkle	0.526	Y
Cotoneaster spp.	Cotoneaster	0.517	Y
Dipsacus fullonum	Wild Teasel	0.508	Y
Digitalis purpurea	Foxglove	0.480	Y
Festuca arundinacea	Tall Fescue	0.467	Y

Priority Species for Whiskeytown

Prioritization of species at Whiskeytown was accomplished using a variety of plot data, as well as expert opinion. Jennifer Gibson, Windy Bunn, Mike Commons, and Gretchen Ring, park ecologists and botanists, all contributed expert opinion to the species classifications and rankings. Of the 208 non-native plant species considered for ranking, 65 were considered serious threats. Fourteen of these were classified into the colonizing phase, 27 into the establishment phase. Because of the relatively high rankings, 25 species were prioritized for park-wide early detection monitoring (Table 10). There were also a large number of equilibrium species. Many of these were low ranking (Table 11). The equilibrium species indicated in Table 11 will be monitored in backcountry areas, defined for Whiskeytown as trailsides above2500 feet in elevation.

Based on expert opinion of park staff who reviewed the rankings and classification post hoc, there are some minor changes noted in the tables below. These are based on information from the region that was not available when the classification and ranking were done in 2005. Most importantly, annual ryegrass (*Lolium multiflorum*), like other annual grasses, does not need to be monitored, and four species should be monitored park-wide that would otherwise not be: Diffuse knapweed (*Centaurea diffusa*) and dyer's woad (*Isatis tinctoria)* now appear to be a much greater threat; tree of Heaven (*Ailanthus altissima*) has been largely controlled, should be classified in the establishment phase of invasion, and should be monitored; and finally, one species, sesbania (*Sesbania exaltata*), has recently began invading riparian areas in the Whiskeytown region.

Table 10. Prioritized invasive species list for park-wide monitoring at Whiskeytown National Recreation Area.

Scientific Name	Common Name	Invasion Phase	Ranking Score
Tamarix spp.-	Tamarisk	Colonization	0.919
Lepidium latifolium	Broad-leaved Pepperweed	Colonization	0.917
Lythrum salicaria	Purple loosestrife	Colonization	0.901
Delairea odorata	Cape Ivy	Colonization	0.893
Euphorbia esula	Leafy Spurge	Colonization	0.866
Centaurea maculosa	Spotted Knapweed	Colonization	0.854
Ulex europaeus	Gorse	Colonization	0.848
Genista monspesullana	French Broom	Establishment	0.824
Cytisus scoparius	Scotch Broom	Establishment	0.816
Ailanthus altissima	Tree of Heaven	Establishment	0.800
Cotoneaster pannosa	Cotoneaster	Colonization	0.783
Aegilops triuncialis	Barbed Goat Grass	Establishment	0.782
Arundo donax	Giant Arundo	Colonization	0.774
Festuca arundinacea	Tall Fescue	Colonization	0.769
Cynaria cardunculus	Artichoke Thistle	Colonization	0.757
Spartium junceum	Spanish Broom	Establishment	0.756
Cirsium arvense	Canada Thistle	Colonization	0.744
Anthoxanthum odoratum	Vernal Grass	Colonization	0.743
Leucanthemum vulgare	Ox-Eye Daisy	Colonization	0.740
Poa pratensis	Kentucky Bluegrass	Establishment	0.729
Foeniculum vulgare	Fennel	Colonization	0.713
Linaria genistifoliassp. dalmatica	Dalmation Toadflax	Establishment	0.713
Brassica tournefortii	Mustard	Establishment	0.708
Park Additions			
*Centaurea diffusa**	Diffuse Knapweed		
*Sesbania exaltata***	Sesbania		
*Isatis tinctoria**	Dyer's Woad	Establishment	

*The latest information suggests that this ranked species may be more of a threat than recognized at the time of prioritization.
**A new invader that is a serious threat in riparian areas on public lands. It was not ranked because this was not known at the time of prioritization.

Table 11. Equilibrium species that may be monitored in select locations at Whiskeytown and status of which species will be monitored in the backcountry, and which will not be, for the reason given.

Scientific Name	Common Name	Monitor in Backcountry?	Ranking
Ailanthus altissima	Tree of Heaven	Y	0.799
Centaurea solstitialis	Yellow Starthistle	Y	0.765
Rubus discolor	Himalaya Berry	Y	0.751
Verbascum thapsus	Common Mullein	Y	0.655
Centaurea melitensis	Tocalote	Y	0.647
Conium maculatum	Wild Hemlock	Y	0.621
Cirsium vulgare	Bull Thistle	Y	0.605
Bromus tectorum	Cheatgrass	N(control infeasible)	0.587
Trifolium hirtum	Rose Clover	Y	0.568
Bromus rubens	Red Brome	N(control infeasible)	0.561
Vulpia myuros	Annual fescue	N(control infeasible)	0.561
Hypericum perforatum	Klamath Weed	N(control infeasible)	0.557
Cynosurus echinatus	Dogtail Grass	N(control infeasible)	0.553
Avena barbata	Wild Oats	N(control infeasible)	0.551
Cynodon dactylon	Bermuda Grass	Y	0.549
Daucus carrotta	Wild Carrot	Y	0.548
Avena fatua	Wild Oats	N(control infeasible)	0.547
Verbascum blattaria	Moth Mullein	Y	0.545
Rumex acetosella	Sheep Sorrel	N(control infeasible)	0.543
Bromus diandrus	Ripgut Brome	N(control infeasible)	0.497
Bromus hordeaceus	Soft Chess5	N(control infeasible)	0.492
Melilotus albus	White Sweetclover	N(control infeasible)	0.485

Revising the Prioritization

Following the first field season, and then every 5 years as part of the Analysis and Synthesis Reports, the prioritization will be revisited. Any new invasive species of concern for the parks will be run through the prioritization process (Appendix A). Existing prioritized species will also be reviewed and any species whose classification or ranking appears suspect will be re-evaluated. The new ranking and classification data will be added to the existing database archived at the Klamath Network (SOP #8: Data Transfer, Storage, and Archive). These databases are set up to feed directly into the ranking software. The software Criterium Decision Plus 3 (http://www.infoharvest.com/ihroot/index.asp) will again be used to rerun the calculations with the new data. The rankings produced by the analytical hierarchy process will again be evaluated by park and network specialists and species whose new ranking scores are sufficiently high to merit inclusion in the list of invasive species for park-wide monitoring, as described above for each park, will be included.

Literature Cited

Saaty, T. 1980. The Analytic hierarchy process: Planning, priority setting, resource allocation. McGraw-Hill Inc., New York.

Randall, J. A., L. E. Morse, N. Benton, R. Hiebert, S. Lu, and T. Killefer. *in press*. The invasive species assessment protocol: A new tool for creating regional and national lists of invasive non-native plants that negatively impact biodiversity. Invasive Plant Science and Management.

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #2: Field Work Preparation

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains procedures that will be completed prior to implementing the field season, including reviewing the budget, hiring and scheduling the field crew, and preparing site description forms and maps, as well as preparing data forms, obtaining GIS layers, meeting park requirements, planning the training, and setting up equipment and the database.

Reviewing the Budget

It is the Network Coordinator's responsibility to provide adequate funding to conduct this protocol. Funding for this project should be clearly stated in the Annual Administrative Work Plan. The Crew Lead will work with the Network Coordinator prior to each field season to review the budget for this project's work plan and ensure that it meets salary, equipment, mileage, and miscellaneous field expenses.

Hiring the Crew Lead

It is the Project Lead's responsibility to hire the Crew Lead. Recruitment for the Crew Lead should begin in late November or early December of the year preceding a field season. Hiring should be completed no later then February. Qualities to seek in potential Crew Leads include:

1. Proficiency at identifying both native and non-native plants. A completed or in-progress botany degree is preferred.
2. Outdoor hiking and camping experience.
3. Moderate or preferably high level of physical fitness.
4. Familiarity with one or more of the KLMN parks.
5. Familiarity with plant communities in the Klamath Region.
6. Leadership experience.
7. Strong organizational skills.
8. Knowledge of, or preferably certification in, wilderness first aid.
9. Ability to work in the field with another crew member for long periods of time.

Once selected, the Crew Lead should review the protocol and discuss any questions with the Project Lead.

Hiring the Field Crew

Recruitment of the field crew member(s) should begin by January of the year preceding field work. Hiring should be completed by March. As with hiring the Crew Lead, initiating the recruitment process early is critical for ensuring that well qualified candidates can be found, background checks can be completed, and hiring paperwork can be processed. Although the field crew member(s) do not need to have the same level of experience, nor all of the required skills as the Crew Lead, similar qualities should be sought. While the first three of the above qualities should be considered mandatory, the others are desirable but not strictly required.

Preparing Data Forms, Databases, and GIS Layers

The Crew Lead, working with the GIS Specialist and Data Manager, will make certain updated electronic forms, baseline GIS layers, and target locations are loaded into the field computers and GPS units. Project files will be loaded onto a laptop, which will be used while in the field. The Crew Lead will set up and test the Trimble unit, Garmin unit, and laser rangefinder to make sure they are functioning properly prior to going into the field (SOP #4: Setting Up the Electronic Field Equipment). It is the Data Manager's responsibility to populate the project database with new site locations prior to the start of the field season.

GIS Layers and Maps

The GIS Specialist should obtain the most up-to-date baseline GIS layers (roads, trails, streams, lakes, park boundary, imagery, etc.) from park staff prior to hiring the Crew Lead. It is the Crew Lead's responsibility to work with the GIS Specialist to create shapefiles of the sites that will be surveyed that year. GIS layers should include attributes that allow the user to break the features in the layer into: (1) 3 km long segments, (2) 500 m long subsegments, and (3) the name of each 3 km long segment. It is critical that shapefiles include the same data fields named the same way each year. The fields that should be included are:

- FID GIS ID number.
- Shape Type of feature, this should be polyline.
- ID Unique ID number for the GIS record.
- Name Name of the road, trail, campground, or powerline corridor.
- Length The length of the route in meters.
- 3kSeg_Name Unique name given to the segment of the road, trail, campground, or powerline corridor that will be surveyed.
- Type Type of segment (road, trail, campground, or powerline corridor)
- StartX Easting coordinate for the start of the survey area
- StartY Northing coordinate for the start of the survey area
- EndX Easting coordinate for the end of the survey area
- EndY Northing coordinate for the end of the survey area
- park_code Park were the survey will be completed

The shapefiles should be provided to the Data Manager 2 weeks prior to starting the field work so he/she can prepare the project database. All GIS layers should be in a WGS84 projection.

It is the Crew Lead's responsibility to create field maps for each site and to help crews navigate around the parks. In most instances, the GIS Specialist will already have pre-designed maps that will need to have the sample units for that year added. These maps are designed using a mapbook utility and can easily be printed out for each crew member.

Detailed GIS instructions for preparing GPS units and GIS data are currently located in the Network's shared drive at:

G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\Methods

Master and Project Database

In order to prepare the database to be used in the field, the Crew Lead will need to provide the Data Manager with a GIS layer of all the sites that will be visited that season in the format described above. In addition, the Crew Lead will need to provide a list of all species that will be monitored or recorded under this protocol and contact information for each person working on this project. Once the Data Manager has the list and GIS layers, he/she can prepare the project database that will be used that year (SOP #9: Databases). Each crew will have a laptop with a Microsoft Access project database loaded onto the desktop of the laptop (SOP #4: Setting up the Electronic Field Equipment). Prior to loading the databases onto the laptop computers, the Data Manager should follow the steps described in SOP #9: Databases to: (1) review and create sites, (2) load electronic forms and toolbars onto the Pocket PC, (3) add historic invasive species data to the Pocket PC, and (4) update baseline data used in pick lists.

Data Forms

Twenty-five percent of the data forms for the season's sampling should be printed or copied using Rite-in-the-Rain paper. Field forms from the previous years' field work, stored in the project folder, should be used before printing new forms. Care should be taken to ensure that field forms from previous seasons represent the current data collection parameters before using them.

Preparing Equipment

Equipment will need to be checked before visiting the field to provide sufficient time for needed repairs or replacement. Electronic equipment (Trimble units, Garmin units, laptop computers, and rangefinders) will need to have the proper settings checked prior to going into the field (SOP #4: Setting up the Electronic Equipment). All equipment should be provided by the KLMN. The following equipment and data are needed:

- Trimble GeoExplorer XM Pocket PC, including external antenna (or another unit of similar quality)
- Garmin 60CSx or 76CSx GPS unit (or another unit of similar quality)
- Background files (DRG, NAIP, park boundary, streams, infrastructure, etc.) and sample units (roads, trails, powerlines, campgrounds, dunes)
- Laptop computer with the project database, protocol and supporting documentation, GIS data (as a backup), backup folder (for new data), species identification cards, and any other miscellaneous materials that might be needed (SOP #4: Setting up the Electronic Field Equipment)
- Laser rangefinder with foliar filter

- Datasheets
- Waterproof map of the park with search units or line transects
- Radios or walkie talkies for communication among observers and with the parks
- Hardcopy guides needed to identify exotic plants, including photographs of plants and look-alike species
- Pencils, sharpies
- Hand lens
- Compass
- Field notebook to record field observations and press temporary plant specimens
- Plant press
- Backpacks
- Binoculars
- Clipboard
- Chargers/batteries for electronic equipment
- Watch

Miscellaneous items

- First aid kit
- Cell phone
- Sun screen
- Insect repellant
- Water
- Standard camping gear (if housing is not available)

Park Requirements

As early as possible after being hired (e.g., March), the Crew Lead should communicate with the Project Lead to determine the contact person for each park**.** The Crew Lead should contact each park to inform them of the survey schedule and to determine:

1. Whether housing or campground sites are available.
2. Whether keys are needed to access survey sites.
3. Whether permits are needed to conduct research in the parks.
4. Whether there are any safety procedures to follow. In particular, whether areas to be sampled need to be checked by law enforcement for safety concerns. This may hamper sampling at Whiskeytown.
5. To determine if there are any road or trail closures that may limit areas available for sampling.

In addition, the Crew Lead should work with each park to ensure the Network radios have been properly configured to work with the communication system at each park.

Prepare for and Schedule Training

The training sessions should be scheduled and materials should be prepared as detailed in SOP #3: Observer Training.

Scheduling Field Work

By sampling the Network's low elevation sites first during the season, then the mid elevation sites, and finally the high elevation sites, crews can ensure that sampling coincides with the optimum time for observing invasive plants (Figure 1). It is the Crew Leader's responsibility to develop a tentative schedule for the entire season at the beginning of the season. However, it is subject to change and only the work assigned for a single field trip should be completed before further instruction from the Crew Lead. Late May through mid-June is a time when sampling is optimal in multiple parks. If necessary, monitoring at Redwood that could be done during this time may be postponed until the end of the field season to allow more flexibility in scheduling.

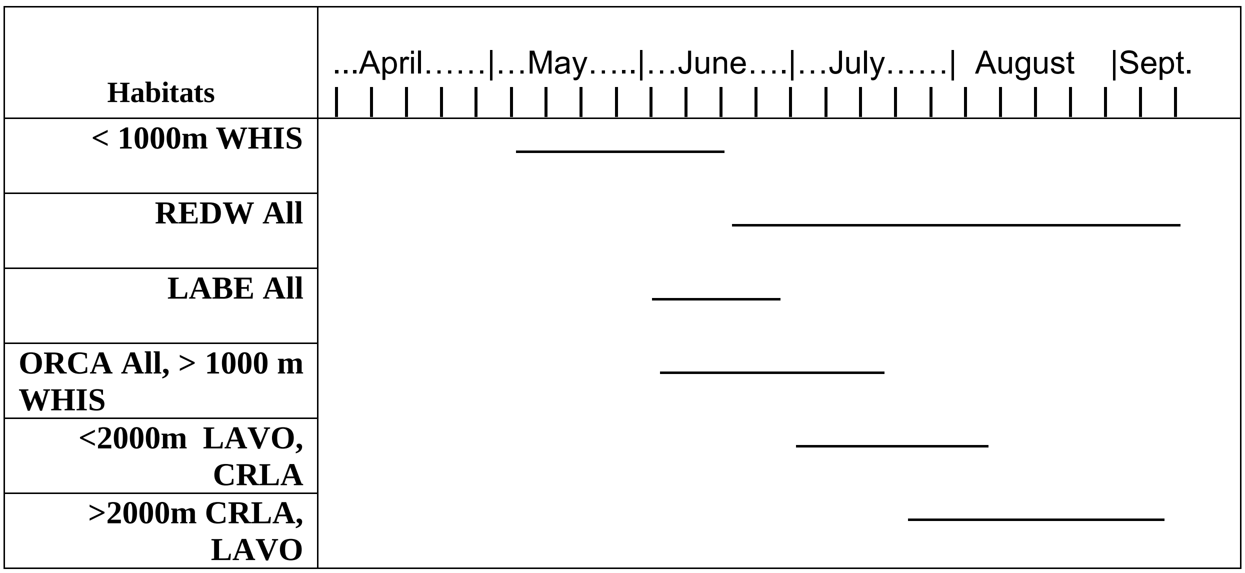


Figure 1. Timing for invasive species sampling in different elevation zones in different parks of the Klamath Network. WHIS = Whiskeytown, REDW = Redwood, LABE = Lava Beds, ORCA = Oregon Caves, LAVO = Lassen Volcanic, and CRLA = Crater Lake.

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #3: Observer Training

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedures for training observers, including survey training, first aid, safety, emergency procedures, backcountry rules and ethics, data entry, and training tracking.

Survey Training

Prior to working in the field, each member of the field crew must review the entire protocol and the job hazard assessment documents. Training will include a presentation of the specifics of the protocol by the Project Lead and Data Manager. The crew will be instructed on how to identify invasive species and how to use the GPS units, databases, and laser rangefinder.

Training Observers in Navigation

Observers are expected to be able to independently navigate in the field using a map, compass, and GPS unit. They will be provided instruction on the following (SOP #4: Setting up the Electronic Field Equipment, SOP #6: Data Collection and Entry):

a. Basic features of Garmin and Trimble GPS units.
b. Using ArcPad to collect data.
c. Confirming zone and datum.
d. Ensuring correct identification of search unit (road, trail, powerline) on the GPS unit.
e. Navigation along search units and measuring distance within subsegments for locating random plots.
f. Understanding correspondence between map and GPS, including search units.
g. Use of map, compass, and pacing in conjunction with GPS navigation.
h. Use of the laser rangefinder.

Training Observers in Plant Identification and Collection

Observers are expected to be familiar with plant taxonomy and terminology in order to become quickly familiar with invasive exotic plants encountered in the Network parks. With the Crew Leader, observers will review how to identify invasives that have been prioritized using the outreach materials developed by the Network, and where appropriate, herbarium specimens, keys, and photographs. The Project Lead will work with the Herbarium at Southern Oregon University to develop a complete set of specimens for all prioritized invasives. Field botanists/crew member's training will include:

1. Review lists of priority invasives.
2. Review photographs, taxonomic keys, herbarium sheets, and other plant identification materials prepared by the Network.
3. Practice plant identification, making use of herbarium specimens where possible.
4. The Crew Lead should work with the field crew members to specifically review how to identify prioritized species in particular parks. This should include:
    a. Which species look similar to the prioritized species.
    b. Which habitats are most likely to have infestations of particular species.
5. The Crew Lead will demonstrate how to collect a voucher specimen.

Training Observers in Foliar Cover Estimates

Foliar cover estimates are obtained for invasive species as well as trees and shrubs in field plots. Consistent cover estimates are important for modeling and for tracking changes in cover over time. However, obtaining consistent estimates among observers is notoriously difficult. The following guidelines will be followed to help improve consistency.

1. Foliar cover measures a vertical projection of the leaf area. This can be viewed as the ground area that would be obscured from a downward projection of light above the plant.
2. Conceive of plant cover in 10 m^2 units.
3. Discuss cover estimation in a group setting, allowing for consideration of each other's estimates. With practice and discussion, foliar cover estimates by observers should begin to converge.
4. Practice estimating cover for different life forms, such as forbs, grasses, and shrubs.
5. Throughout the sampling season, review foliar cover estimation. Periodically compare observer's cover class estimates.
6. Ensure good communication among the crew about observer patterns of cover estimation.
7. As vegetation dies back, discuss estimation standards for estimating foliar cover of senescing vegetation.

It is the Crew Lead's responsibility to test each member of the crew on their ability to measure foliar cover.

Training the Observer in Data Collection Techniques

Data are collected using field computers and GPS units. Instructions for setting up the GPS units are provided in SOP #4: Setting up the Electronic Field Equipment. The data to be entered and entry methods are described in SOP #6: Data Collection and Entry. Each member of the crew will attend a 1-2 day training on how to use the electronic equipment to collect data. It is the responsibility of the Data Manager, with the help of the Crew Lead, to develop the training materials and conduct the training prior to beginning field sampling. At the end of the training, each crew member will be tested to ensure that they understand how to collect and store data using the electronic equipment. If a crew member does not pass the test, the Data Manager will need to work closely with him/her until he/she learns the methods.

First Aid, Safety, and Emergency Procedures

The field crew will be working in some remote areas; it is therefore essential that everyone, to the extent possible, be prepared for emergency situations. Numerous safety issues and concerns are associated with implementing a long-term, service-wide monitoring program that includes extensive field work and sampling by network staff or other cooperators/contractors. Field work requires an awareness of potential hazards and knowledge of basic safety procedures. Field personnel routinely come in direct and indirect contact with rough terrain, potentially hazardous plants and animals, and adverse weather conditions. Advanced planning can reduce or eliminate many safety hazards.

The Klamath Network is committed to safety and will work to meet the goals and adhere to the beliefs of the NPS NPSafe program. To this end, the Klamath Network has developed job hazard assessment documents specific to each park, to which crew members will strictly adhere while working at the parks (Appendix E). The safety protocol addresses known hazards (e.g., poison oak, rocky terrain, etc.), wildlife issues, communications, first aid, and an emergency response plan. Prior to going into the field, the Crew Lead shall review safety procedures and job hazard analyses (Appendix E) with all field crew personnel.

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #4: Setting up the Electronic Field Equipment

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the process for setting up the handheld Pocket PC, Global Position System (GPS), laptop computer, and laser rangefinder to collect and store data associated with this protocol. This SOP describes the process associated with using a Trimble GeoExplorer 2005/08 series Pocket PC, a Garmin 60 or 76 series GPS unit, and the TruPulse 200 Laser Rangefinder. It is expected that this equipment will be updated throughout the life of the protocol. This SOP will need to be updated accordingly.

Review of the Data Collection Methods

As part of this protocol, the Klamath Network (KLMN) will collect data digitally and in hardcopy format for the first few years of the project. Hardcopy datasheets will be compared to data collected digitally to ensure the data's accuracy. Data will be collected using an integrated system of hardware and software that works to simplify the collection and management of invasive species data. The central piece of the data management system is the relational MS Access database that works to keep track of all weed occurrences, random plots, survey information, and treatments. This database will be used in combination with a handheld Pocket PC (Trimble series) to facilitate field data collection. The database was designed using the NPS Natural Resource Database Template (NRDT) and incorporates many of the features currently available with The Nature Conservancy (TNC) weed information management system (WIMS) database. For more information on the database for this project see SOP #9: Databases.

Setting Up the Trimble GeoExplorer Pocket PC

Prior to preparing the Trimble units for data collection, it is the responsibility of the Crew Lead to provide the Data Manager with shapefiles showing the sites that will be surveyed that year, the contact information for each crew member, and a species list of all the species being surveyed (SOP #2: Field Work Preparation). Once the Data Manager has the sites and species list, it is his/her responsibility to set up the Pocket PC. The Pocket PC settings should be completed in the following manner.

On the Pocket PC, under the start menu select [Settings]. At the bottom of the screen select the [System] tab. Open [System Information]. Go to the following Trimble web site: http://www.trimble.com/geoxt_ts.asp?Nav=Collection-9554 and make certain the Pocket PC has the most up-to-date software.

Make certain the latest available version of ESRI ArcPad, Trimble GPSCorrect, and ActiveSync is loaded onto the Pocket PC. ActiveSync must also be loaded on the Desktop.

Load the DateTime.shp and PlotLocn.shp files onto the Pocket PC following the steps below. NOTE: You CANNOT get the database from the TNC web site since the database has been altered to meet the needs of the KLMN.

Open ArcPad on the Pocket PC and tap the small drop-down arrow next to the GPS Tools  and tap on [GPS Preferences].

There are several tabs at the bottom of the screen. For the **GPS tab**, set the following:
Protocol = Trimble GPScorrect
Port = Com3: TSIP Serial Port
BAUD = 9600
Make certain the following are check marked: “Automatically Active,” “Show GPS Activity in System Tray,” and “Automatically Pan View.”
On the **Capture tab**, set the following:
Checkmark “Enable Averaging”
Points = 30
Vertices = 5
Position Interval = 1
Distance Interval = 5
On the **Quality tab**, set the following:
Checkmark “No Warnings”
On the **GPS Height tab**, set the following:
Antenna Height = 3
Geoid Separation = 0
Checkmark “Use Map Units for Height Units”
Checkmark “Use Height in Datum Transformation”
On the **Datum tab**, set the following:
GPS Datum = D_WGS_1984
On the **Alerts tab**, set the following:
Turn off all the alerts should be turned off
On the **Location tab**, set the following:
Latitude, Longitude, and Altitude will automatically populate
Checkmark “Restore Location”
DST Distance Alert = 10 and units should be = m

Tap the small drop-down arrow next to the GPS Tools  and tap on [Trimble GPScorrect].
Tap [Logging Settings] and make certain the settings are correct.
Log GPS to SSF = On

Log H-Star Data = No
Antenna Height = 3.000 m
Tab [GPS Settings] and make certain the settings are correct.
DOP Type = PDOP
Max PDOP = 12
Min SNR = 39
Min Elevation = 15
Velocity Filter = Auto
Tab [Real Time Settings] and make certain the settings are correct.
Choice 1 = Integrated SBAS
Choice 2 = Use Uncorrected GPS
Real-Time Age Limit = 4 min
Load the weeds, site, and pick list data onto the Pocket PC using the process outlined in SOP #9: Databases.

Setting Up the Garmin 60/76 GPS Unit

Field crews mainly use the Garmin GPS unit to navigate to the beginning of the site. In the event that a GPS coordinate cannot be obtained using the Trimble unit, the Garmin unit may be used to get the GPS coordinates, which should then be hand entered into the Trimble unit (SOP #6: Data Collection and Entry). It is the responsibility of the Data Manager to prepare the GPS units for the field crews. The following steps should be used to prepare the GPS units.

Make certain you have the latest version of the program DNR Garmin. This program can be obtained from the following web site:
http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html

Obtain the following layers from the GIS Specialist:
Trails and Roads to be surveyed, broken down into segments
Park Boundaries
All roads and trails for a park
Invasive species locations from previous I&M visits
Invasive species locations from park visits

Make certain all the layers are in a WGS84 projection.

Use DNR Garmin and the following steps to load the GPS data onto the Garmin units.

Open DNR Garmin and go to [file→ load from file] and under “Files of type” select [ArcView Shapefile].

Make sure the Garmin is plugged into the computer and is recognized by the DNR Garmin program.
Depending on if you are loading routes or waypoints, click on the proper drop-down menu and select upload.

Repeat these steps for all GIS layers.

Use the program Topo Pro for ArcGIS to upload background imagery, if desired by the field crew.

Once you have the data loaded, go to the main menu in the Garmin unit and select [Setup]. Use the default settings for this unit with the exception of the following changes:
Under [setup→system] make certain WASS / EGNOS is "Enabled."
Under [setup→map] make certain the proper maps are showing for the areas where you will be surveying.
Under [setup→time] change the format to [24 hour] and make certain the time zone is [US - Pacific].
Under [setup→units] change the format to [hddd mm ss.s], Map datum should be WGS 84, Distance = Metric, Elevation = Meters (m/min), Temperature = Celsius.

Setting up the TruPulse Laser Rangefinder
The TruPulse Laser Rangefinder has three buttons, an up and down arrow on the left side of the unit, and the "fire" button on the top of the unit. Make certain the unit has new batteries and then follow these basic steps to set-up the unit:

Hold the down arrow button down for 4 seconds while looking through the eye piece of the unit. You should see the words "UnitsS." Push the fire button and you should see a measurement type (Yards, Meters, Feet) under the UnitsS caption. Use the up and down arrows to set this to [Meters]. Hit the fire button once you have selected meters.

Look through the eyepiece and at the bottom of the screen you should see one of the following SD, VD, HD, INC, HT. Use the up and down arrow to set this to SD (Slope Distance).

Setting Up the Laptop Computer
Prior to heading into the field, the Data Manager should load the field project folder onto the desktop of each laptop to be used. The field project folder should be renamed to include the initials of each crew member that will be using the folder and the current year separated by underscores (e.g., DO_SM_2008). The field project folder contains the six subfolders described below.

Project_Database. This is the Access database into which data from the Trimble units will be loaded each night (SOP #9: Databases, SOP #6: Data Collection and Entry).

Documentation. This folder will contain any documentation that might be needed while in the field (e.g., ISED Protocol, Equipment User Guide).
GIS_Data. This folder contains a copy of all the GIS data that were loaded on the Trimble unit and Garmin unit prior to starting the field season. These data are available as a backup in case something goes wrong with the layers on the handheld units.

Backup. At the end of each day, the field crew will place into the folder a copy of the Assessment, Occurrence, and Treatment shapefiles on their Trimble units. This will act as a backup of the data collected in the field in case something goes wrong with the handheld units.

Identification. This folder will contain any information needed to help with the identification of invasive plants (e.g., Identification Guide, ID Cards).

Other. An addition folder that can be used for any data files that do not "fit" into one of the above categories.

Radios

The Klamath Network currently utilizes Icom FC-F70DT VHF two-way radios for use by the field crew. These radios are light-weight, powerful, fairly robust to field use, and provide a safety measure and logistical contact to local park staff.

It is the responsibility of the field crew to familiarize themselves with radio use and operation. It is the responsibility of the Crew Lead to communicate with the local park staff to establish local radio procedures (e.g., check-ins [if required], call signs).

Any problems with programming or operations should be reported to Klamath Network office staff as soon as possible.

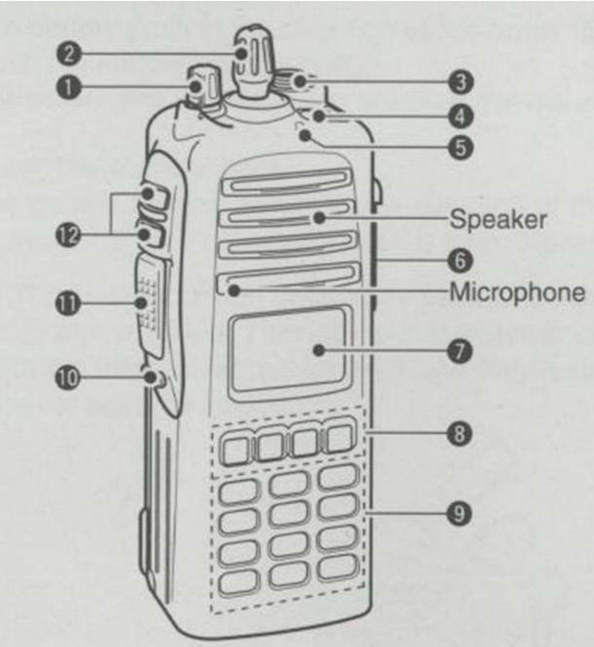
Radio Specifications:

Maximum number of channels: 256

Power: 5 watt

Operational Range: 5 to 7 miles (8 to 11 kilometers), but highly dependent on local conditions.

Battery Life: 14.5 hours of continuous operational use (intermittent crew use should extend this).



1. Power and Volume Control
2. Rotary Channel Selector
3. Antenna Connection
4. Emergency Switch
5. Busy/Transmit Switch (green = receiving/squelch open) (Red = transmitting)
6. Connector cover
7. Display
8. Function Keys
9. Keypad
10. "Monitor Switch" – programmed to "user set"
11. PTT – Push To Talk
12. Up/Down Switches

Basic Operation:

Turn the radio on by rotating knob (**1**) clockwise (this also controls volume).
Rotate knob (**2**) to the appropriate channel (confirm channel on screen [**7**]).
Push PTT button (**11**).
Talk, holding the transmitter upright and 2 to 4 inches from mouth.

Release PTT button (**11**) to receive.

Changing Channels: Depending on the park, location within a park, or the location the radio was last used, the channel zone and channel may need to be changed for proper usages (Contact local park staff to establish proper channels for usage).

Establish the Proper Zone (Table 1):

With the radio on, depress button "P_0" from the Function Keys (**8**).
Use the Up/Down Switches (**12**) to scroll through the zones.
The changing zones will be displayed on the screen (**7**).
Upon finding the correct zone, depress "P_0" to set the zone.

Changing the Channel within the Zone: Turn the Channel Select Knob (**2**) until you reach the proper channel.

In Emergency Situations: If you are in an emergency situation, and you are unable to reach park staff, you have two options.

1. Depress the orange button (**4**). This sends an emergency signal on the currently selected channel (no voice necessary). If you are set on the wrong channel, no one may hear you.
2. Switch the zone to one of the counties closest to you (e.g., Jackson County or Shasta County). Within these zones there are a variety of sheriff and fire fighting settings. Attempt communication with any of these entities.

Useful Information: There are additional tidbits of radio usage that may help the radio operator.

Be Patient – It takes time for a voice message to be received and transmitted. When talking, depress the PTT, wait a second, and then begin to talk. When you are done talking, finish by saying "OVER." This lets the receiver know that you are done talking, so that they can reply. The receiver should wait a few seconds before replying.

Push To Talk – Do not depress this button unless you are actively engaging in talk. Holding this button down will prevent others from talking on this frequency. You may anger people if you abuse the radiowaves.

Battery Life – the battery should last 14 hours or so, for typical usage. If not transmitting or receiving, it should last considerably longer. Keep the battery charged as much as possible. Note that the battery can be charged detached from the radio if needed (e.g., charging a back-up battery). There is a battery life indicator on the display screen in the upper right hand corner. If you anticipate needing longer battery life, contact Klamath Network office staff for extra batteries.

Signal Strength – there is an indicator in the upper left corner of the display.
Scan – Function key "P_1" is set to scan. Depressing the button will cause the radio to scan all zones and all channels (except for NOAA weather forecast zone). Note that if squelch is set low, it may "pick up" static.

Squelch – Squelch is controlled through "user settings." Squelch is basically noise reduction, hiding the background static over a certain threshold. Depending on the channel and your location, the amount of static that needs to be reduced can vary. Generally, increase the squelch until the static just fades out. Changing the squelch will affect all channels in all zones. To set or adjust squelch, follow this procedure:

- With the radio on, depress the "Monitor Switch," (**10**), until the radio beeps.
- This will enter into a series of screens that the user can adjust – there should be little need to change any, except for the squelch.
- Pushing the same button will cycle through options – push repeatedly until SQL appears. A number will be next to it, from 0 – 255. If you are hearing just static, increase the squelch. If you are not hearing transmissions, decrease the squelch.
- Use the up/down switch (**12**) to adjust the squelch.
- Push and hold the "Monitor Switch" (**10**) until the radio beeps again and goes into standard operating mode.
- The effect of changing the squelch will only be heard when you go back into the standard operating mode (e.g., while changing the squelch, you will not get real-time feedback on your changes).
- Adjust as necessary.

Light – You can create a backlight on the screen by depressing button "P_2."

Compander – The compander function can create a clearer signal, if both the receiver and transmitter are equipped with this function. Compander can be turned on and off by depressing button "P_3."

Waterproof – Although the radio is waterproof (down to 1 meter for 30 minutes), do not test this. The radio is very expensive.

NOAA Radio – There are seven different NOAA radio weather forecast frequencies programmed in the radio. If you can pick up a signal, the forecast should be applicable to your area.

Troubleshooting: Although every attempt has been made to ensure that the radios are properly functioning, problems may arise.

"The radio does not turn on."

Confirm that the battery case is fully snapped into place. Depress the latch on the bottom of the radio, and reinsert the battery. Change the battery. If the radio is equipped with a battery unit using AA batteries, change these batteries.

"I can't hear any transmission, and nobody responds to me."

Antennae may be loose – tighten it up.
You may be on the wrong channel – try changing channels, and repeat.
Squelch may be to high – adjust squelch to a lower setting, and repeat.

You may be out of range – either try to move closer to the base station or repeater, or move to higher ground to establish line of sight.

For additional problems, return radio to Klamath Network office staff.

Table 1. Currently assigned channels and zones for Klamath Network Icom Radios (as of July 2009). Names are derived from park supplied lists, and are set up according to park specifications (e.g., “channel 1 on a CRLA radio should be channel 1 on KLMN radio, when set to Zone 1). Everything has been done to insure compatibility with park radios.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
	CRLA	LABE	LAVO	ORCA	REDW	WHIS	KLMN LE	NOAA	Jackson Co.	Shasta Co.
Channel 1	CLNPWA	LABE Local Trans	LNP Direct	None Currently Assigned	NPS Direct	WHIS 1	CLNPWA	NOAA 1	JackSheriff1	CDF dis
Channel 2	CLNPSC	LABE Schonin	LNP Peak		NPS Crescent City	WHIS 2	CLNPSC	NOAA 2	O.P.E.N.	CountyNet
Channel 3			LNP Hark		NPS Requa	WHIS 1 N	LABE 2	NOAA 3	JackSheriff2	CottonwoodFi
Channel 4			LNP Pros		NPS Red Mtn.	WHIS 2 N	SISK SO	NOAA 4	AshlandPOdis	AndersonFi
Channel 5			LNP Tactical 1		NPS School House		REDW DIR	NOAA 5	AshlandFDdis	ReddingFDdis
Channel 6			LNP Tactical 2		NPS Tactical		REDW REP	NOAA 6	AslandSkiPa	ReddingFDta1
Channel 7			NIFC 1		NOAA Weather		LNP PEAK	NOAA 7	PhoenixPOdis	ReddingFDta2
Channel 8			NIFC 2		CDPR Direct		LNP HARK		PhoenixPOtac	ShastaCoSher
Channel 9			LNF Dir		CDPS Pt. St.		WHIS 1		TalentPOdis	ShastaCoStac
Channel 10			LNF Pros		CDPR Requa		WHIS 2		TalentPOtac	ForestNet
Channel 11			LNF Trnr		CDPR Red Mtn.		DOI LE		SoCountFD	ForestNetRep
Channel 12			USFS A2G		CDPR Prairie		KLMNTAC1		MedfordPOdis	TravelNet
Channel 13			CALCORD						MedfordPOtac2	USFSTac1
Channel 14			TGU LOCL						MedfordPOta3	
Channel 15									MedfordFDdis	
Channel 16									NOCountFD	

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedures (SOP) #5: Field Survey Methods

Version 1.00 (February 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP details field data collection methods to be used in this protocol. Field data collection is completed using electronic and manual means. The core staffing for the field data collection will be two GS-5 level seasonal employees who will be trained by and work closely with the Crew Lead and Project Lead. To prepare for field data collection, each member of the crew, or supplemental staff, will attend training on how to use the electronic equipment to collect data (SOP #3: Observer Training). It is the responsibility of the Crew Lead to ensure that the seasonal crew members are proficient in all the field data collection, entry, and management methods before going into the field.

Selecting Sampling Sites

Monitoring of prioritized species will occur along roads, trails, and powerline corridors. Roads will include those in campgrounds. Prior to visiting a park, the Crew Lead will develop a list of segments that will be sampled that year. These segments will be randomly selected from all sampling units within the sampling frame developed by the GIS Specialist (SOP #2: Field Work Preparation). Busy roads will not be sampled due to safety concerns.

The roads, trails, and powerlines will be divided into 3 km segments (Figure 1). In some instances, segments will be shorter than 3 km, for example, where the total distance of a road, trail, or powerline is less than 3 km, or where the division of the road, trail, or powerline into 3 km segments creates a terminal section that is shorter than 3 km. Each 3 km segment will be divided into 500 m long subsegments (Figure 1). There will be some cases where roads or trails themselves are less than 500 m. In addition, where segments are less than 3 km for reasons discussed above, there will be a subsegment that is shorter than 500 m. These will be treated the same as 500 m subsegments. The subsegments will be numbered 1-6 with increasing distance from the trailhead in each 3 km segment. Segments shorter then 3 km will be numbered accordingly, but will have fewer than six subsegments. Starting points for segments may be at the discretion of the field crew, depending upon the most likely points of access to the segment from the existing road and trail network. In campgrounds, crews will walk all roads, and investigate all vacant sites. The width of segments will generally be 20 m on either side of the road or trail.

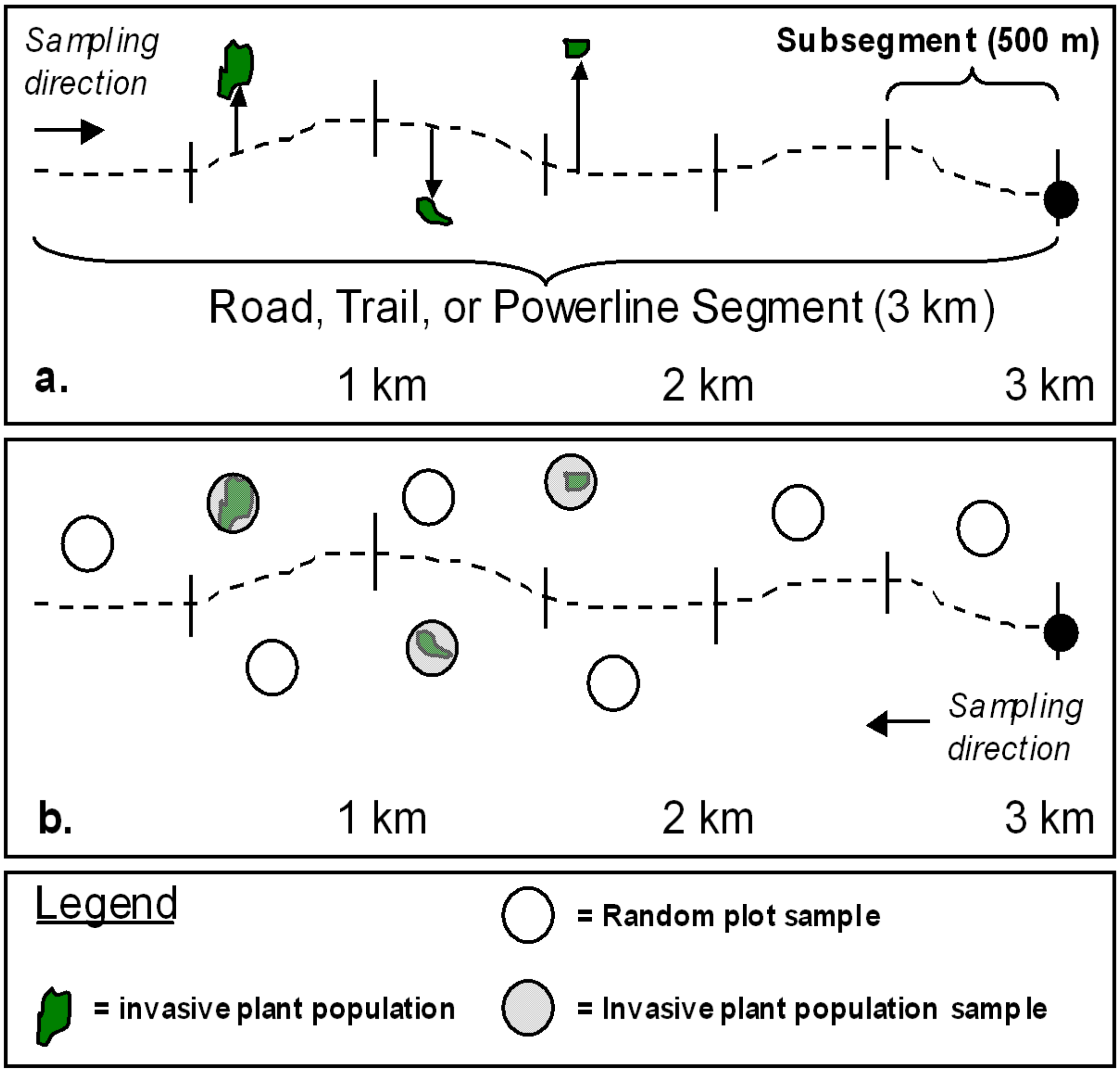


Figure 1 a and b. Illustration of the invasive species early detection response design to be completed at each randomly selected road, trail, or powerline segment in a park: a) location mapping and sampling of invasive plant populations; and b) plot sampling of random locations and the invasive plant populations located.

Collecting Occurrence Data

Data will be collected using a Trimble GeoExplorer Pocket PC (or similar product). Hardcopy datasheets will also be used (see Figure 2 at the end of this protocol) and Garmin units will serve as a backup for obtaining geographic coordinates and for navigation when a signal for the Trimble unit cannot be obtained (SOP #6: Data Collection and Entry). GIS shapefile templates for recording information described below will be pre-loaded onto the Trimble unit prior to field sampling (SOP #2: Field Work Preparation, SOP #4: Setting Up The Electronic Field Equipment, and SOP #9: Databases). GIS data loaded on the Trimble and Garmin units include:

background imagery, roads and trails, streams and lakes, and sampling units color coded by subsegment.

Starting with the first subsegment of a road, trail, or powerline corridor, the field crews will walk, searching for prioritized invasive species. In most areas, prioritized species are in the colonization and establishment phases of invasion (SOP #1: Invasive Plant Prioritization). In remote areas and park designated weed free zones, infestations of species in the equilibrium phase will also be recorded if found (SOP #1: Invasive Plant Prioritization).

As the crew hikes the segment, a GPS record of the location of all prioritized species observed from the route will be recorded in the Trimble unit, as well as on paper datasheets. Infestations will be considered distinct if they are separated by the maximum detection distance of 20 m. Detection distance will not be consistent among segments because this will vary with vegetation. Detection distance will be high where ground vegetation is minimal and low where ground vegetation is dense (e.g., in dense chaparral). Recording changes in detection distance was not considered feasible, and the pilot study affirmed this. The distance from the road, trail, or powerline corridor to the infestation will be determined using a laser rangefinder. For every occurrence of a priority species, a minimal amount of data will be collected as described in the data collection section below.

Based on the 2009 sampling season, there will rarely be four or more infestations of early detection species along a subsegment. In the exceptional cases where more than four infestations do occur, it is very time-consuming to map them. Thus, the maximum number of individual infestations per 500 m subsegment per species will be four. If there are more, the whole segment will be considered infested, suggesting to managers that the entire segment be searched and treated for the species found. If the crew should encounter more than four infestations, this will be recorded in the observation in the notes section on the back of the last datasheet under infestation #5 and in the site notes section on the Trimble unit. All other infestations (#5 and above) of that species in that 500 m subsegment will be ignored.

Should the species occur in a continuous pattern, the distance between plot sampling start and end points for the continuous population will be recorded in the note's field of the GPS and no infestation size will be recorded. In this case, center points will be at least 40 m apart (20 m on each side of a plot center). If the infestation is continuous along both sides of the trail, a random side will be chosen for an infestation plot center. In a "worst case" scenario, the crew will have mapped 24 infestations of a single species on a 3 km segment. From these 24 mapped infestations, three are randomly selected to have site data recorded.

Sampling will proceed until the end of the segment is encountered. Once the survey has been completed, crews will walk back along the route they surveyed and collect additional data at random and infestation plots.

Plot Sampling

The circular 100 m plots will be laid out by stretching two tapes out to 11.34 m, the diameter of a 100 m^2 circle. The tapes will be crossed at their middle and placed perpendicular to one another. The edges of adjacent plots will be a minimum of 20 m apart.

Random Plots

Crews will place one circular 100 m^2 plot randomly in each subsegment, except in campgrounds, where plots will not be sampled. The random plots will document conditions in uninfested areas to aid with future invasive species habitat modeling. Plots will be located based on the following. First, a random side of the road or trail will be selected for sampling. A random number between 6 m and 494 m will then be selected for the longitudinal coordinate. This will ensure the entire plot is placed longitudinally within the proper subsegment. Then a random number between 6 m and 14 m will be selected for the transverse coordinate to ensure that a portion of the plot does not fall on the sampled segment. The coordinate will be the distance from road or trail edge of the plot center. These numbers will be identified ahead of time, even prior to the field season, and can be reused.

Infestation Plots

Additional circular 100 m^2 plots will be centered on infestations of priority species, excluding any equilibrium species that may be documented in remote and/or weed free areas. The number of infestation plots to be sampled will depend on the number of infestations encountered along the segment. The maximum number of plots for each invasive species prioritized for monitoring will be three. There are a number of different scenarios for locating these plots:

1. For each invasive in which there are three or fewer infestations on a segment, a plot will be centered on each infestation, regardless of the location of the infestation, or the segment length.
2. For each invasive in which there are more than three infestations on a segment, a total of three will be chosen to sample. One each will be chosen randomly from infestations in subsegments 1, 3, and 5 if possible. If the distribution of infestations does not allow for this, sampling sites will be chosen to maintain their dispersion by randomly selecting two sites from the two most far apart subsections containing infestations. The third site would then be located randomly in one of the remaining subsections containing infestations.
3. If infestations are only found in two subsections, all three sampling locations would be selected at random from these.
4. If all infestations of an invasive are located in one subsegment, sampling plot locations will be chosen at random from among the separate infestations.

To choose infestations randomly, each infestation is numbered in sequential order. A random number from the appropriate range, depending on the considerations described above, will be selected using the seconds output from a digital watch or a random number table.

Data Collection

The database being used to collect data for this project was developed using the Natural Resource Database Template (NRDT) and incorporates several features currently being used in The Nature Conservancy’s Weed Information Management System (WIMS) (SOP #9: Database). For this project, we will use a Trimble Pocket PC and ArcPad to collect data while in the field. The ArcPad setup on the Trimble unit includes forms that incorporate pick lists, auto-populated fields, and domain values to ensure that data are being collected in an efficient and accurate manner (SOP #6: Data Collection and Entry). The following sections list the general data that will be collected as part of this protocol. For more detailed information about the data, see the data dictionary in SOP #9: Databases.

All Infestations

The following parameters will be entered into the Pocket PC for all infestations encountered.

1. Name of the park.
2. Name of feature (road, campground, trail, powerline).
3. The subsegment where the infestation is located.
4. Unique name of the infestation in the format: 4 digit park code_yyyymmdd_hhmmss (e.g. 20070913_054603.
5. Calendar date at time of data collection, input format is yyyymmdd.
6. List of crew involved in sampling the site, first name and last name.
7. GPS unit used to collect the location of the infestation.
8. GPS error associated with the location.
9. Latitude and Longitude.
10. Scientific name and common name of the observed species.
11. Distance from the road, trail, or powerline corridor to the infestation (record value from laser rangefinder).
12. Infestation size, chosen from one of the following:
    a. $< 1\ m^2$
    b. $1\text{-}25\ m^2$
    c. $> 25\ m^2$
13. Whether or not the invasive species was treated.

Plot Sampling

At infestation plots, all the parameters listed in the above section will be recorded. However, for random plots, only parameters 1-9 will be recorded. In addition, for each random plot, and for plots located at infestations, the following parameters will be recorded.

1. Type of plot that is being measured. There are two possible options:
    a. Infestation plot
    b. Random plot
2. If the plot was selected to collect vegetation parameters at its location.
3. Slope of the plot measured as a percent using a clinometer (field crew will be trained in methodology).
4. Aspect in compass degrees facing out from site clinometer (field crew will be trained in methodology).
5. Percent cover of the priority invasive species in the plot. This is an ocular estimate. Supposing a view above the plant, foliar cover is the area of ground that would be obscured by the leaf surface area of the plant.

5. Light index measured using a Densiometer total count, average of four cardinal directions.
6. Evergreen tree cover. Percent of plot, ocular estimate.
7. Deciduous tree cover. Percent of plot, ocular estimate.
8. Shrub cover. Percent of plot, ocular estimate.
9. Herbaceous cover. Percent of plot, ocular estimate.

10. Litter, woody debris. Percent of plot, ocular estimate.
11. Bare ground. Percent of plot, ocular estimate.
12. Rock. Percent cover of bedrock and/or rocks bigger than 15 cm in diameter.
13. Estimated average height of the most dominant three species of canopy trees. Selected from the following list:
    f. 0.5-5 m
    g. 5.1-10 m
    h. 10.1-20 m
    i. 20.1-30 m
    j. >30 m
14. Percent of soil disturbance in the plot, ocular estimate.
15. Percent of surface water in the plot, ocular estimate.
16. Type of surface water found within survey site. Select from the list below. If no surface water is observed, then upland should be used.
    a. **Flooded Permanently or Semi-Permanently:** Surface water persists throughout all or almost all the year in all years. Vegetation is composed of obligate hydrophytes.
    b. **Seasonally/Temporary:** Surface water is present for portions of the growing season, but the water table usually lies well below the soil surface for most of the season.
    c. **Seep:** Site of low volume groundwater disharge. Ponded water may or may not be present.
    d. **Upland**: Surface water present only during heavy precipitation.
17. Land use is recorded if the plot has historically been altered for one of the following uses:
    a. Cultivation
    b. Campground
    c. Ditch / diversion
    d. Graded
    e. Pasture
    f. Logging
    g. Mining
    h. Homestead
    i. Roads

Additional data that are used to create field maps (these data are automatically associated with infestation and random sites once they are loaded into the desktop database):

1. State and County.
2. USGS 7.5 minute topographic map.
3. Public Land Survey System locations.

Treatment of Invasive Species

One of the primary goals of this project is to survey trails, roads (including those in campgrounds), and powerline corridors to record occurrence data and associated habitat information to be used for analysis (SOP #10: Reporting and Analyses of Data). It is neither the goal of this project nor the responsibility of the Inventory and Monitoring Program to eradicate observed invasive species. The primary management contributions of this monitoring effort will be to provide occurrence data, statistical summaries, and field observations in a timely fashion to support more substantive park or Network-based treatment efforts. Therefore, a major responsibility of the Crew Lead is to report any known locations of a priority species to the Park Contact in a timely manner and to maintain close communication with park managers throughout the year.

Completion of Field Work

The attribute form on the Trimble unit should be examined immediately after completing the electronic forms to make sure all fields have been populated. Hardcopy datasheets should be reviewed before leaving the monitoring segment to make certain they are complete. At the end of the field day, data are transferred electronically through an automated process from the Pocket PC to an Access database located on the desktop computer. Once the data have been transferred, the field crew should compare the hardcopy datasheets to the forms in the Access database to make sure they match. Errors should be corrected immediately following the process outlined in SOP #6: Data Collection and Entry. At the end of a park-specific sampling trip, it is the responsibility of the field crew to transfer all data (databases, datasheets, GIS layers, pictures, and metadata) to the Crew Lead. It is the Crew Lead's responsibility to follow the data management methods and guidance outlined in the KLMN Data Management Plan and SOP #9: Databases, prior to transferring products to the Data Manager following methods in SOP #8: Data Transfer, Storage, and Archiving.

KLMN INVASIVE MONITORING PROJECT

Date:__________________________________
(YYYYMMDD)

Site Type Infestation / Random
(Circle One)

Is this a Randomly Selected Infestation site? Yes / No
(Circle One)

GPS Unit Trimble XM / Trimble XT / Garmin 76CSx / Other
(Circle One)

Accuracy: **Trimble PDOP:** __________ **Garmin Ept:** ________ **ft**

Lat: **Long:**

Park Unit: ____

Trail / Road/ Power Line:____

Segment: Seg 1 / Seg 2 / Seg 3 / Seg 4 / Seg 5 / Seg 6
(Circle One)

Crew:____
(Last Name, First Name)

Data Recorder:____
(Last Name, First Name)

Scientific Name:____

Infestion %______________ **Infestation distance (m)**______________
(% of plot)

Infestation Size: < 1 sq meter / 1 - 25 sq meter / >25 sq meter
(Circle One)

Phenology: Bolting / Bud / Dead / Flowering / Mature / Rosette / Seed Set / Seedling
(Circle One)

Infestation controled Y/N

Macro Position

Top = apex, hill, or ridge top.• **Up** = upper 1/3 of a hillslope.
• **Mid** = middle 1/3 of a hillslope.• **Low** = lower 1/3 of a hillslope.• **Bot** = bottom of a hillslope adjoining a valley

Micro Position
Convex• Concave• Straight• Undulating

Plot Slope:________ % **Plot Aspect**:_______ Degrees

Hydrology: Flooded Perm-Semi perm/ Seasonally-Temporary /Seep / Upland
(Circle One)

Land Use:	Cultivated / Campground / Ditch / Graded / Pasture / Logging / Mining / Homestead / Roads /Burn		
Evergreen: _______ %		**Deciduous:** _________ %	
Herbaceous: _______ %		**Shrub:** _________ %	
Woody Debris:_______ %		**Litter:** _________ %	
Bare Ground: _______ %		**Light Index:** _________ %	
Soil Disturbance:_____________%		**Surface water %**_____________	
Avg Height of canopy species (m)____________		.5-5;5.1-10;10.1-20;20.1-30;>30	
Red = All Infestation, **Bold = Random Selection**		Page ______ or _____ for Trail	

KLMN INVASIVE MONITORING PROJECT
Comments About the Visit to the Segment
•

•

Figure 2. The invasive species early detection field datasheet.

Invasive Plants, Adaptive Sampling Early Detection Protocol

Standard Operating Procedure (SOP) #6: Data Collection and Entry

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the process for collecting data in the field, uploading the data to the project database, and validating and verifying the data. Prior to implementing this SOP, you should have already read and followed the processes outlined in SOP #4: Setting up the Electronic Field Equipment. You should also be familiar with SOP #9: Databases.

Responsibilities

It is the responsibility of the Crew Lead to make certain field crews have all necessary equipment and field forms to help when collecting data. The Crew Lead should work closely with the Data Manager to develop a 1-2 day training session on how to use the data collection equipment. It is the Crew Lead and field crew members' responsibility to follow all validation and verification process when collecting data.

Understanding ArcPad

Field data collection for this protocol is done using a mobile mapping technology. Trimble Pocket PCs with ArcPad are used to record information while in the field. This information is then loaded into a Microsoft database, where it goes through validation and verification processes and is eventually loaded into the master database. In order to be able to properly collect the data while in the field, field crews will need to understand the basics of ArcPad. This section provides some of the details about the tools available in ArcPad. Field crews will gain a more in-depth knowledge of this hardware and software during the 2-day training session (SOP 3: Observer Training).

The ArcPad project that is used for this project has three main toolbars: the main toolbar (Figure 1), browse tool bar (Figure 2), and the drawing toolbar (Figure 3). The main toolbar is used to open or save a project, create a new shapefile, add shapefiles, set the properties of shapefiles, activate the GPS, set the properties of the project, and provide some general help. Figure 1 details the general features of this toolbar.

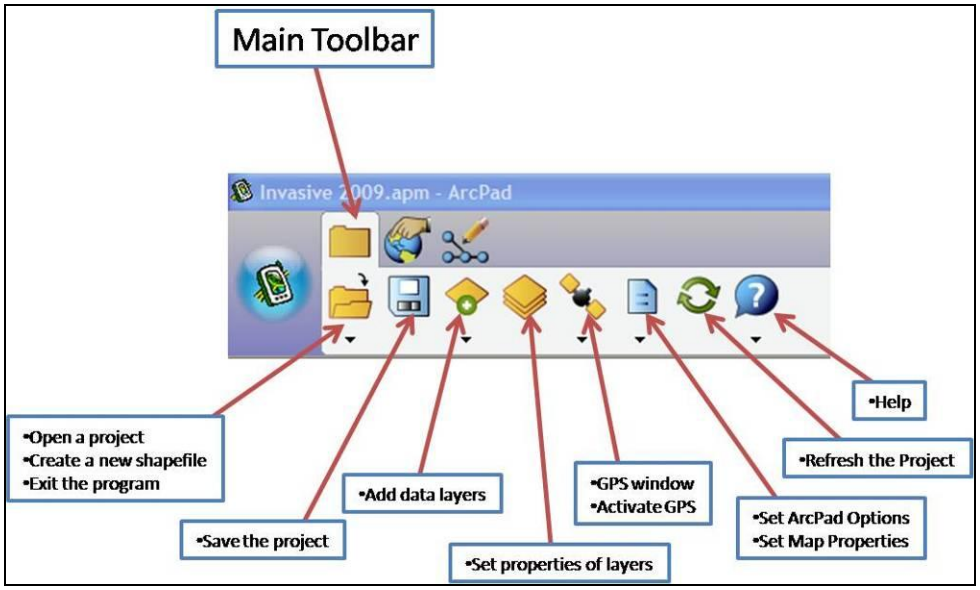


Figure 1. Description of functions available in ArcPad using the main toolbar.

The browse toolbar is used to navigate around the map. The tools available in this toolbar allow you to zoom in and out, pan, zoom to a previous view, identify an item, find an item, measure a distance, set a bookmark, and clear a selected feature. Figure 2 details the general features of this toolbar.

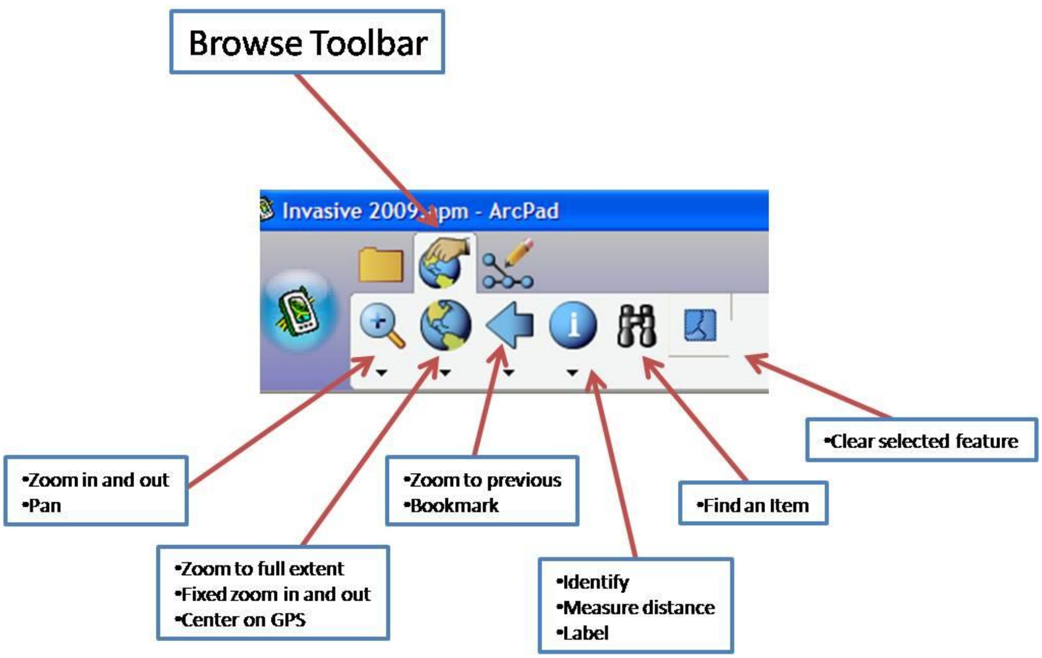


Figure 2. General features available on the browse toolbar in ArcPad. The drawing toolbar is used to select shapefiles to edit, draw a feature, capture a GPS location, offset a GPS location, and edit the attributes of a feature. Figure 3 details the general features of this toolbar.

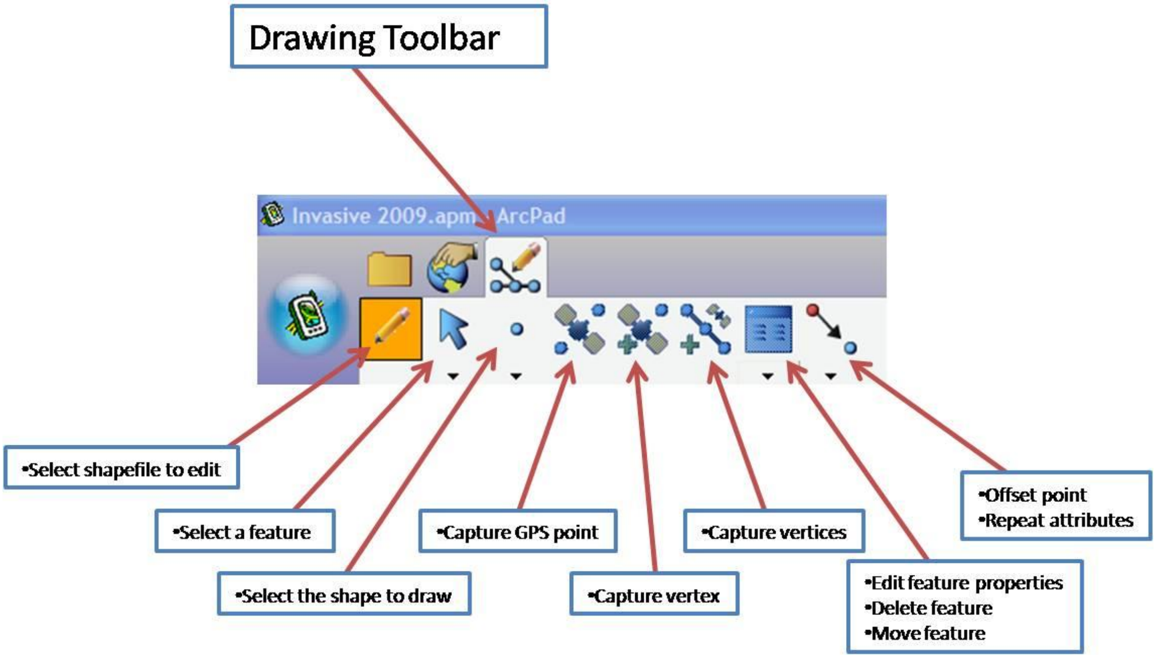


Figure 3. General features available on the drawing toolbar in ArcPad.

Data Collection

Now that you know the basics of ArcPad, you are ready to collect data. Once you have navigated to the start of the site you are surveying, you should follow the steps listed below to collect the project data.

Opening the Project File in ArcPad

A. When you arrive at the start of the site, turn on the Trimble unit by clicking the [**green**] button on the bottom of the unit. If the cover page shows general contact information, tap anywhere on the screen.

B. Tap the word [**GPS**] at the bottom, right side of the screen.

C. Be patient while ArcPad opens.

1. The program is set up to directly take you to a list of projects, select [**Invasive XXXX.apm**] from the list where the "XXXX" is the current year (Figure 4). Once selected, click the [GO] button at the bottom of the screen.
2. If the list of projects does not open, go to step D. If you were able to select the project, go to step E.

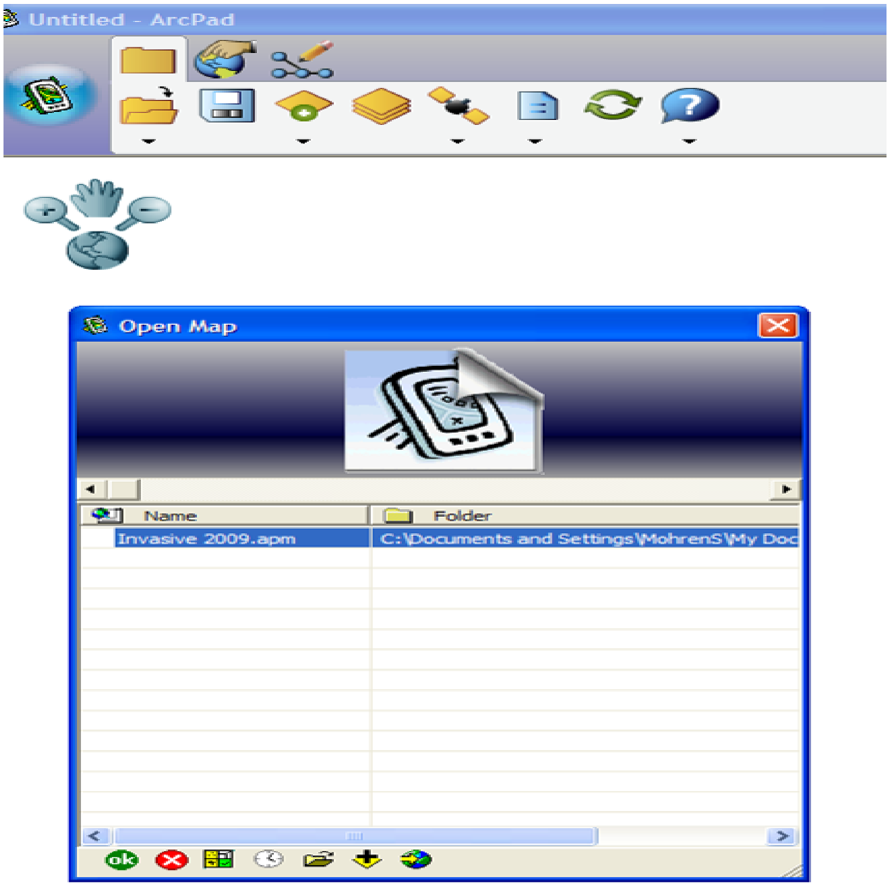
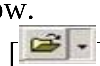


Figure 4. Selecting the project file on the Trimble unit to begin entering data.

D. If the list of projects did not open, then you will need to manually find and select the project by following the steps below.
   1. Tap the small arrow next to the [] button at the top of the screen.
   2. Tap [Open Map 

].
   3. You should see the Invasive_XXXX.apm file, Tap the file twice to open it.

E. When the project opens, it should have loaded the data shapefiles and background shapefiles (roads, trails, start points, etc.). In addition, the GPS should already be turned on and the unit should begin acquiring satellites. If it does not, you will need to activate the GPS by following the steps below and looking at Figure 5.
   1. under the satellite icon, select [**GPS ACTIVE**]

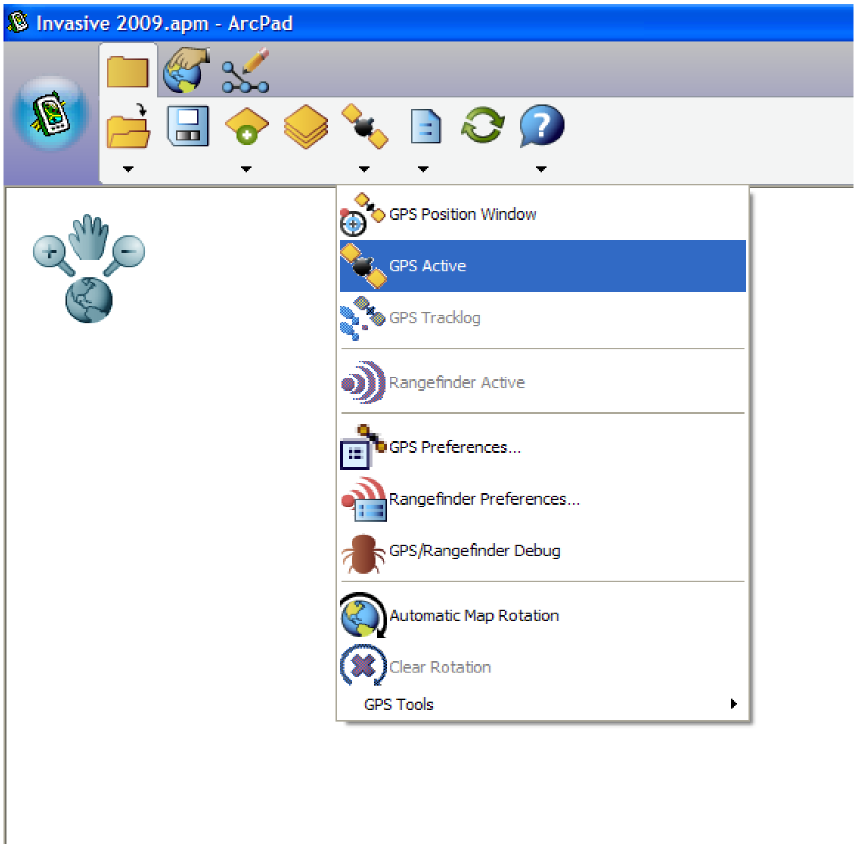


Figure 5. Activating the GPS unit so it will begin to acquire satellites.

F. Now you can add the background imagery. Note: You do not need to do this step; it is personal preference whether you want to use imagery or not.

1. Tap the [**Layers** ] button, under the invasive folder, you should see five files (Invasive XXX.apm, Backup_Files, Data,Images, Shapefiles).
2. Open the Image file and check the images you want to add. Please note it is the responsibility of the Crew Leader to ensure these files are available.
3. Once you have checked the files, tap the green [**OK**] button at the bottom of the screen.
4. Tap the [**World**] button to zoom to the park boundary.

Recording the Start Date and Time

A. When you are ready to begin surveying the route, you will need to record the start time. To do this task, follow these steps.

1. Zoom into the beginning of the route you are about to survey.
2. Under the drawing tool, activate the "DateTime.shp" shapefile by taping the shapefile under the start/stop editing tool (Figure 6).
3. Once you have selected the DateTime shapefile select the "Capture Vertex" button and chose [**Point**].

4. Using the stylus, draw a new point as close to the start of the transect as possible. Please note, this point does not need to be precise and time should not be spent making it

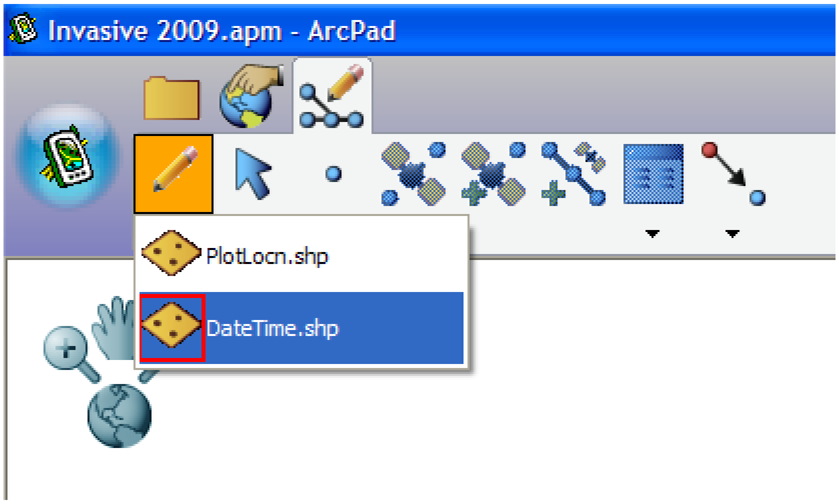


Figure 6. Activating the DateTime shapefile so you can enter the start and end date and time.

5. When you enter a new point, a form should open (Figure 7). This form has three tabs which need to be populated. To populate this form, follow the steps below.
   a. Using the pick list, enter the name of the [**Park**].
   b. Using the pick list, enter the name of the [**Route**].
   c. Click the Date/Time tab at the top of the screen.
   d. The day one start date should be automatically populated with today's data. However, you still need to check the box next to the date or use the dropdown arrow which will open a calander and allow you to enter a different date.
   e. Enter the starting time in military format with no colons (e.g., 0825, 1215, 2244).
   f. Click the green [**OK**] button at the bottom of the screen. Do not worry about the end time or the Day Two information. This is discussed later in this document.

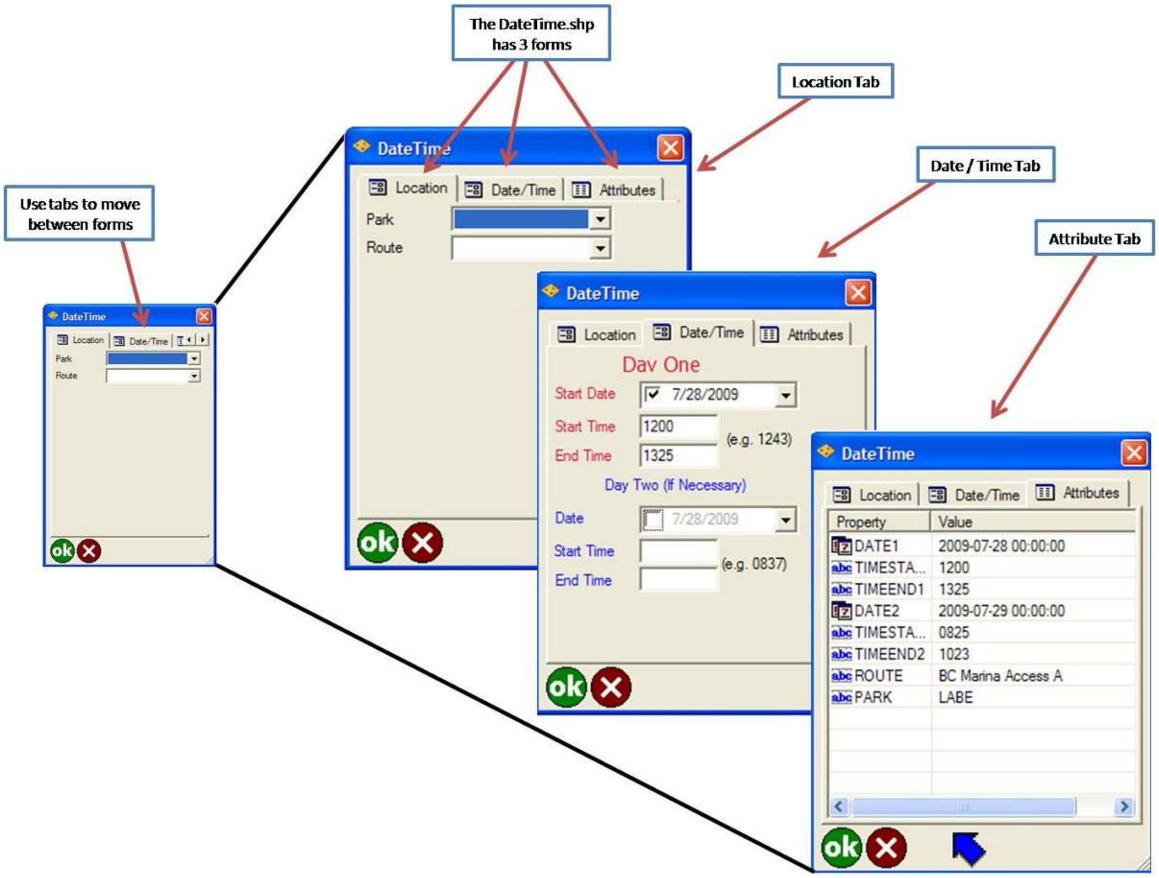


Figure 7. Forms associates with the DateTime shapefile. These forms are used to record the survey date and survey start and end times.

Beginning the Survey

B. You are now ready to start searching for invasive species. Hike along the trail and when you come to an invasive species, complete these following steps.

1. Select the [PlotLocn.shp] shapefile using the same methods as described in Step 2 under the Record the Start Date and Time section of this document.
2. Walk into the middle of the infestation and tap the [**Capture GPS Point**] button under the Drawing Tool (Figure 3). This will open up a form that contains six tabs that will need to be completed (Figure 8). This form is only partially completed at this time. To complete this form, follow these steps.
   a. Using the pick list, select the [**Route**] you are sampling.
   b. Using the pick list, select the [**Segment**] where the species was found.
   c. Select the [**GPS unit**] you are using to record the location information. Note: See the “GPS Capture Issues sections” below for information on EPE fields.
   d. If the Trimble has satellite coverage, the [**PDOP**], [**Latitude**], and [**Longitude**] fields will automatically populate when you close the form.
   e. Select the Species tab and use the pick list to enter the [**Encounter Class**]. There are two possible values:
      (a) Infestation = A weed location
      (b) Random = A random plot

f. Use the pick list to enter the [**Vegetation**]. There are two possible values:
   (a) Yes = Vegetation data was collected at this site.
   (b) No = Vegetation data was not collected at this site.
g. Using the pick list, select the [**Species**] you have observed.
h. Using the pick list, select the dominant [**Phenology**] of the invasive species. There are eight possible options.
   (a) Bolting
   (b) Bud
   (c) Dead
   (d) Flowering
   (e) Mature
   (f) Rosette
   (g) Seed Set
   (h) Seedling
i. Using the laser range finder, enter the [**Distance**] from the route to the center of the infestation in meters.
j. Estimate the [Size] of the infestation and use the pick list to enter the appropriate size. There are three size classes.
   (a) <1 square meter
   (b) 1-25 square meters
   (c) >25 square meters
k. Select the CREW TAB and use the pick list to enter the name of the person recording the data on the Trimble unit.
l. Use the pick list to enter the next most qualified crew member under the [**Crew 1**] field.
m. Use the pick list to enter the next most qualified crew member under the [**Crew 2**] field.
n. Skip the habitat tabs and select the TREATMENT TAB. Enter Yes or No if the site was treated.
o. Since you have not done your random selections yet, set the [**Randomly Selected**] field to NO.
p. Click the ATTRIBUTE tab and review the information you entered. This is one of the validation steps the crew is responsible for and should not be glossed over.
q. Once you have reviewed the information, click the green [**OK**] button at the bottom of the screen.
r. You can now move on and search for more infestations. Repeat this process until you have reached the end of the survey.

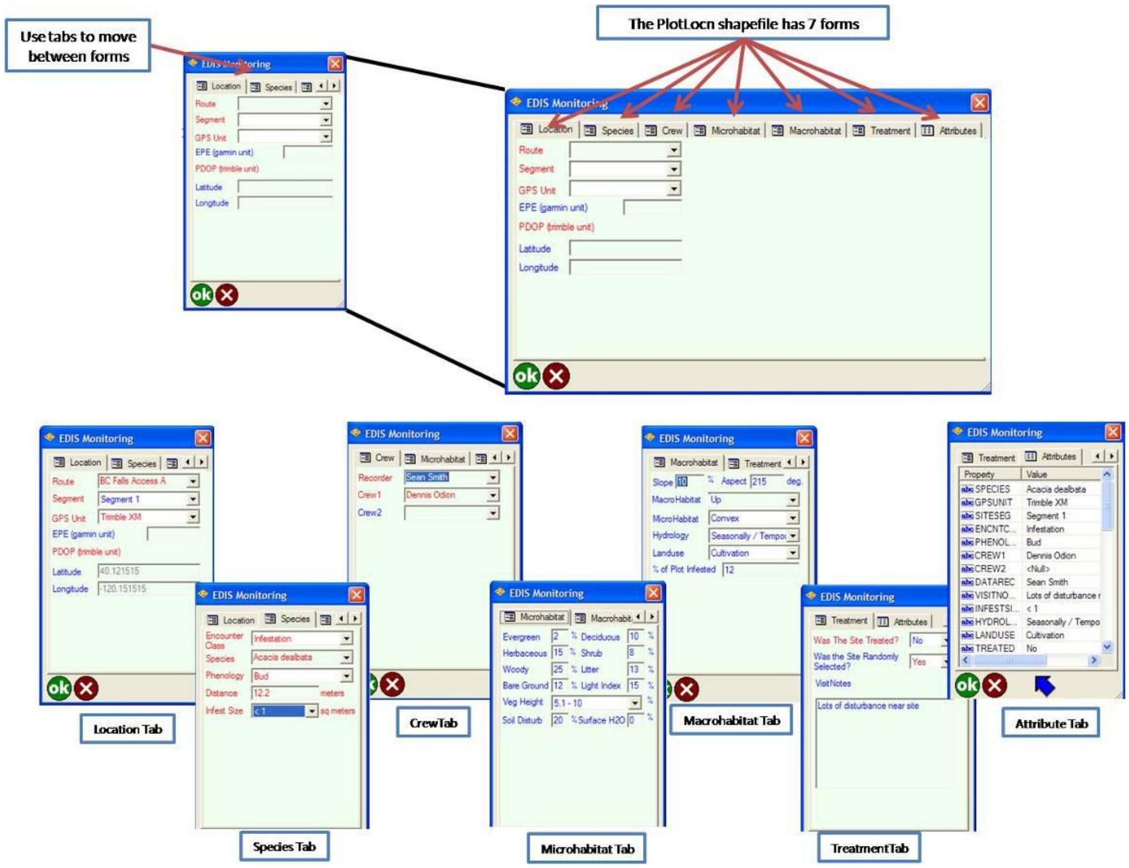


Figure 8. Forms associated with the PlotLocn shapefile. These forms are used to enter vegetation data associated with a random site or infestation.

Collecting Habitat Parameters

C. Now that you have found all the infestations along the trail, you will need return to the random sites and selected infestation sites to collect habitat data. To complete this process, follow the steps below. Steps are slightly different for random sites versus infestation sites because you have already collected some data for the infestation sites.

INFESTATION SITES

1. Under the drawing toolbar, select the [Selection] tool. Make certain you are still editing the [PlotLocn.shp] shapefile and tap on the infestation site where you want to collect additional data.
2. On the toolbar, tab on the [Feature Properties] button and this will bring up the form for the infestation.
3. The data under the LOCATION, SPECIES, and CREW tabs should already be populated so click on the MICROHABITAT tab.
4. Enter the estimated percent cover for all the fields listed below.
    a. **Evergreen Cover**
    b. **Deciduous Cover**
    c. **Herbaceous Cover**
    d. **Shrub Cover**
    e. **Woody Debris Cover**

    f. **Litter Cover**
    g. **Bare Ground Cover**
    h. **Light Index**
5. Using the pick list, select one of the [**Veg Height**] classes. There are five potential classes.
    a. 0.5-5 meters
    b. 5.1-10 meters
    c. 10.1-20 meters
    d. 20.1-30 meters
    e. >30 meters
6. Enter the estimated percent cover for the remaining fields listed below.
    a. **Soil Disturbance**
    b. **Surface Water**
7. Select the MACROHABITAT TAB and enter the following fields.
    a. [**Slope**] as a percent
    b. [**Aspect**] in degrees
    c. Using the pick list, select the [**Macrohabitat**]. This field has five potential values.
        (a) Top
        (b) Up
        (c) Mid
        (d) Low
        (e) Bottom
    d. Using the pick list, select the [**Microhabitat**]. This field has four potential values.
        (a) Convex
        (b) Concave
        (c) Straight
        (d) Undulating
    e. Using the pick list, select the [**Hydrology**]. This field has four potential values.
        (a) Flooded Permanently
        (b) Seasonally / Temporary Flooded
        (c) Seep
        (d) Upland
    f. Using the pick list, select the [**LandUse**]. This field has nine potential values.
        (a) Campground
        (b) Cultivation
        (c) Ditch / Diversion
        (d) Graded
        (e) Homestead
        (f) Logging
        (g) Mining
        (h) Pasture
        (i) Road / Trail
    g. % of plot infested
8. Select the TREATMENT TAB
    a. The [Treatment] field should already be set; change it now if you decided to treat the site.

   b. The [Randomly Selected] field should already be set to "NO," since you did select this site you will need to change this to "YES."
   c. Enter any [Visit Notes].
9. Click the ATTRIBUTE TAB and review the information you entered.
   a. All the fields should be complete at this point (with maybe the exception of the notes field). This is one of the validation steps the crew is responsible for and should not be glossed over.

RANDOM SITES

1. Select the [PlotLocn.shp] shapefile using the same methods as described in Step 2 under the *Record the Start Date and Time* section of this document.
2. Walk into the middle of the random plot and tap the [**Capture GPS Point**] button under the Drawing Tool (Figure 3). This will open up a form that contains six tabs that will need to be completed. To complete this form, follow these steps.
   a. Using the pick list, select the [**Route**] you are sampling.
   b. Using the pick list, select the [**Segment**] where the species was found.
   c. Select the [**GPS unit**] you are using to record the location information. Note: See the "GPS Capture Issues sections" below for information on EPE fields.
   d. If the Trimble has satellite coverage, the [**PDOP**], [**Latitude**], and [**Longitude**] fields will automatically populate when you close the form.
   e. Select the Species tab and use the pick list to enter the [**Encounter Class**]. There are two possible values:
      (a) Infestation = A weed location
      (b) Random = A random plot
   f. Use the pick list to enter the [**Vegetation**]. There are two possible values:
      (a) Yes = Vegetation data was collected at this site.
      (b) No = Vegetation data was not collected at this site.
   g. Using the pick list, select the [**Species**] you have observed.
   h. Using the pick list, select the dominant [**Phenology**] of the invasive species. There are eight possible options.
      (a) Bolting
      (b) Bud
      (c) Dead
      (d) Flowering
      (e) Mature
      (f) Rosette
      (g) Seed Set
      (h) Seedling
   i. Using the laser range finder, enter the [**Distance**] from the route to the center of the infestation in meters.
   j. Estimate the [Size] of the infestation and use the pick list to enter the appropriate size. There are three size classes.
      (a) <1 square meter
      (b) 1-25 square meters
      (c) >25 square meters
   k. Select the CREW TAB and use the pick list to enter the name of the person recording the data on the Trimble unit.

    l. Use the pick list to enter the next most qualified crew member under the [**Crew 1**] field.
    m. Use the pick list to enter the next most qualified crew member under the [**Crew 2**] field.
3. Click the MACROHABITAT TAB and enter the estimated percent cover for all the fields listed below.
    a. **Evergreen Cover**
    b. **Deciduous Cover**
    c. **Herbaceous Cover**
    d. **Shrub Cover**
    e. **Woody Debris Cover**
    f. **Litter Cover**
    g. **Bare Ground Cover**
    h. **Light Index**
4. Using the pick list, select one of the [**Veg Height**] classes. There are five potential classes.
    a. 0.5-5 meters
    b. 5.1-10 meters
    c. 10.1-20 meters
    d. 20.1-30 meters
    e. >30 meters
5. Enter the estimated percent cover for the remaining fields listed below.
    a. **Soil Disturbance**
    b. **Surface Water**
6. Select the MACROHABITAT TAB and enter the following fields.
    a. [**Slope**] as a percent
    b. [**Aspect**] in degrees
    c. Using the pick list, select the [**Macrohabitat**]. This field has five potential values.
        (a) Top
        (b) Up
        (c) Mid
        (d) Low
        (e) Bottom
    d. Using the pick list, select the [**Microhabitat**]. This field has four potential values.
        (a) Convex
        (b) Concave
        (c) Straight
        (d) Undulating
    e. Using the pick list, select the [**Hydrology**]. This field has four potential values.
        (a) Flooded Permanently
        (b) Seasonally / Temporary Flooded
        (c) Seep
        (d) Upland
    f. Using the pick list, select the [**LandUse**]. This field has nine potential values.
        (a) Campground
        (b) Cultivation

(c) Ditch / Diversion
(d) Graded
(e) Homestead
(f) Logging
(g) Mining
(h) Pasture
(i) Road / Trail

g. % of plot infested

7. Select the TREATMENT TAB
   a. Select Yes or No if you did or did not [**Treat**] the site.
   b. Select Yes under the [**Randomly Selected**] field because this was a randomly selected site.
   c. Enter any [**Visit notes**].
8. Click the ATTRIBUTE tab and review the information you entered. This is one of the validation steps the crew is responsible for and should not be glossed over.
   a. Once you have reviewed the information, click the green [**OK**] button at the bottom of the screen.
   b. You can now move on to the next location where you plan on collecting habitat data.

Completing the Survey – END TIME

D. You have now completed collecting data for all the infestation and random plots that you selected. Once you are back at the vehicle, you will need to record the end time of the survey. To do this, follow these steps.
   1. Make certain you are editing the "DateTime.shp" shapefile.
   2. Under the drawing toolbar, select the "Select Arrow."
   3. Tap on the dot that you drew at the beginning of the survey.
   4. Tap on the "Feature Properties" button and this will open up the forms.
   5. The [Park] and [Route] fields should already be populated so click on the DATE / TIME TAB.
   6. The start date and start time should already be populated. All you need to do is enter the end time in the proper format.
   7. Once complete, click the green [OK] button at the bottom of the screen.
   8. You are now done with this survey and can return back to the vehicle.

Surveys that Take Two Days

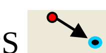
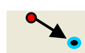
E. In most cases, surveys can be completed in 1 day. However, if a survey does take more than a day, you will need to add the date, start time, and end time for the second day. To do this, follow these steps.
   1. Make certain you are editing the "DateTime.shp" shapefile.
   2. Under the drawing toolbar, select the "Select Arrow."
   3. Tap on the dot that you drew at the beginning of the survey the previous day.
   4. Tap on the "Feature Properties" button and this will open up the forms.
   5. The [Park] and [Route] fields should already be populated so click on the DATE / TIME TAB

6. The day two start date should be automatically populated with today's data. However, you still need to check the box next to the date or use the dropdown arrow which will open a calendar and allow you to enter a different date.
7. Enter the starting time in military format with no colons (e.g., 0825, 1215, 2244).
8. Complete the survey as described above.
9. Once done with the survey, under the drawing toolbar, select the "Select Arrow."
10. Tap on the dot that you drew at the beginning of the survey the previous day.
11. Tap on the "Feature Properties" button and this will open up the forms.
12. All fields should already be populated so all you need to do in enter the [End Time] for the second day.
13. Once complete, click the green [OK] button at the bottom of the screen.
14. You are now done with this survey and can return back to the vehicle.

Cannot Capture Satellites Using the Trimble Unit

F. In a few cases, you may not be able to get good enough satellite coverage while standing in the middle of the random or infestation plot. There are two options at this point. The preferred option is to do an offset using the Trimble unit. The other option is to get the coordinates from the Garmin unit and then enter them into the Trimble unit. To do this, follow these steps.

Using an offset

1. If you cannot get a GPS signal, you need to use the Offset GPS  button.
    a. Stand in an open area where you can get a GPS signal and can see the center of the weed infestation.
    b. Click the [**Offset GPS** ] button.
    c. Click the [**Capture GPS Point** ] button.
    d. Look through the eyepiece of the rangefinder, make sure SD is selected at the bottom of the rangefinder screen, hold down the fire button, and remember the distance.
    e. Use your compass to get a bearing from the location you are standing to the location of the weed.
    f. Enter the bearing (from your compass) and the distance (in meters) from the rangefinder to the center of the infestation then click [**OK**] in the bottom right side of the screen.
2. If you still cannot get coverage, add the background NAIP imagery.
    a. Click the [**Draw Point**] button.
    b. Using the stylus, add a point to the map as close as possible to your known location.
    c. When the Occurrence form opens, enter the coordinates from the Garmin unit into the proper latitude and longitude fields. Be sure to list "Garmin" in the GPS unit field on the field form.
3. If you cannot get satellite coverage with the Trimble OR Garmin unit, then follow steps 2 a and b, above. Just leave the hand drawn coordinates and be sure to list "Hand Drawn" in the GPS unit field.

Returning from the Field

Uploading the Data

Once you have collected the data in the field, you need to upload the data to the project database and validate the data to ensure their accuracy. To upload the data, open the project database on the laptop computer and place the Trimble unit into the cradle. Make sure ActiveSync begins to run and recognizes the handheld unit. Now follow the steps below to copy the data from the Trimble unit into the Access Database.

A. Open up Microsoft Windows Explorer and go into the Mobile Device folder.
B. Go to the Invasives folder on the Trimble unit and copy the [Data] folder.
    1. To copy, right click on the folder and select copy.
C. Paste the folder in the Invasives_XX_XX (XX are the initials of the field crew)/GIS_Data/Backup/YYYYMMDD. Where YYYYMMDD is the name of a new folder you create named using the date you downloaded the data.
    1. To create the new folder, open up the backup folder and right click.
    2. Select new folder and then name the folder with today's date in the format YYYYMMDD.
D. Go to the Invasives_XX_XX/GIS_Data/Template folder and copy all the files in this folder and paste them on the Trimble unit at Invasives/data folder. It will ask you if you want to do a replace; say yes. NOTE: This will erase any data on the Trimble Unit, so be sure you have properly completed steps A-C.
E. Open the project database, which is located on your desktop in the Invasives_XX_XX/Project_Database folder.
F. Click the [Administrative Tools] button and then click the [Data Upload] button.
G. Using the browers, browse to the DateTime.shp and PlotLocn.shp files you placed in the GIS folder in step C above. Then click the [Load Data] button.
H. Click the [Click to Open QA/QC Report] button.
I. Address any issues that were identified by the program (see QA/QC section below).
J. Close the QA/QC report and click the tab called [Step 3: Upload Data].
K. Click the [Click to Complete the Upload Process].
L. Your data should now be uploaded to the database.

Entering Hardcopy Datasheets

In some cases, issues with the Trimble unit may prevent collecting data electronically. In this instance, you will need to use the hardcopy datasheet and enter the record into the project database by hand. This should be done as soon as you return from the field each night, unless otherwise directed. To enter the data into the project database, follow the steps listed below.

A. Open the project database located on your desktop at: Invasives_XX_XX/Project_Database.
B. Click the [Enter/Edit Data] button.
C. Complete the User Information as directed on the form and the select [OK].
D. The filter is already turned on, so set the [Park] field to the name of the park where you collected the data you want to enter.
E. Click the [Add New Record] button at the top of the form.
F. Since this is a new location, click the [Add New] button next to the location field.
G. Complete ALL fields on the location form and the select the [Close] button.

H. Complete the Protocol Name, Start Date, Start Time, End Time fields.
I. If there was a 2nd start date, enter this along with the appropriate times.
J. Enter any visit information, if necessary.
K. Using the picklist, enter the names of all the crew members and their roles. Keep in mind the person who recorded the data is the "Recorder" and all others are "Crew Members."
L. In the middle of the form, make sure the MACRO HABITAT TAB is selected and complete all the fields on this form.
M. Next, click the MICRO HABITAT TAB and complete all these fields.
N. Once done, either click the [New Record] button if you have another record to enter or click the [Close] button if you are done entering data.
O. If you are done, you should now see the record in the list of records on the Data Gateway form. Click the [Close] button on this form.
P. When you are done adding records or editing a record, click the [Back up data] button. A message will appear asking you if you want to backup the database; click [YES].
Q. In the project folder on your desktop browse to Invasive_XX_XX/Project_Database/Backup and save a copy of the database. Be sure to use the default name.
R. Close the database. You are done.

Verifying the Data

Now that you have loaded the data into the database, you need to go into each record in the database and make sure they match the hardcopy forms. If no hardcopy forms are available, you still need to review the data to make certain all the fields have been populated. To do this, follow the steps listed below:

A. If the database is not already open, open the project database located on your desktop at: Invasives_XX_XX/Project_Database.
B. Click the [Enter/Edit Data] button.
C. Complete the User Information as directed on the form and the select [OK].
D. The filter is already turned on, so set the [Park] field to the name of the park where you collected the data you want to enter. You should now see a list of all the sites (infestations and random sites) located in the database.
E. Double click on the visit date for a record will open the record.
F. Review all the fields on the form including the three tabs in the middle of the form. Make revisions as necessary.
G. Close the form and repeat steps E-G until all the records have been reviewed.
H. If changes were made, make a backup of the database following steps P-R in the section above.

You are now done verifying the data and it is ready to be reviewed by the Project Manager and/or the Crew Leader.

NOTE: If you have followed the steps above, you now have black shapefiles on your Trimble unit and a clean, verified dataset on your laptop computer. Do not put old shapefiles on the Trimble unit because they will contain data that have not been reviewed.

Validating the Data

Once the field crew has finished sampling a park, and if there are multiple crews, the Crew Lead should collect each database and give it to the Data Manager. The Data Manager will combine the databases and provide the Crew Lead with one database that contains all the data from that park. The Crew Lead is responsible for another round of data validation and verification. The Crew Lead should examine the digital records and compare them to the hardcopy forms. Errors should be addressed immediately. If they cannot be addressed, they should be documented explaining the error. Errors on datasheets should be corrected using a red pen. In addition to the database, the Crew Lead should look at the data in the database and by using ArcGIS to make sure the data make sense and “look” correct (sites are in the correct spots, no outliers, etc.).

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #7: Photo Management

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP includes instructions for managing photos taken for this monitoring protocol. This document covers photographic images collected by the Crew Lead and field crew during the course of conducting project-related activities.

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

1. To document a particular feature or perspective for the purpose of site relocation.
2. To capture site habitat characteristics and to indicate gross structural changes over time.
3. To document species detection.
4. To document field crew activities during surveys and site set-up.

It is the responsibility of the Crew Lead to ensure that images are properly named and stored in the correct location along with the image metadata as described below. Photographs are not a required component of this protocol (unless used to help voucher species); however, the KLMN utilizes a variety of photographs in their outreach and training materials. Efforts should be made to periodically photograph field crews implementing the protocol. In addition, photographs are a great way to document the discovery of rare species or unique features.

Camera Set-up

The KLMN does not standardize on a specific camera type. However, most cameras have similar generalized functions that need to be checked on a regular basis. Some are:

1. *Date and Time* – It is important to make sure the date and time are accurate on your camera prior to going into the field. The date and time are embedded in the header file of a JPEG and will be used to check the date and time reported in the metadata. A good rule of thumb is to synchronize your camera with your GPS unit.
2. *Naming* – Many cameras can be set to automatically name photographs. Depending on the brand of camera, photographs can be automatically named using several methods,

including sequential order starting each time a memory card is formatted, sequential order which loops from 0001 to 9999, or a date-photo sequence. The Network prefers the date-photo sequence method as the primary method to name photographs.

3. *Ricoh Camera* – If you are using a Ricoh GPS Camera, be sure to work with the Data Manager for additional training on how to set up and use this camera.

File Structure Set-up

Download and Processing Procedures

Any crew member who takes data photos should complete the following procedures for downloading and processing those photographs.

1. A folder entitled "Photographs" should be located in the field project folder on the technician's laptop computer (SOP #4: Setting up the Electronic Equipment).
2. Create a folder inside the photographs folder with the date you are downloading the images. In this folder, create two more folders and entitle them "Raw" and "Final."
3. Download the raw, unedited images from the camera into the "Raw" folder.
4. Make a copy of all the images and paste them into the "Final" folder. Be sure to make a copy of this folder and place the images on a disk if you want them for your personal interest.
5. In the "Final" folder, delete all bad and personal photographs.
6. Complete a record in the Excel image metadata table for each image in the "Final" folder. A blank image metadata table should be located in the photographs folder. In addition, a copy can be obtained from the KLMN Internet web sites or by contacting the KLMN Data Manager. An example of the metadata table is included at the end of this SOP.

Deliver Image Files for Final Storage

It is the Crew Lead's responsibility to compile all images into a common set of folders and to transfer processed images and metadata (Table 1) to the KLMN Data Manager (SOP #8: Data Transfer, Storage, and Archive).

To transfer images from computers and to transfer the compiled set of images to the KLMN Data Manager, copy the folder for the appropriate year and all associated sub folders and images onto a CD or DVD for delivery. These files will be stored in the Invasive Species_Image folder, a sub folder of the Invasive Species Monitoring folder located on the Klamath Network server. Metadata for the images will be loaded into the KLMN Image Database, which is linked to the photographs in the project image folder. Images and metadata will be backed up and archived following the methodologies outlined in the Klamath Network Data Management Plan.

Table 1. Required metadata table for all images.

*Park Code	*Network Code	Project	*Photo Name	*Date	*Photographer	Site Name	*Description	UTM East	UTM North	Datum	*Category Folder	*Ext.	*Rights	Collection	Publisher	Resource Type
	KLMN	Invasive species								NAD 83 Zone 10		.jpg	Public	KLMN	NPS	Image
	KLMN	Invasive species								NAD 83 Zone 10		.jpg	Public	KLMN	NPS	Image
	KLMN	Invasive species								NAD 83 Zone 10		.jpg	Public	KLMN	NPS	Image
	KLMN	Invasive species								NAD 83 Zone 10		.jpg	Public	KLMN	NPS	Image

1) * Required fields.
2) Populated fields are populated with their default values as shown above.
3) Fields include:

Park Code – CRLA, LABE, LAVO, ORCA, REDW, WHIS
Network Code – KLMN
Project – Name of the project in which you are working
Photo Name – Name of the photograph, do NOT include the extension
Date – Date the photograph was taken in the format MM/DD/YYYY
Photographer - The name of the person who took the photograph
Site Name - If you are at a site, provide the name of the route.
Description – A DETAILED description of the photograph, including the name of the site, if applicable
UTM East and North – The UTM coordinates where the picture was taken, if applicable
Datum – The datum and zone for the UTM coordinates. The default is NAD 83 Zone 10
Category Folder – The name of the folder where the picture is being stored
Ext. – The extension; the KLMN requires photographs to be in jpeg format
Right – Generally, rights are “Public”
Publisher – Owner of the photograph, usually NPS
Resource Type – What is it? Image, PPT, Graphic; usually Image

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #8: Data Transfer, Storage, and Archive

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedures for the transfer of invasive species data and information to the Network Data Manager. In addition, data certification, storage, archiving, and a timeline for project deliverables are addressed.

Data Transfer

All project deliverables, including but not limited to raw data, processed data, Metadata Interview Forms, updated data dictionary (if necessary), images with metadata, training logs, datasheets, spatial files, and Certification Forms will be transferred to the KLMN Data Manager following the timeline listed in Table 1. Ultimately the Project Lead is responsible for delivery of these projects.

Pre-Season Information

At least 3 weeks prior to the start of the field season, the Crew Lead needs to provide the Data Manager with the following: (1) contact information for each person conducting field work (first and last name, position, mailing address, work number, email address), (2) a GIS layer of all the site being visited that year (broken down into 3 km and 500 m segments), and (3) a list of the plants being surveyed that year (scientific name, common name, and family). The Crew Lead will need to work closely with the GIS Specialist to develop a shapefile of the routes and subsegments that will be sampled that year. It is the GIS Specialist's responsibility to ensure the shapefiles are properly named and field use the same names as previous years.

Certification Form

The Klamath Network utilizes a Certification Form for all products developed following this protocol. The form should be submitted to the Data Manager by the Crew Lead to ensure that:

1. The data are complete for the period of time indicated on the form.

2. The data have undergone the quality assurance checks indicated in the Invasive Species Monitoring Protocol.
3. Metadata for all data have been provided (when applicable).
4. Project timelines are being followed and all products from the field season have been submitted.

A new Certification Form should be submitted each time a product is submitted. If multiple products are submitted at the same time, only one Certification Form is needed for those products. Certification Forms can be obtained from the KLMN Internet and Intranet web sites or by contacting the KLMN Data Manager. An example of the Certification Form is included at the end of this SOP.

Field Forms

Hardcopy datasheets will be provided to the Data Manager following the target timelines in Table 1. The datasheets should be checked for errors or missing information prior to transferring them to the Data Manager. It is the responsibility of the Data Manager to scan the datasheets into a PDF document within 1 month of receiving the hardcopies. The datasheets will be organized by park, site, and then by date.

The scanned document will be named with the park and the year in which the data were collected. For example, the scanned document associated with Redwood would be named Invasive_Datasheets_Redwood_2007.

Electronic files will be stored at:
G:\Monitoring\Invasive_Species_Monitoring\ISED_Data\Datasheets\Seasonal_Data\YYYY on the KLMN server. Additional details on storage methods are described below.

Databases

This protocol will use an integrated system of hardware and software that works to simplify the collection and management of invasive plant data. The central piece of this system is a relational MS Access database ("the database") that works to keep track of all invasive species' occurrences, survey information, vegetation plots, and treatments for invasive species in a defined area. This database is being used in combination with ArcPad (the handheld version of ArcGIS) and a Trimble Pocket PC, which is used to collect the data. At the end of the day, data collected using the Trimble units are uploaded into the Access databases, which are located on a laptop computer. In addition, at the end of the day, GPS files located on the Trimble unit should be copied from the unit and placed in properly named backup folders as described in SOP #6: Data Collection and Entry.

At the end of the field season, the project database will be provided to the Network Data Manager along with Metadata Interview Forms and, if necessary, an updated data dictionary (SOP#11: Metadata Guidelines). It is the responsibility of the Crew Lead to examine each database for accuracy and completeness prior to transferring the database to the Data Manager. Once the database(s) have been transferred to the Data Manager, he/she will run the data through one more round of validation/verification checks and then load the data into a master database that contains all the data from previous years.

GIS Information

At the end of each field season, after the database has gone through the validation and verification process, it is the responsibility of the Data Manager to create shapefiles of the species and vegetation plot locations. The Data Manager should submit the data to the GIS Specialist to be uploaded onto the GIS Server. In addition, the GIS Specialist should work with the Crew Lead to ensure all sites initially planned on surveying were completed. Sites not surveyed should be removed from the final GIS layer. It is the GIS Specialist's responsibility to manage the GIS data and ensure the information is in the proper format, contains metadata, and is stored in the proper location.

Log Books

Log books are used keep track of equipment changes, datasheets, unique events that could affect the data, and staff training. It is the responsibility of the Crew Leader to complete these logs throughout the field season and submit them to the Data Manager following the schedule in Table 1. Completed log books will be stored on the Network server at:
G:\Monitoring\Invasive_Species_Monitoring\ISED_Documents\Log Books\YYYY.

Photos

Images and associated metadata will be transferred to the Data Manager following the timeline in Table 1 and in the format explained in SOP #7: Photo Management. Photographs will remain in the project image folder and metadata will be uploaded to the KLMN Image Database.

Reports

Biennial Reports and Analysis and Synthesis Reports will be developed as part of this protocol. It is the responsibility of the Project Lead to submit each report in the NPS Technical Report Series format, unless utilizing another series format for publication. Reports should be submitted to the Data Manager following the timeline in Table 1. Scientific publications created by Network staff or by any member working under the Invasive Species Monitoring Protocol should be submitted to the KLMN Data Manager upon completion. All reports should be reviewed by the appropriate individuals (SOP #10: Data Analysis and Reporting) before being submitted to the Data Manager.

Data Storage

Project folders have been created for each monitoring protocol the KLMN plans to implement (Figure 1). Project folders contain five standard subfolders using a naming convention that includes the project title and one of the following: Documents, GIS, Data, Images, or Analysis. These five subfolders will contain all the data and information for a project as follows:

a) **Invasive_Documents.** This folder contains the reports, budgets, work plans, emails, protocols, contracts, datasheets, and agreements associated with a specific project.
b) **Invasive_GIS.** This folder contains shapefiles, coverages, layer files, geodatabases, GPS files, GIS/GPS associated metadata, and spatial imagery associated with a project.

c) **Invasive_Data.** This folder contains the KLMN invasive prioritization database and .dbf files from the field database.
d) **Invasive_Images.** This folder contains any photographs related to the project and associated image metadata. In addition, copies of all photographs and metadata will be transferred into the KLMN Image Database. Details on the KLMN Image Database can be found in the KLMN Data Management Plan.
e) **Invasive_Analysis.** This folder will contain derived data and associated metadata created during analysis.

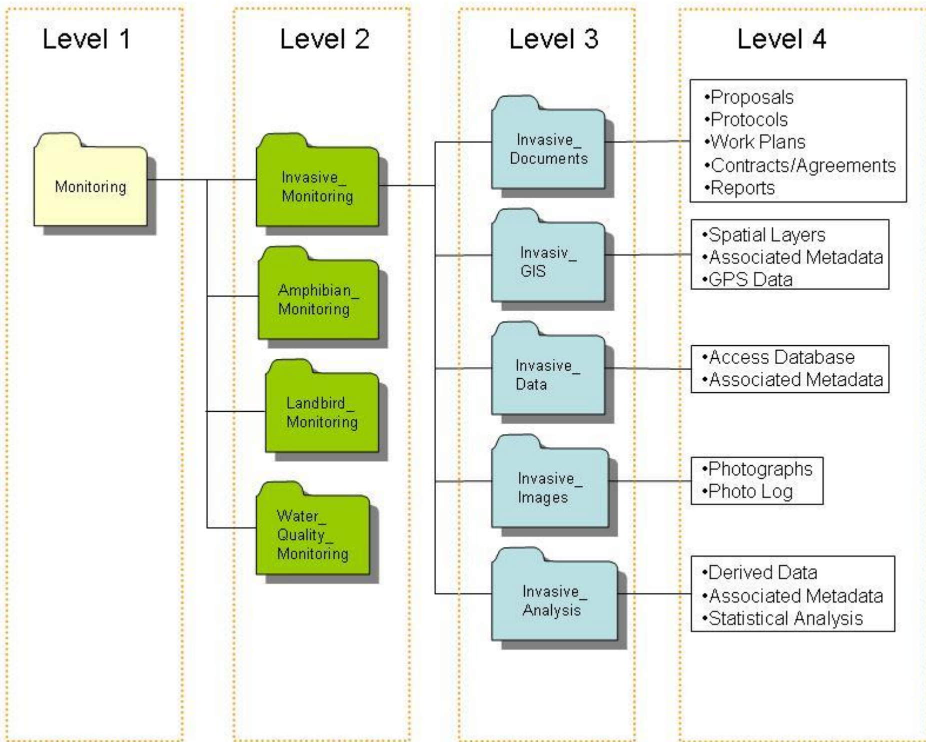


Figure 1. The invasive species file structure the KLMN will use to store all invasive species data and information.

Core Network staff will have read-only access to all final products to prevent changes to the information. If write access is needed, it will be necessary to contact the Network Data Manager. It is the responsibility of all KLMN staff to inform the Data Manager when they have added new material to the project folder.

Storage, Backup, and Archiving

A copy of the project folder will be stored in the KLMN archive drive whenever any new information is added to the folder. The KLMN Archive and Network drives are subject to all backup and archiving processes described in the KLMN Data Management Plan. The KLMN relies on Southern Oregon University (SOU) for the backup and long-term storage requirements. Nightly backups are done by SOU to store information that has been edited. This is not a full backup but is intended to protect products that have been manipulated. This information is stored for a 1 week period before it is recycled. SOU begins a weekly full backup of their servers every Friday and stores the files on tape drives. Backups are stored for 60 days before the tapes are reused. SOU will run quarterly backups on March 31st, June 30th, October 31st, and December 31st of each year. Files stored on a quarterly basis are maintained for 1 year before being recycled (Mohren 2007).

Table 1. Deliverable products, responsible individual, due data, and store location for all products developed while implementing the KLMN Invasive Species Monitoring Protocol.

Deliverable Product	Primary Responsibility	Target Date	Instructions for KLMN
GIS Files of Preliminary Sites	Crew Lead with help from the GIS Specialist	3 weeks prior to beginning the first field season.	Store in Invasive_GIS[5]
Contact Information	Crew Lead	3 weeks prior to beginning the first field season.	Store in Invasive_Document[5]
Priority Species List	Crew Lead	3 weeks prior to beginning the first field season.	Store in Invasive_Data[5]
Metadata Interview Form	Crew Lead	Prior to beginning the first field season and by Feb 1st of the following year when updates occur.	Store in Invasive_Data[5], Use to create and revise full metadata.
Updated Data Dictionary	Crew Lead	Prior to beginning the first field season and by Feb 1st of the following field seasons when updates occur.	Store in Invasive_Data[5], Use to create and revise full metadata.
Full Metadata (Parsed XML)	Network Data Manager	Prior to beginning the first field season and by March 1st of the following field seasons.	Store in Invasive_Data[5], Upload the Parsed XML Record to the NPS Data Store. [2]
Protocol Changes (if made)	Project Lead	Feb 1st of a field season, prior to implementing the change.	Store in Invasive_Document[5], Update Protocol on Websites and NPS Data Store, Send Copy to Parks.
Data Certification Report	Crew Lead	Every time a product(s) is submitted	Store in Invasive_Document.[5]
Field Data Forms	Crew Lead	Oct 1st of the survey year	Scan Original, Marked-up Field Forms as PDF Files and Store in Invasive_Document[5]
Databases	Crew Lead	Oct 1st of the survey year	Store in Invasive_Data[5], Send Copy to Parks
GIS Backup Files	Crew Lead	Oct 1st of the survey year	Store in Invasive_GIS[5]
Training Log Book	Crew Lead	Oct 1st of the survey year	Scan Original, Marked-up Field Forms as PDF Files and Store in Invasive_Document[5]
Datasheet Log Book	Crew Lead	Oct 1st of the survey year	Store in Invasive_Document[5]
Equipment Log Book	Crew Lead	Oct 1st of the survey year	Store in Invasive_Document[5]
Event Log Book	Crew Lead	Oct 1st of the survey year	Store in Invasive_Document[5]
Digital Photographs and Metadata	Crew Lead	Oct 1st of the survey year	Store in Invasive_Image[5], Copies of Photographs in KLMN Image Library, Copies of Image Metadata into KLMN Image Database linked to Photographs

Table 1. Deliverable products, responsible individual, due data, and store location for all products developed while implementing the KLMN Invasive Species Monitoring Protocol (continued).

Deliverable Product	Primary Responsibility	Target Date	Instructions for KLMN
Biennial Report	Project Lead with help from Crew Lead	November 1st of the following year	Store in Invasive_Document[5], Upload to NPS Data Store[2], Send Copy to Parks, Post on the KLMN Internet and Intranet Websites
Six Year Analyses and Synthesis Report	Project Lead	Every Five years on March 1st	
Other Publications	Project Lead, NPS Staff	As completed	
Other Records	Project Lead	Review for retention every April 1st	Digital Files that are Slated for Permanent Retention Should be Uploaded to the KLMN Invasive Project Folder. Retain or Dispose of Records Following NPS Director's Order #19 [4].

[1] The KLMN Image Library is a hierarchical digital filing system stored on the KLMN file servers. The image library is linked to an image database that stores metadata on each image.
[2] NPS Data Store is a clearinghouse for natural resource data and metadata (http://science.nature.nps.gov/nrdata). Only non-sensitive information is posted to NPS Data Store. Refer to the protocol section on sensitive information for details.
[3] NatureBib is the NPS bibliographic database (http://www.nature.nps.gov/nrbib/index.htm). This application has the capability of storing and providing public access to image data (e.g., PDF files) associated with each record.
[4] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm.
[5] The KLMN Invasive project folder located on the shared file server at the KLMN office. The project folder contains five folders including: Invasive_Documents, Invasive_Data, Invasive_Analysis, Invasive_GIS, and Invasive_Image used to separate and store data and information collected as part of the Invasive Species monitoring.

Literature Cited

Mohren, S. R. 2007. Data management plan, Klamath Inventory and Monitoring Network. Natural Resource Report NPS/KLMN/NRR—2007/012. National Park Service, Fort Collins, Colorado.

KLMN Certification Form

1) Certification date: ____

2) Certified by: ____
Title: ____
Affiliation: ____

3) Agreement code: ____________________
Project title: ____

4) Range of dates for certified data: _____________________________________

5) Description of data being certified: ___________________________________
____
____
____

6) List the parks covered in the certified data set, and provide any park-specific details about this certification.

Park	Details

7) This certification refers to data in accompanying files. Check all that apply and indicate file names (folder name for images) to the right:

_____ Hardcopy Datasheet(s): ____
_____ PDF Datasheet(s): ____
_____ Database(s): ____
_____ Spreadsheet(s): ____
_____ Spatial data theme(s): ____
_____ GPS file(s): ____
_____ Geodatabase file(s): ____
_____ Photograph(s): ____
_____ Data Logger(s) files: ____
_____ Other (specify): ____
_____ Certified data are already in the master version of a park, KLMN or NPS database.
Please indicate the database system(s): _________________________________

8) Is there any sensitive information in the certified data, which may put resources at greater risk if released to the public (e.g., spotted owl nest sites, cave locations, rare plant locations)?

_____ No   _____ Yes   Details:

____
____
____

9) Were all data processing and quality assurance measures that the protocol outlined followed?

Yes / No

If No, Explain ____
____
____

10) Who reviewed the products?

____

11) Results and summary of quality assurance reviews, including details on steps taken to rectify problems encountered during data processing and quality reviews.

____
____
____

Invasive Species Early Detection Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #9: Databases

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP describes how to set up and use the desktop databases (project and master database) that will be used to store and maintain raw data and to develop summary reporting information. The Network Data Manager will maintain a master database that stores all the raw data for this protocol. Each year, field crews will be given a project database where they will store the data they collect while in the field. Data are collected using Trimble Pocket PCs and then uploaded to the Access project database using automated features.

Introduction

Development of a national, standardized invasive plant database is essential to the effective collection, dissemination, and consistent interpretation of invasive plant data. This is particularly true for early detection and rapid response efforts, which rely on predictable and transparent communication tools to engage an appropriate management response. At this time, an NPS national invasive plant database is still in the planning stages while the NPS Natural Resource Program Center (NRPC) transitions data systems to a Service-oriented Architecture and XML (web-based) services development approach for data management and delivery. Therefore, the Network began to research the availability of other invasive species databases.

After examining several potential databases such as WIMS, APCAM, and GEOWEED, it was determined that we could utilize the Natural Resource Database Template (NRDT) and incorporate many of the features developed by the Nature Conservancy in their Weed Information Management System (WIMS). The result is a database that gives us the opportunity to use mobile mapping technologies and Microsoft Access to collect data accurately and efficiently.

The Klamath Network (KLMN) data collection system is an integrated system of hardware and software that works to simplify the collection and management of invasive plant data. The central piece of system is the relational MS Access database (“the database”) that works to keep track of all surveys, infestations, and random vegetation, and treatment data (Figure 1). This database can be used in combination with ArcPad (the handheld version of ArcGIS) and a Windows-compatible GPS unit, like the Trimble GeoXT or Thales Mobile Mapper CE. If technical difficulties arise, data can also be collected on paper and manually entered into the database. Once a national database has been completed, we will reassess the database methods of this protocol to see if converting to the national database is necessary.

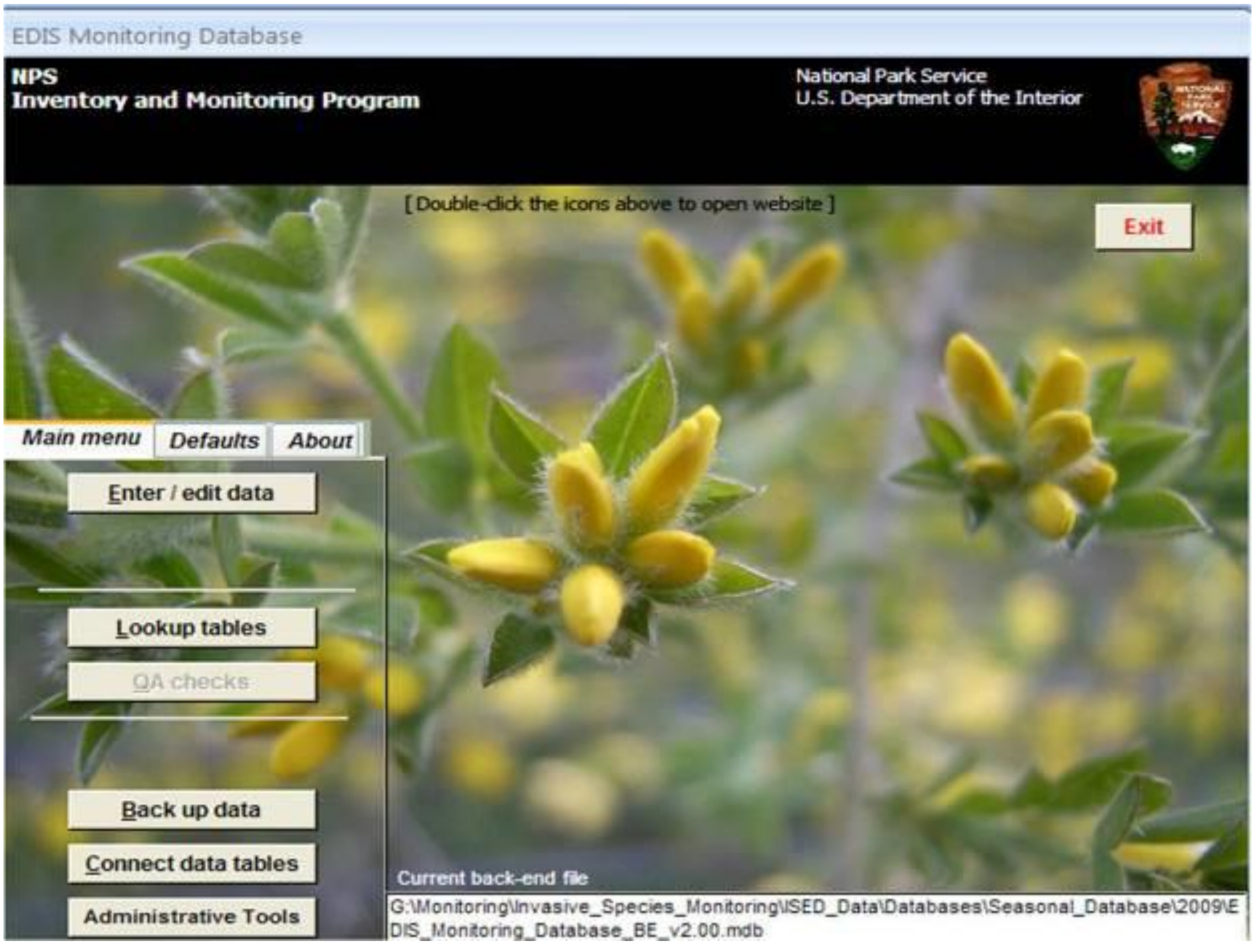


Figure 1. The main screen of the database that will be used to store information as part of this project. Clicking on the "Enter / Edit Data" button will bring up a list of all the areas in the database and the option to add new areas to the database.

Preparing the Database for Field Work

In order to prepare the database to be used in the field, the Crew Lead with help from the GIS specialist will need to provide the Data Manager with a GIS layer of all the sites that will be visited during the upcoming season, a list of field crew members and contact information, and a list of all species that will be recorded as part of this protocol (SOP #2: Field Work Preparation). Once the Data Manager has these lists, he/she can begin to prepare the project database that will be used by the field crews that year.

Entering New Sites

To prepare the project database so it can be used in the field, there are a variety of steps that need to be followed that are listed below.

1. The first thing the Data Manager must do is load a list of sites that will be surveyed that year into the database.
    a. It is the responsibility of the Project Manager to work with the GIS Specialist to develop this list of sites.
    b. The final list of sites to be surveyed should be located at: G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\PARK\YYYY and the name of the file is PARK_3kmSegs_YYYY.dbf. In both the file pathway and the file name, the "PARK" is the 4 letter park code and YYYY is the year of the survey.
    c. You need to make a copy of this file and place it in: G:\Monitoring\Invasive_Species_Monitoring\ISED_Data\Databases\Segments\YYYY\PARK.
2. Open the front-end of the database that you have placed in your working directory.
3. Click on the [Administrative Tools] button.
4. Click the [Upload Sites] button.
5. Browse to the location of the file you created in step 1c above.
6. Click the [Upload Sites] button.
7. The sites table should now be populated with the following:
    a. Site_ID
    b. Site_Name
    c. Site_Description (Road, Trail, Powerline, Campground)
    d. Unit_Code
    e. Starting X-Coordinate
    f. Starting Y-Coordinate
    g. Ending X-Coordinate
    h. Ending Y-Coordinate
    i. GIS ID Number
    j. GIS Shapefile Name
8. The project should now be ready to be used by the field crew.

Entering Contact Information

Next, the Data Manager will need to enter the contact information for each of the individuals that could be working on this project. To complete this task, follow the steps below.

1. Open the front-end of the database and click the [Lookup Tables] button.
2. Using the pick list, select tlu_contacts
3. Delete any of the contacts that are not going to be involved in the project this year.
4. Add any new contacts (such as new crew members) that will be involved in the project that year. Be sure to include the following information.
    a. Last Name
    b. First Name
    c. Middle Initial (if available)
    d. Organization
    e. Position Title
    f. Address
    g. Email

h. Phone Number

Updating Pick List

Since this is a standardized protocol, the pick list values should not be changed with the exception of a few rare occasions. It is the responsibility of the Project Manager to follow all change procedure processes associated with this protocol prior to having the Data Manager change one of these values. Once proper procedures have been followed, the Data Manager should follow these steps to update a pick list.

1. First, determine which fields need to be updated.
2. Click on the [Lookup tables] button on the main form of the database.
3. Using the pick list, select tlu_Enumerations.
4. Find the Enum_Group associated with the list of data you want to edit.
5. Delete any values you no longer want to use.
6. Add any new values that are needed. Be sure to complete all fields, including:
    a. Enum_Group exactly as it is in the database
    b. Sort Order, which is the order you want the data to appear in the pick list.
    c. Enum_Code, the value that is stored in the database.
    d. Enum_Description, a description of the value that is stored in the database.
7. Once you are done, click the [Close] button in the upper, right corner of the form.
8. If will ask you if you want to save your changes, click [YES].
9. You are done.

Preparing the Trimble Handheld Pocket PC

Before moving the data files onto the Trimble units, make certain you have followed SOP #4: Setting up the Electronic Field Equipment. After you have the Trimble, properly plug the cradle of the Trimble unit into your desktop and place the unit into the cradle. Make sure ActiveSync starts up and is working properly. Follow the steps below to setup the file structure and add the files to the Trimble unit.

1. Using Microsoft Explore, go into Mobile Devise.
2. Create a new folder called "Invasives." If this folder already exists, talk to the Project Manager to make sure it is OK to delete the old file.
3. Inside the invasives folder ,create the following folders:
    a. Applet - this is where applets for this project are stored.
    b. Backup_Files – this contains blank copies of all files.
    c. Data – this is the data files called PlotLocn and DataTime.
    d. Images – Background imagery is here is desired.
    e. Shapefiles – Non-data collection project shapefiles are located here such as segments, roads, trails, and sub-segment starting points.
4. Go to: G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\Template\ArcPad_Shapefiles and make a copy of all the files in this folder and place them in the "Data" folder on the Trimble unit.
5. Go to: G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\Template\ArcPad_Project and you should see two files called "Invasive xxxx.apm" and "Invasive xxxx.apm.bmp." Make a copy of these files and place them directly into the invasives folder on the

Trimble unit. Once on the Trimble unit, rename the files by replacing the xxxx with the field year (e.g. 2010).

6. Go to: G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\Template\ArcPad_Applets and make a copy of all the files in this folder and place them on the Trimble unit at program files/Arcpad/applet.
7. Create a .dbf file of the species that will be surveyed for during the field season. Make certain the file is name "Specieslist.dbf" and only contains two fields called "SCIENTIFIC" and "ITIS." An example can be found at: G:\Monitoring\Invasive_Species_Monitoring\ISED_Data\Databases\Species List\2009.
8. Make a copy of this dbase file and place it on the Trimble unit at: G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\Template\ArcPad_Shapefiles. You will be asked if you want to replace the current file; click [YES].
9. Go to: G:\Monitoring\Invasive_Species_Monitoring\ISED_Data\Databases\Segments\YYYY\PARK. The files of segments to be surveyed should be here and you should have already used this file to update the Access database.
10. Open the file using ArcMap and delete all the fields except the "3kSEG_NAME" field.
11. Make a copy of this dbase file and place it on the Trimble unit at: G:\Monitoring\Invasive_Species_Monitoring\ISED_GIS\Template\ArcPad_Shapefiles. You will be asked if you want to replace the current file; click [YES].
12. Let the GIS Specialist know the Trimble unit is ready for him/her to upload the background imagery and base shapefiles.
13. The GIS Specialist should consult with the Crew Leader to determine what imagery is needed. At the very least, DRG images for all the parks should be loaded.
14. At the very least, the GIS Specialist should load the following shapefiles:
    a. Roads, Trails, and Powerlines.
    b. Segments to be surveyed, where sub-segments are different colors (use dark color).
    c. Starting points for each sub-segment.
15. The Trimble units should now be ready for the field. It is the Crew Leaders responsibility to test the units before sending them out with field crews.

Collecting Data in the Field

Now that you have transferred the supporting tables, ArcPad forms and toolbars, and GIS data to the Trimble unit, you are ready to begin collecting data. SOP #6: Data Collection and Entry describes the processes to use the Trimble unit, hardcopy field forms, and project database to collect data.

After Collecting Data in the Field

Once you have collected the data using the Trimble unit, you will need to upload the data into the project database. Once the data have been uploaded into the project database, the data will need to be verified by the field crew. For step-by-step instructions for this process, see SOP #6: Data Collection and Entry. At the end of the field season, the crew members should submit their database, GIS files, images and associated metadata, and hardcopy datasheets to the Crew Lead.

The Crew Lead is responsible for organizing the data and submitting them to the Data Manager following the timeline outlined in SOP #8: Data Transfer, Storage, and Archiving.

Uploading into the Master Database

After the data have been validated and verified by the field crew members and the Crew Lead (SOP #6: Data Collection and Entry), a Data Certification Form and Metadata Interview Form should be completed by the Crew Lead. Both forms and the finalized Project Database should be submitted to the Data Manager so he/she can incorporate the data into the Master Database.

Once the Data Manager has received the proper forms and the finalized database, he/she can upload the data to the master database. To complete this process, follow the steps below.

1. Make a copy of the back end of the database and place it in the backup folder that is located in the same location. The back end is located at: G:\Data_Management\Databases\Monitoring\Invasives.
2. Open the front end of the master database located at: G:\Monitoring\Invasive_Species_Monitoring\ISED_Data\Databases\Master_Database.
3. Click the "Administrative" tool button and then click the "Upload Project Database."
4. Browse to the location of the project database and click "Upload."
5. Close the database.
6. Send an email to all parties that the finalized database is ready so they can begin working on the annual report.

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #10: Reporting and Analyses of Data

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP provides details of the reporting and analysis elements of the Invasive Species Monitoring Protocol. The reporting and analysis of data are tailored to the monitoring objectives for the invasive species protocol:

1. Detect populations of selected invasive plants by sampling along roads, trails, and powerline corridors, and in campgrounds, where introduction is most likely.
2. Provide the information to park management on a timely basis to allow effective management responses.
3. Develop and maintain a list of priority invasive plant species with greatest potential for spread and impact to park resources for monitoring in each park.
4. Adapt spatial sampling as knowledge improves through monitoring.
5. Use monitoring data collected from this protocol and the vegetation protocol to estimate possible trends and develop and refine models of invasive species habitat requirements and of the most susceptible habitats (both along roads and trails and not).

In order to accomplish these objectives, data and results will be reported and analyzed in reports prepared at varying frequencies and levels of detail (Table 1). Reports will be stored in NatureBib, posted on the Klamath Network Internet and Intranet web sites, and uploaded to Southern Oregon University's Bioregional electronic archive collection. Reports will also be sent to the Technical Advisory Committee and to park staff involved in invasive species management. In addition, reports and the database will be used to update NPSpecies. Reports will be formatted using the Natural Resource Technical Report template found at NPS Natural Resource Publications.

Table 1. Overview of general reporting tools with purpose/objectives and reporting year.

Report	Year	Purpose/Objective				
		1. Detect populations and trends of selected invasive plants.	2. Provide the information to park management on a timely basis.	3. Develop and maintain a list of priority invasive plant species with greatest potential for spread.	4. Adapt spatial sampling as knowledge improves through monitoring..	5. Use monitoring data collected from this protocol and the vegetation protocol to develop and refine models.
Park Briefing	All sampling years	X	X			
Biennial Reports	All Non-sampling years	X	X		X	
A&S Report 1: Management Effectiveness	Year 6		X	X		
A&S Report 2: Spatial Models	Year 12	X	X		X	
A&S Report 3: Temporal Dynamics	Year 18	X		X	X	X

Briefings

To accomplish the first monitoring objective, parks will be briefed on the invasive species early detection findings expeditiously in three ways. First, field crews will meet with park resource staff to present findings during or upon completing their seasonal field work. The purpose of these meetings will be to convey the most urgent findings verbally, so that park managers can schedule immediate treatments if appropriate and feasible. In some cases, the crew may use cell phones to contact park managers from a field location. Second, a one page briefing paper will be developed after the field season (by December 1st). This paper is not meant to convey all the findings and efforts for the year but to act as an interest document that summarizes the most urgent and relevant information to managers, Network-wide, to facilitate rapid response. Third, all occurrences of priority species documented will be provided as a GIS layers to be delivered no later than December 1st of the year of a survey.

Biennial Reports

More detailed and formal reports will be prepared in years following the field seasons. These reports will focus on the status of invasives, the time spent surveying, and kilometers covered presented in tabular data as shown in Appendix B. To address monitoring objective one, the reports will document all findings related to goals of early detection and include management recommendations to be implemented during alternate years. Biennial reports will be prepared and distributed by May 1st of the year following monitoring.

Biennial reports will include occurrences of priority species by road, trail, campground, and powerline in map and tabular form. A separate map will be constructed for each priority invasive at each park (Figure 1). Maps are intended to assist resource managers in designing control strategies for invasive species. New invasions, previous invasions, concentrations of invasions, and invasion-free areas will be highlighted on these maps. Summary statistics will also be provided in these reports. Summary statistics will include invasive species frequency by park. Frequency is defined as the number of segments in which an invasive occurs. Frequency will be calculated in the following manner:

Equation 1: Frequency of an invasive species (%) =

$$\frac{\Sigma \textit{ segments occupied by species} * 100}{\Sigma \textit{ units sampled}}$$

Correlations between invasive species and plot level variables, as shown in Table 2, will also be provided. Pearson Product Moment correlations will be calculated if data have a normal distribution or can be transformed to have one. If cover data cannot be normalized following transformation, then non-parametric Spearman Rank Correlation coefficients will be calculated. The correlations in Table 2 illustrate a fairly strong negative relationship between the invasive, St. John's wort, or Klamath weed (*Hypericum perforatum*), percent cover of litter, and low light conditions.

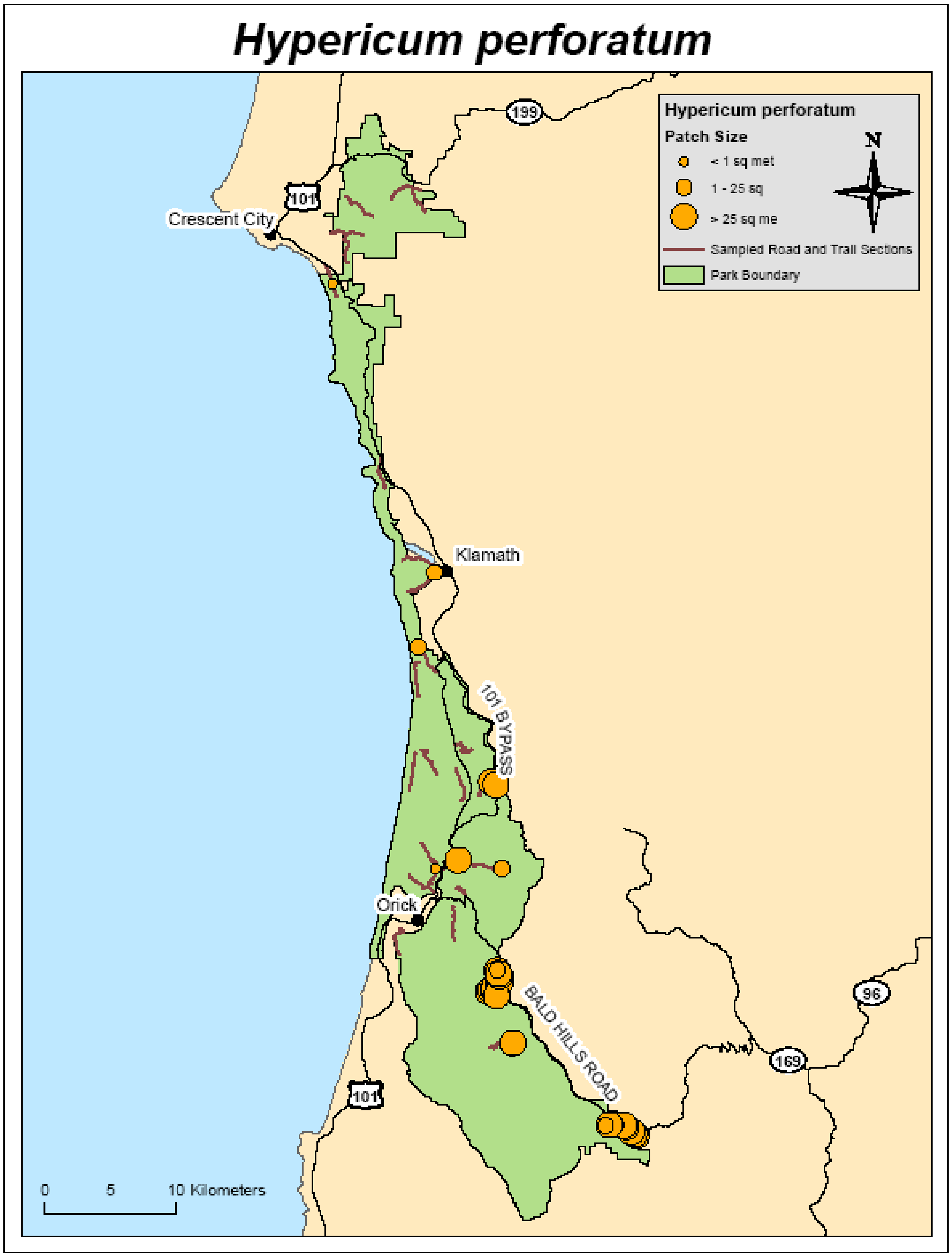


Figure 1. Map showing 2007 infestation location and size for Klamath weed (*Hypericum perforatum*) at Redwood National Park.

Table 2. Spearman Rank correlation coefficients between plot variables and Klamath weed (*Hypericum perforatum)*. Data analyzed are from the pilot study (Lundgren et al 2008, Appendix A).

	***Hypericum* cover**	**Slope**	**Aspect**	**Ever-green cover**	**Decid-uous cover**	**Herb-aceous cover**	**Shrub cover**	**Woody debris**	**Litter**	**Bare ground**	**Light Index**	**Disturbance**
***Hypericum* cover**	1.000											
Slope	-0.171	1.000										
Aspect	-0.042	0.218	1.000									
Evergreen cover	-0.251	0.169	0.075	1.000								
Deciduous cover	-0.074	0.036	0.051	-0.251	1.000							
Herb cover	0.106	0.119	0.074	-0.031	-0.275	1.000						
Shrub cover	-0.111	-0.051	-0.134	-0.095	0.258	-0.387	1.000					
Woody debris	-0.389	0.265	-0.009	0.527	-0.015	-0.030	0.138	1.000				
Litter	-0.459	0.201	0.044	0.610	0.079	-0.069	0.185	0.590	1.000			
Bare ground	0.215	-0.072	-0.053	-0.427	-0.018	-0.018	-0.250	-0.403	-0.796	1.000		
Light index	-0.363	0.200	-0.028	0.538	0.196	-0.278	0.333	0.511	0.589	-0.417	1.000	
Disturbance	0.242	-0.027	0.082	-0.363	0.133	0.067	-0.178	-0.346	-0.477	0.587	-0.378	1.000

An additional analysis that may be done with continuous multivariate normal data is to construct a directed acyclic graph (DAG) or chain graph that displays the dependence relationships among the variables (Shipley 2000). Although a DAG or chain graph is a "causal model," one can interpret the results in terms of associations among variables in the context of observational data. Such an exploratory graph is an additional tool to a correlation matrix because it displays the partial correlations in addition to the first order correlations.

The Tetrad software, available as a free download from http://www.phil.cmu.edu/projects/tetrad/, can be used to generate a directed acyclic graph based on the correlation structure between the continuous habitat variables measured at each plot. Currently, the available technology is only developed for all continuous or all categorical variables. An example is provided in Figure 2, displaying the relationships among the measured habitat variables. Because the cover of the invasive species, Klamath weed (*Hypericum perforatum*) was only measured at three levels in the pilot study, it was not possible to include this parameter with the continuous variables. However, future monitoring will measure cover of invasives on a continuous scale and it can be included in an analysis such as this.

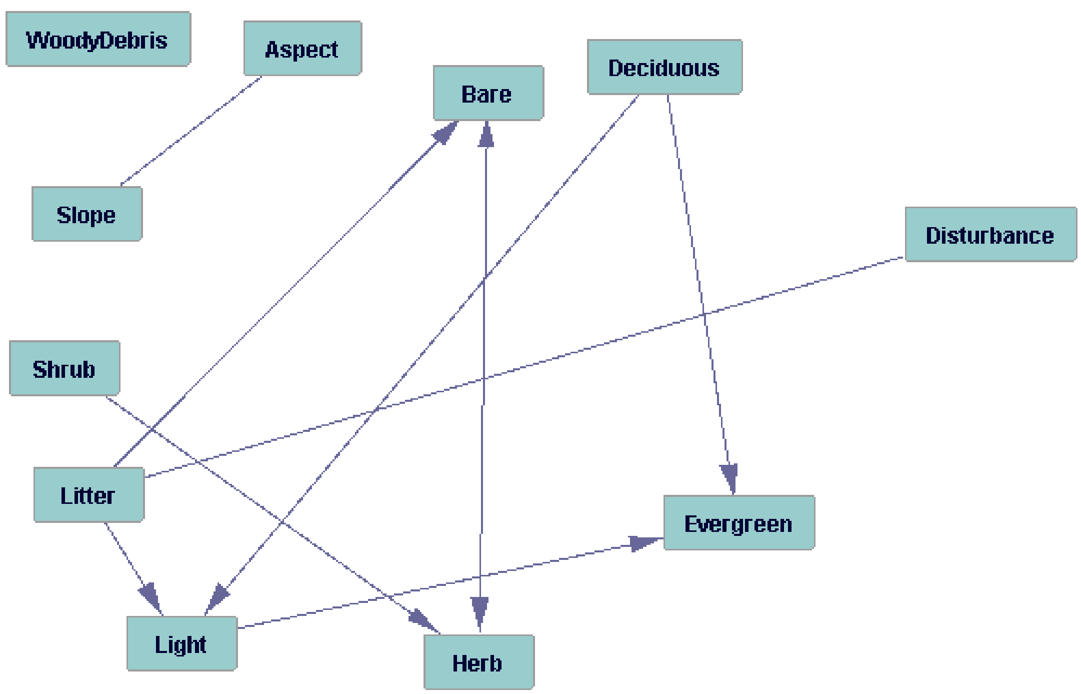


Figure 2. Chain graph for Klamath weed (*Hypericum perforatum*) habitat variables only. A directed arrow suggests a "causal" relationship between the variables.

Figure 2 is a chain graph that shows directed arrows (→) and bi-directed arrows (←→). A directed arrow suggests a "causal" relationship between the variables. For instance, the percent cover of deciduous trees influences the light index at a site. A bi-directed edge or a line without arrows suggested a correlation between variables. For example, as disturbance and litter are associated, notice in Table 1 that they have a negative correlation.

Figure 2 is a hypothetical example of a chain graph without any user input. The graph structure can also be restricted based on the known biology of the system. For example, if we know overstory structure would influence whether a light-demanding understory species may occur, we would only allow for edges in that direction. The edges in the graph can be estimated using Maximum likelihood or Bayesian estimation procedures. Ultimately, this analysis can allow managers to identify what environments are most susceptible to invasion.

Analysis and Synthesis Reports

Analysis and Synthesis Reports will be prepared every 6 years to address specific management and scientific objectives (Table 3). They will be prepared and distributed by June 1st, every sixth year. Specific Analysis and Synthesis Reports, hereafter A&S Reports, will address specific objectives and topics, ranging from management effectiveness to the autecology of invasive species in park landscapes. The scope and delivery schedule for A&S Reports is intended to provide specific topical information; not all questions of interest can be addressed in each report. We have assigned initial topics for the first three A&S Reports (Table 1).

A&S Report 1-Invasive Species Management Effectiveness

This report will evaluate the overall effectiveness of the protocol in providing useful, accurate, and timely information for the parks of the Klamath Network. The report will include maps illustrating cumulative sites visited over three sampling seasons for each park, locations and sizes of infestations encountered, and preliminary models of encounter probabilities for selected species.

The Program Lead will work with Park Contacts to coordinate and convene an assessment meeting in fall or winter following the third sampling season. At the meeting, I&M staff will present general scientific findings from the program (the first section of the report) and engage the park staff in a discussion about the monitoring approach and its effectiveness in assisting park management. In addition, I&M staff will request treatment data from the parks to help in the visualization of possible linkages between treatment actions and species presence over the initial period. Specific topics addressed at the meeting will include 1) a reevaluation of the method for invasive species selection and prioritization; 2) efficiency and comprehensiveness of sampling for providing management data supporting particular actions; 3) effectiveness of briefings, GIS data layer summaries, and biennial reports for supporting management actions; and 4) evaluation and description of linkages between management actions and species abundances, if applicable. The second section of the report will summarize the findings and recommendations arising from the invasive species management meeting.

A&S Report 2-Spatial Models of Invasive Species in the Klamath Network

This report will focus on the development of quantitative habitat models in the parks of the Klamath Network using spatial and nonspatial modeling (e.g., Guisan and Zimmermann 2000, Lawler and Edwards 2002, Edwards et al. 2007). The data available for use in model development will include six sampling cycles of invasive species monitoring data and three sampling cycles of vegetation monitoring data. As this report may require specialized programming and analysis techniques, it is possible that the Network will choose to contract this report out to scientists with the USGS or academia. However, improvements in spatial modeling features in standard mapping software (e.g., model builder in ArcGIS) may allow this report to be prepared in-house, if funding is limiting.

For example, we summarize a modeling approach in Appendix B that used general linear modeling to produce interpolated maps from point sampling data of the mean response variables and associated standard error terms from our pilot data. Landscape scale variables were generated in ArcGIS 9 and used to create species-environment matrices for each the species being modeled. These matrices were imported in the statistical package "R," where species-environment relationships were explored and modeled. The resultant models were mapped using the ArcGIS raster calculator and a testing dataset was used for model validation in R. Appendix B provides step-by-step directions, R scripts for modeling, and examples of each step of the process using data from the pilot study. Maps of the modeled surfaces are produced with the step-by-step instructions and procedures for model testing and validation are provided. Pertinent modeling literature is also reviewed.

Models will aim to predict beyond the current known range of invasive species to new areas in the parks that may be susceptible to invasion, facilitated by use of data from the vegetation monitoring protocol. Because all samples, even with the vegetation monitoring data, will be based on sampling within 1 km of roads and trails, the predictions cannot presume the same probability of invasion occurs in environments beyond this distance. However, as explained in the Klamath Network's monitoring plan (Sarr et al. 2007), the environments within a km of roads and trails are very representative of those park-wide. The biggest difference is the presence of the roads and trails. Examples of the modeling output using data from the pilot study are shown in Figures 2-3. Note that different variables were included in the final models for each species.

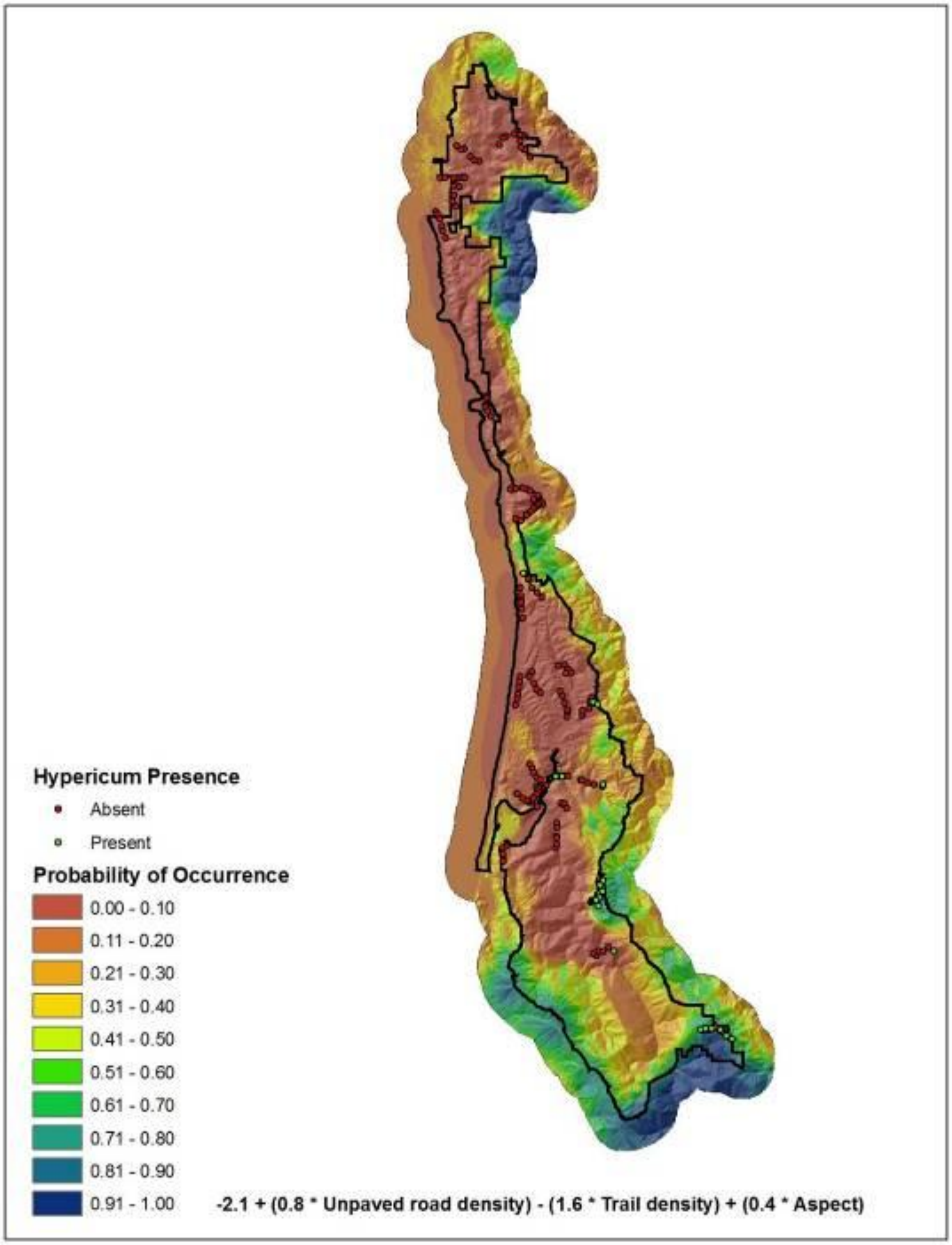


Figure 2. Interpolated surface showing the probability of occurrence of Klamath weed (*Hypericum perforatum*) at Redwood National Park.

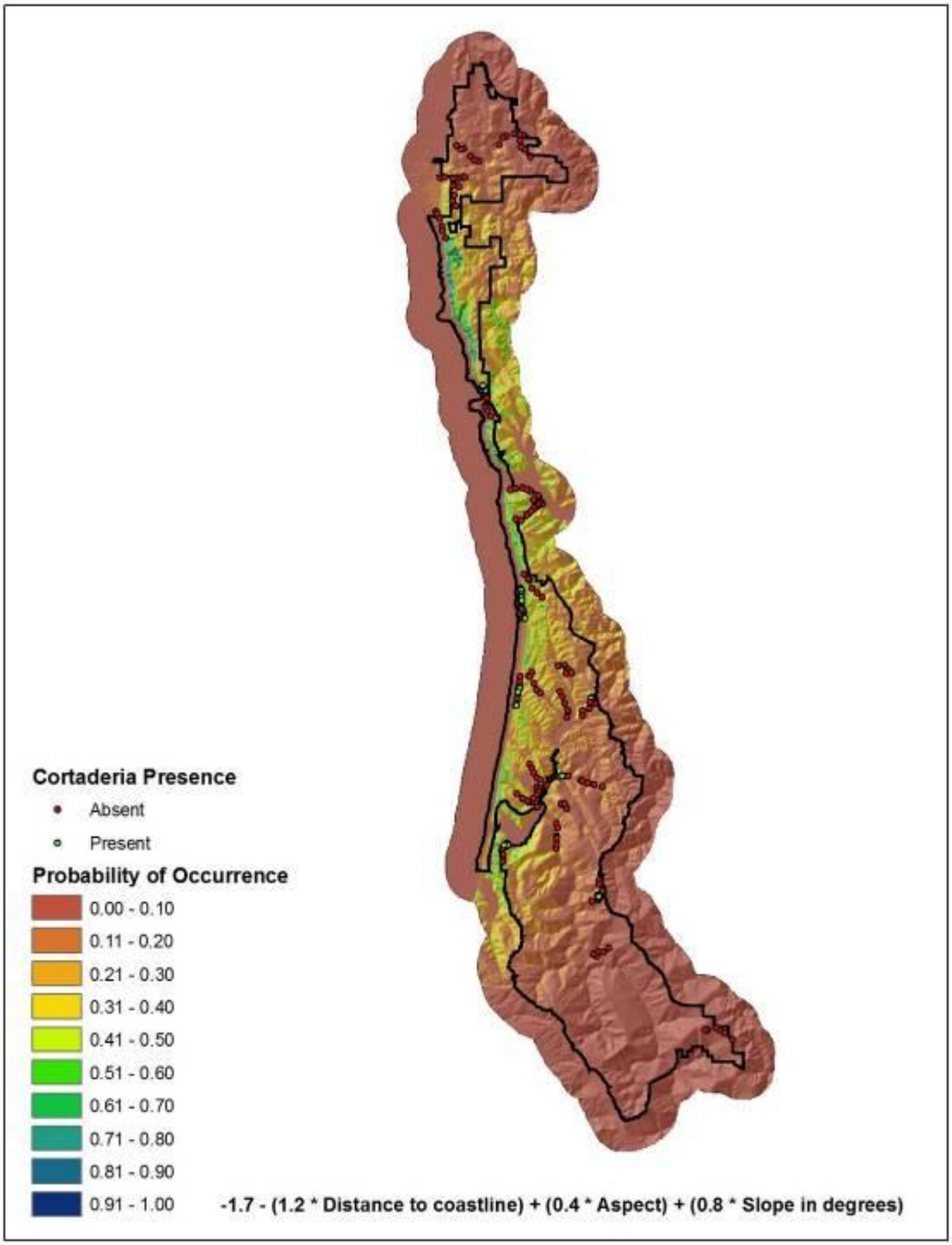


Figure 3. Interpolated surface showing the probability of occurrence of pampas grass (*Cortaderia jubata*) at Redwood National Park.

A&S Report 3-Temporal Dynamics of Invasive Species in the Klamath Parks

This report will use data from nine sampling cycles of invasive species and five sampling cycles of vegetation monitoring to evaluate the temporal dynamics of invasive plant species in the

Klamath parks. Trend detection will be a lower priority for this monitoring protocol than in other Network monitoring protocols because we expect that monitoring data will support invasive species control, removal, and possible eradication. Nonetheless, a better understanding of the temporal dynamics of invasion is very important both for management and for our program's contributions to invasive species science.

Where appropriate, estimates of invasive species trends will also be addressed using standard methods for temporal trend detections. Data from the vegetation protocol will be instrumental for this objective. Four calculations compare changes in individual segments sampled over time by species: 1) change in density for each segment between years (Equation 2), 2) changes in area occupied in segments sampled between years (Equation 3), overlap in segment occupancy (Equation 4), and 4) persistence over all sampling periods (Equation 5). Segments may not be resampled until the third or fourth sampling season in some cases, so it will be necessary to perform more than one different analysis for each type of trend and then evaluate the averages. Mean values for road, trail, and powerline segments in a park or across the Network can also be calculated for equations 2-3, allowing for confidence intervals and statistical comparisons over different windows of time. These calculations will be presented in summary tables.

Equation 2. Changes in density class in co-sampled segments =
(*density in segments during time 2 – density class in same segments during time 1*)

Equation 3. Changes in area occupied in co-sampled segments =
Σ *infestation sizes* (m^2) *in segments during time2 -* Σ *infestation sizes* (m^2) *in same segments during time 1*

Equation 4. Overlap in segment occupancy =

$$\frac{\textit{number of segments occupied in Time 1 and Time 2}}{\textit{the lower of the number of same segments occupied in Time 1 or Time 2}}$$

Equation 5. Persistence = *Number of years in which a segment was occupied*

Geostatistical-temporal modeling (Kyriakidis and Journel 1999) and general linear models (Manley 2001) will also be used to identify whether or not the spatial patterns are changing over time. After several sampling cycles, trends will be tested statistically using repeated measures ANOVA. Interpretation of trends will require assessment by park managers of any park management actions that may have affected invasive species abundance in areas surveyed.

The association between species establishment and persistence in specific landscape or stand conditions has been a major goal in plant ecology, and has important implications for the composition and structure of the ecosystem (Bormann and Likens 1977, Oliver and Larson 1996). The "niche" of a given invasive species in a park landscape is usually poorly known, but is essential information for long-term resource protection. Spatial models will likely provide important insights into where species can invade and why, but temporal information is also very desirable, particularly where there is a linkage with management.

Many management activities, such as prescribed fire, may create opportunities for some species and limit others. Analysis and synthesis of temporal dynamics in invasive species will require connecting data from this protocol with supplementary data from the vegetation protocol to detect meaningful changes in invasive species abundance and distribution over time. At a minimum, analyses of nontrend dynamics will include outlier and control chart analyses (Gilbert 1987, Morrison 2008) to document irruptive events relative to the baseline developed over several sampling cycles. More sophisticated analyses will explore linkages among potential drivers, such as park management history; wildfire and other natural disturbances; climatic variability; and invasive species abundance, distribution, and diversity. Such a synthesis will involve opportunistic analyses of pre-disturbance and post-disturbance data, as well as development of temporal correlations between climatic or other fluctuations and species spread.

Because many management activities may affect invasive species dynamics, a major goal of a collaborative early detection and rapid response program for the Network will be development of standardized means to record and summarize management data over time. Such an effort will require considerable input and support from park managers and is not part of the protocol at this time. However, the data collected under this protocol will be well suited to allow such analyses when matching park support materializes. In the interim, insights into ecologically relevant landscape changes (e.g., landcover transitions from forest to grassland) may be available from the Klamath Network Landcover Protocol currently under development.

Vector and Pathway Analyses. Many new exotic species tend to be introduced into communities via similar vectors or along the same pathways as previous introductions (Ruiz and Carlton 2003). As a simple descriptive analysis, we will develop GIS maps of invasives species location and abundance over time. These can be converted to PNG images and converted to space-time animations using software such as the Geographic Resources Analysis Support System (GRASS) and uploaded to Windows Movie Maker to create Windows Media Video (WMV) files. Such movies can be developed for each species and park to illustrate both the locations of detection, and subsequent movement through the park. We expect that these sorts of analyses will become much easier over time as desktop imaging software improves. Panels of invasion time series will be included in the report, with movies posted to the I&M web site. Our data will also allow much more sophisticated modeling analyses to be conducted by USGS or university partners, as needed.

These briefing, Biennial reports, and A&S Reports described here are intended to be feasibly completed by the I&M staff, with assistance from park staff, and occasional academic partners within the limits of available funding and staff time. We anticipate that meaningful studies of will also be conducted by outside scientists describing many aspects of invasive species ecology and biology in the parks. These will be accomplished through supplemental funding or staffing.

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Invasive Species Early Detection Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #11: Metadata Guidelines

Version 1.00 (February 2010)

Revision History Log:

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Acronyms used in this SOP are defined at the end.

This SOP explains the procedures for completing metadata for products developed using this protocol. This includes, but is not limited to, databases, documents, GPS data, and GIS data. Details on metadata for photographs can be found in SOP #7: Photo Management. This SOP is based on metadata recommendations developed by the Klamath Network (KLMN) (Mohren 2007), the Natural Resource GIS Program (NR-GIS Data Store 2005a-i), and the NPS North Coast Cascades Network (NCCN 2006a, NCCN 2006b, NCCN 2006c).

Documentation is a critical step towards ensuring that products collected as part of this monitoring effort are usable for their intended purposes now and in the future. This involves the development of metadata, which is defined as structured information about the content, quality, condition, and other characteristics of a product. In addition to spatial information, metadata includes information about data format, collection and analysis methods, time of collection, originator, access/use constraints, and distribution. Metadata provide the means to catalog products, within Intranet and Internet systems, making them available to a broad range of potential users. While most frequently developed for geospatial data, metadata describing non-geospatial datasets are also important (NCCN 2006a).

Timelines

It is the responsibility of the Crew Lead to submit metadata or metadata products (e.g., Metadata Interview Form, data dictionary) to the Klamath Network Data Manager, in the proper format, when he or she submits the product with which the metadata are associated. SOP #8: Data Transfer, Storage, and Archive provides the details on the products to be delivered to the Data Manager, the due dates for those products, and the persons responsible for those products.

Responsibilities and Standards

Metadata are among the most important pieces of documentation to help guarantee the long-term usability of data. The degree of documentation will vary depending on the product, but a few standards will always hold true.

1. Metadata for spatial data collected through I&M funded projects will meet FGDC, NBII, and NPS standards.
2. Crew Leads will be expected to submit a data dictionary (for tabular and spatial data) and a Metadata Interview Form (for spatial data) prior to the start of the first field season.
3. Crew Leads will be expected to review and revise all data dictionaries and Metadata Interview Forms at the end of each field season and report changes following the timeline listed in SOP #8: Data Transfer, Storage, and Archive.
4. It is the responsibility of the Data Manager to develop the official metadata based on the data dictionary and Metadata Interview Form provided by the Crew Lead.
5. It is the Data Manager's responsibility to parse and transfer metadata to the NPS Data Store, if applicable.
6. The Data Manager will work with the Project Lead and park staff to determine the sensitivity level of any data.

Reports

Three main types of reports are expected to be developed during this monitoring effort, including Biennial Reports, Analysis and Synthesis Reports, and Scientific Publications (SOP #10: Reporting and Analyses of Data). It is the responsibility of the individual creating the reports to ensure that the following guidelines are met.

1. First and last name of all authors are included on the report.
2. Affiliations of the authors are included on the report.
3. Version numbers are used on all drafts of the report.
4. The date the report was completed is included on the report.
5. The date representing the information presented in the report is included in the report.
6. Series number is included in the report when applicable.
7. The NatureBib accession number has been added to the subject field in the properties of the document in the format: NatureBib #123456. This will be created by the Network Data Manager.

Spatial Data, Databases, and Spreadsheets

The Data Manager, working closely with the GIS Specialist, is responsible for creating and maintaining the official metadata for all GIS and GPS products, relational databases, and spreadsheets. It is the responsibility of the Crew Lead to provide Metadata Interview Forms and data dictionaries to the Data Manager prior to implementing the field work as described in SOP #8: Data Transfer, Storage, and Archive. The Data Manager will use the Metadata Interview Form, data dictionary, and protocol to develop complete metadata for each product. Each year that field work occurs, the Crew Lead must submit a data dictionary (if changes to the product have occurred) and Metadata Interview Form following the timeline in SOP #8: Data Transfer, Storage, and Archive.

Steps for Metadata Creation

Step 1: Metadata Interview Form and Information Gathering (Figure 1)

A. The Crew Lead should obtain and complete the KLMN Metadata Interview Form at project onset to facilitate compiling the information required to create compliant metadata.
   1. The KLMN Metadata Interview Form is posted on the KLMN Internet and Intranet web pages. In addition, the form can be obtained by contacting the Network Data Manager.
   2. Best attempts should be made to populate the Metadata Interview Form as completely as possible prior to starting field work. However, it is recognized that changes to the form will occur throughout the project.

B. A data dictionary must be created to provide information to help the Data Manager create or update the official metadata and in some cases, the project database. The data dictionary should include:
   1. The name and purpose of each table, shapefile, coverage, or feature class.
   2. A list of attribute names, types, sizes, and descriptions by table. An example of a data dictionary in the proper format is provided at the end of this SOP.
   3. If the database was not designed by the KLMN, it is the responsibility of the Project Lead to provide the Data Manager with the data dictionary.

C. If a taxa list other than a current ITIS certified taxa list was used, the Crew Lead will need to provide the list that was used at the end of each field season. Taxa lists should include:
   1. Taxon group (plant).
   2. Scientific name.
   3. Common name.
   4. Any special code that defines a species.

D. The Crew Lead should send a copy of any additional information that might be valuable for the development of metadata.

Step2: Sensitivity Review: Sensitive Data (Species Locations, Site Locations, etc.) May not be Subject for Release to the Public

A. The current version of NPS Data Store does not screen for sensitive information. Therefore, any data with a sensitive status will not be posted on the Data Store.

B. The Network Data Manager will be responsible for posting data as sensitive. Status of the data will be based on comments provided by the Crew Lead under the "Sensitivity" question in the Metadata Interview Form and certification form. In addition, the Klamath Network will consult with park staff if the sensitivity status of any data is questionable.

Step 3: Metadata Software Selection

A. The Klamath Network will utilize ArcCatalog, NPS Metadata Tools and Editor, and the Database Metadata Extractor to create metadata for all projects.
   1. ArcCatalog automatically harvests spatial organization and reference information, as well as entity and attribute information for GIS datasets.

2. The NPS Metadata Tools and Editor is provided as a standalone program or as an extension for ArcCatalog and is available at: http://science.nature.nps.gov/nrdata/tools/
   i. It can be used for metadata creation and editing.
   ii. It can import, export, and parse metadata.
   iii. It cannot harvest entity and attribute information; however, this is an anticipated feature for the next version.
3. The NPS Database Metadata Extractor (MTE) is a custom software application for authoring, editing, and managing NPS metadata. The MTE operates either as an extension to ArcCatalog versions 8.3/9.x or as a standalone desktop application. Eventually, this tool will be incorporated into the NPS Metadata Tools and Editor. Features of this tool include:
   i. Automatically harvests entity (table) and attribute (field) metadata from Access databases, including domains.
   ii. Allows the user to edit and review the harvested metadata and make batch edits.
   iii. Allows the user to export metadata to an FGDC-compliant XML file.
   iv. Allows exported XML to be used in the Metadata Tools and Editor either by opening it to start a new metadata record or by updating it with a template to fill in Section 5 of an existing metadata record.

Step 4: Additional Requirements

A. Along with the required metadata, the Klamath Network requires the following information be included in the metadata document.
   1. The name and agreement code for the project. These references can be entered in the Related Key element in the Program Information section (NPS Section 0) on the NPS Profile.
   2. References to all products (GIS, GPS, Databases, Reports) generated by the projects. These references can be entered in the repeatable Cross Reference element of the Identification Information section.
   3. Standard language for NPS liability should be inserted into the Distribution Liability metadata element of the Distribution Information (FGDC Section 6). This can be found at: http://www.nps.gov/gis/liability.htm.

Step 5: Biological Data Profile

If a dataset includes biological information, the Biological Data Profile provides a set of extended metadata elements to document the species observed, taxonomic information, methods, and analytical tools.

A. The most direct, and KLMN preferred, means to populate the Biological Data Profile metadata elements are outlined in Biological Profile (National Biological Information Infrastructure - NBII) Metadata Guide (NR-GIS Data Store 2005a).
   i. This approach primarily utilizes the NPS Metadata Tools and Editor and may also require the entity and attribute harvesting capability of NPS Database Metadata Extractor for Access datasets.

B. The two documents at the following links describe alternative approaches to completing the Biological Data profile for a metadata record. Note that the first

requires the use of additional metadata creation software (Spatial Metadata Management System, or SMMS):
   i. Metadata Tools Used in the Creation of the FGDC Biological Data Profile (Callahan and Devine 2004).
   ii. National Biological Information Infrastructure (NBII) Metadata Steps (McGuire 2004).

Step 6: Metadata Review

The Data Manager should review metadata for quality control (QC) prior to posting to NPS Data Store. A useful QC Checklist is available for download on the NPS Intermountain Region GIS website at: http://imgis.nps.gov/tips_templates.html.

Step 7: Metadata Parsing and Exporting to XML Format

The NPS Data Store requires that metadata records be parsed into FGDC-structured metadata and then exported to XML format.

A. If using ArcCatalog, these steps can both be done directly with the NPS Metadata Tools and Editor. See Parsing Metadata with the NPS Metadata Tools and Editor (NR-GIS Data Store 2005i) for more information.

B. If using other applications, export the metadata first to ASCII text format and then parse with Metadata Parser (MP). MP can simultaneously output an XML format metadata file as well.
   i. MP must be customized to handle NPS, Biological Data, or ESRI Profile metadata elements. For specifics, refer to:
      a. The README.txt file included in the zipped NPS Metadata Profile configuration files, available from the NPS Data Store website at: http://science.nature.nps.gov/nrdata/docs/metahelp/metahelp.cfm.
      b. Parsing Metadata with the NPS Metadata Tools and Editor (NR-GIS Data Store 2005i).

Step 8: Metadata Posting

Post the metadata to the NPS Data Store.

A. Authorized NPS staff may request upload and edit access to the NPS Data Store through the NPS Natural Resource Universal Web Login (UWL), available at: https://science1.nature.nps.gov/nrdata/. This is also the portal for uploading data.

B. More information about metadata upload format requirements is available at: http://science.nature.nps.gov/nrdata/docs/metahelp/metainfo.cfm and in Metadata and Data Uploading Guidance (NR-GIS Data Store 2005g).

Step 9: Editing/Updating Metadata Already Posted to NPS Data Store

As of Version 1, the NPS Data Store application allows online editing of NPS Theme Category and ISO Theme Keyword information and the deletion of single metadata records and/or datasets only (see help documentation at: http://science.nature.nps.gov/nrdata/docs/metahelp/edithelp.cfm).

A. For metadata records simply needing edits to NPS Theme Category or ISO Theme Keyword elements, refer to Editing Category Information (NR-GIS Data Store 2005f).

B. If a metadata record posted to the NPS Data Store contains errors or requires edits to other elements, it will need to be deleted from the NPS Data Store, edited, and then reposted. Refer to Deleting Single Records (NR-GIS Data Store 2005e).

   i. The user should first download the metadata record (save in XML format) to the local system, then edit as needed in a text editor or metadata software program.
   ii. The edited metadata record can then be resubmitted to the NPS Data Store.
   iii. If the dataset documented by the metadata record requires no edits, it will not need to be reposted. Simply ascertain that the metadata file still specifies the correct pathway to the dataset on the NR-GIS Data Server before resubmitting the metadata file.

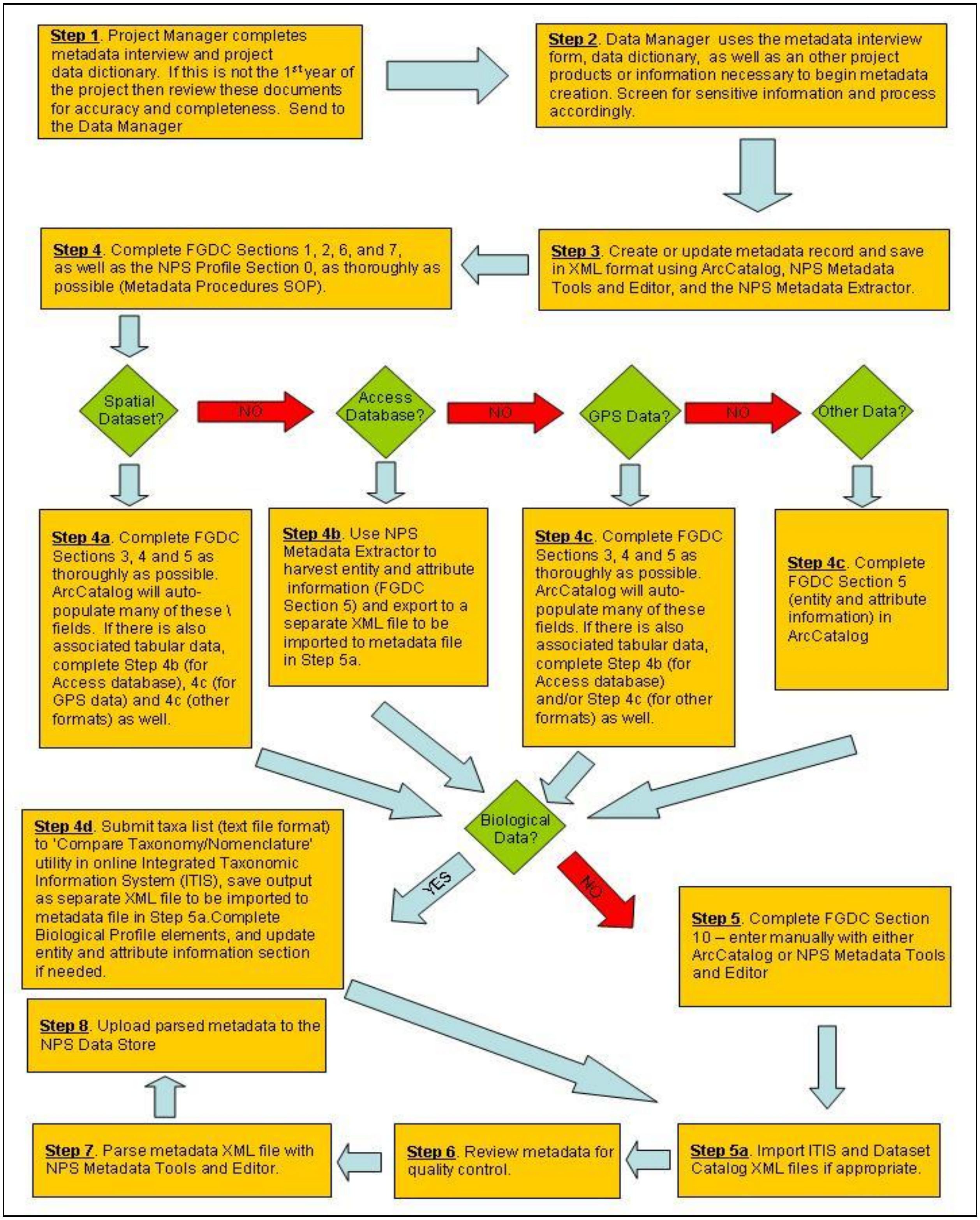

Figure 2. The general workflow for metadata creation for spatial and tabular data.

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Electronic Metadata Interview

[**Note: Please make your responses directly within this word document in "Red" type**.]

1. Have you already prepared metadata for this dataset?
    a. If yes, please send a copy of the document or reference to where it can be found and skip to item **18**.

2. What is the title of the dataset?

3. Who is the originator(s)/owner of the dataset? (Include address and telephone number)?
    a. If someone else should answer question about the data, please list the name, address, and telephone number.

    b. Are there other organizations or individuals who should get credit for support, funding, or data collection and analysis?

4. Does the dataset contain any sensitive information that should not be released to the public? NPS?
    a. Explain why the data should not be released to the public.

    b. Explain why the data should not be released to non-park NPS staff.

5. Is the dataset published or part of a larger publication?
    a. If so, what is the reference?

6. Include a brief (no more that a few sentences) description of the dataset.

7. Why were the data collected in the first place?

8. What is the time period represented by the dataset?

9. Were the data developed primarily through:
    a. Field visits?
    b. Remote instrumentation (e.g., temperature recorders, etc.)?
    c. Existing data sources?

10. What is the status of the data you are documenting? – *complete, in progress, planned*
    a. Will the dataset be updated? If so, how frequently?

11. Where were the data collected? Include description and coordinates, if known.

12. List some keywords to help search for this dataset.
    a. Thematic, Place, Temporal, Strata, Taxonomy

    b. If a controlled vocabulary was used, what is the reference?

13. List any related datasets that could be documented for cross-reference.

14. The FGDC Biological Profile includes the means to document tabular datasets, taxonomy, field methods, and the use of analytical tools or models.
    a. Was your dataset developed using a model or other analytical tool?

        i. If so, what is the reference?

        ii. If the model or tool is available, include a contact and/or URL.

    b. Does the dataset contain biological information? If no, skip to item **15**.
        i. What species or communities were examined?

        ii. Did you use a taxonomic authority or field guide for identification? If so, what is the reference?

        iii. Briefly summarize your field methods (cut and paste from other documents!).

        iv. If you used existing protocols or methods, list the references.

        v. If you use a different taxonomic hierarchy than what is available in ITIS, then you need to supply the taxonomic hierarchy for all species within the dataset.

15. Is your dataset archived in a databank or data catalog? If yes, please include a reference to the documentation and skip to item 16. If No:
    a. What measures did you take to make certain that your dataset was as nearly correct as possible?

    b. Were there any things that you excluded from your data collection (e.g., stems less than a certain diameter or streams without surface flow)?

    c. What is the form of your dataset? - *spreadsheet, ASCII file, GIS layer, database, other*.

    d. What is the filename for your dataset?
        i. For each file or table, list the fields in the dataset and for each field list:

            - The definition of the field**.**

            - If the data are coded (Enumerated Domain), list the codes and the definitions.

            - If the codes come from a published code set (Codeset Domain), list the reference**.**

            - If the data are measured (Range Domain), list the units and the minimum and maximum allowable values ("no limit" is acceptable).

        ii. Otherwise, the domain is unrepresentable. Include a brief description of what is in the field**.**

16. Is this a GIS dataset? If no, skip to item 17.
    a. Include a path to where the data can be accessed over the network or send a copy of the ArcInfo export file, an ArcView shapefile, or an ArcCatalog exported metadata file (txt or xml).
        i. Include projection parameters, if necessary.

    b. List any source datasets you used. For each source, list:
        i. Source name, originator, and publication date.

        ii. Source time period and scale.

        iii. Source presentation form and media type.

        iv. Contribution of source to your analysis.

    c. List the processing steps you used to create your dataset, including the approximate date of processing.

17. Is the dataset available for distribution? If no, go to 18.
    a. Are there legal restrictions on who may use the data?

    b. Do you have any advice for potential users of the dataset?

    c. What are your distribution instructions?

18. You are done. Send this completed document with the relevant responses to this interview to your metadata coordinator (Sean Mohren, Klamath Network Data Manager Sean_Mohren@nps.gov, 541-552-8576).

Example Data Dictionary

Dataset: ASXXYY
File Type: mdb
Relationship: Area Search Header (one) to Area Search Data (many)
Table: Area Search Header

Field Name	Field	Required (Y/N)	Type	Length	Decimal	Definition	Enumerated Domain	Range Domain
RecNum	1	Y	Numeric	Integer	0	Auto Number based on order of entry; Key Field		Integer starting at 1, no limit
Project	2	Y	Character	20		Project or Region Code		
Site	3	Y	Character	20		Site name (often 4-letter code)	Each 4-letter code represents itself	
Point	4	Y	Character	2		Point (Search area)	Typically designated A or B	
Month	5	Y	Character	2		Month		01 to 12
Day	6	Y	Character	2		Day		01 to 31
Year	7	Y	Character	4		Year		
PrimObs	8	Y	Character	4		Primary observer's initials		
SecObs	9	N	Character	20		Secondary observer's initials, if multiple observers, initials separated by ","		
Temp	10	Y	Character	3		Temperature		Degrees Celsius, range=-10 to 40
CldCvr	11	Y	Character	3		Cloud Cover		Percentage, range=0 to 100%

Definitions and Acronyms

ArcCatalog — Module in ESRI's ArcGIS software within which metadata for spatial datasets (coverages, shapefiles) can be created.

Biological Data Profile — Set of definitions for the documentation of biological data through the creation of extended elements to the FGDC Content Standard for Digital Geospatial Metadata (CSDGM).

CSDGM — Content Standard for Digital Geospatial Metadata. The FGDC-promulgated metadata standard established to provide a common set of terminology and definitions for documenting digital geospatial data.

Dataset Catalog — NPS Inventory and Monitoring Program tool for metadata creation, ideal for abbreviated dataset documentation but not for fully FGDC-compliant metadata creation.

ESRI® — Environmental Systems Research Institute. A GIS software company.

FGDC — Federal Geographic Data Committee. The interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.

GIS — Geographic Information System. A computer system for capturing, manipulating, analyzing, and displaying data related to positions on the Earth's surface.

ISO — International Organization for Standardization. A network of national standards institutes of 150 countries, responsible for the "ISO 19115" international metadata standard.

Metadata — Data about the content, quality, condition, and other characteristics of a dataset, documented in a standardized format.

MP — Metadata Parser. A command-line program developed by the USGS to locate syntax errors in metadata files, verify FGDC-compliance, and convert between file formats.

NBII — National Biological Information Infrastructure. Collaborative program instrumental in developing the Biological Data Profile of the FGDC's CSDGM.

NPS Profile	The NPS Natural Resource and GIS Metadata Profile extends the FGDC CSDGM to incorporate NPS-specific elements such as park and project details. The NPS Profile includes the Biological Data Profile and the ESRI Profile.
NPS Data Store	The NPS Natural Resource, GIS, and I&M Programs' web-based system (incorporating a database, data server, and secure web interface) to integrate data dissemination and metadata maintenance for Natural Resource, GIS, and other program data sets, digital documents, and digital photos.
SGML	Standard Generalized Markup Language. An ISO standard flexible markup language (predecessor to XML) used in many applications, including electronic publishing on the Web.
XML	Extensible Markup Language. A simple and flexible text format (a profile, or subset, of SGML) that facilitates large-scale electronic publishing and exchange of data on the Web.

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #12: Revising the Protocol

Version 1.00 (February 2010)

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This document explains how to make and track changes to the KLMN Invasive Species Early Detection Monitoring Protocol, including its accompanying SOPs. While this monitoring protocol has been developed using current standardized methodology, all long-term monitoring programs need to be flexible to adapt to changes. As new technologies, methods, and equipment become available, this protocol will be updated as appropriate. Current best practices will be weighed against the continuity of protocol information in determining revisions. Project staff should refer to this SOP whenever edits are necessary and should be familiar with the protocol versioning system in order to identify and use the most current versions of the protocol documents. All changes will be made in a timely manner with the appropriate level of review.

All edits require review for clarity and technical soundness. Small changes to existing documents (e.g., formatting, simple clarification of existing content, small changes in the task schedule or project budget, or general updates to information management handling SOPs) may be reviewed in-house by project cooperators and KLMN staff. However, major changes to data collection or analysis techniques, sampling design, or response design will trigger an outside review. The Project Lead should determine if outside review is needed with input from the Pacific West Regional Inventory and Monitoring Coordinator.

Revision Procedures

The following procedures will ensure that both minor and major revisions to this document will align with the monitoring plan.

1. Discuss proposed changes with other project staff prior to making modifications. It is imperative to consult with the Data Manager prior to making changes because certain types of changes may jeopardize dataset integrity unless they are planned and executed to avoid this. Also, because certain changes may require altering the database structure or

functionality, advance notice of changes is necessary to help minimize disruptions to project operations. Consensus should be reached regarding who will be making the changes and in what timeframe.

2. Make the agreed-upon changes in the appropriate protocol document. Note that the protocol is split into separate documents for each appendix and SOP. Also note that a change in one document 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 documents. Also, the project task list and other appendices may need to be updated to reflect changes in timing or responsibilities for the various project tasks.

3. Document all edits in the Revision History Log embedded in the protocol narrative and each SOP. Log changes only in the document being edited (i.e., if there is a change to an SOP, log those changes only in that document). Record the date of the changes (i.e., the date when all changes were finalized), author of the revision, the change and the paragraph(s) and page(s) where changes are made, the brief reason for making the changes, and the new version number. Version numbers increase incrementally by hundredths (e.g., version 1.01, 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0). Record the previous version number, date of revision, and author of revision; identify paragraphs and pages where changes are made, rationale for revisions, and the new version number.

4. Circulate the changed document for internal review among project staff and cooperators. Minor changes and clarifications will be reviewed in-house. When significant changes in methodology are suggested, revisions will first undergo internal review by the project staff. Additional external review including, but not limited, to National Park Service staff with appropriate botanical and statistical expertise, will be required.

5. Upon ratifying and finalizing 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) are updated properly throughout the document.
    b. Make a copy of each changed file to the protocol archive folder (i.e., a subfolder under the Protocol folder in the project workspace).
    c. The copied files should be renamed by appending the revision date in YYYYMMDD format. In this manner, the revision date becomes the version number and this copy becomes the “versioned” copy to be archived and distributed.
    d. The current, primary version of the document (i.e., not the versioned document just copied and renamed) does not have a date stamp associated with it.
    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. Inform the Data Manager so the new version number(s) can be incorporated into the project metadata.

6. As appropriate, create PDF files of the versioned documents to post to the Internet and share with others. These PDF files should have the same name and be made from the versioned copy of the file.

7. Send a digital copy of the revised monitoring plan to the Project Lead and Network Data Manager. The revised monitoring plan will be forwarded to project and park staff who had been using a previous version of the affected document. Ensure that surveyors in the field have a hardcopy of the new version.

8. The Network Data Manager will place a copy of the revised protocol in the proper folder on the Klamath Network shared drive. In addition, the Network Data Manager will archive the previous version in the Klamath Network archive drive.

9. The Network Data Manager will post the revised version and update the associated records in the proper I&M databases, including but not limited to NatureBib, NPS Data Store, KLMN Intranet and Internet web sites, and the Protocol database.

Invasive Species Early Detection Monitoring Protocol for Klamath Network Parks

Standard Operating Procedure (SOP) #13: Post Field Season

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Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains procedures that will be completed after the field season, which include handling equipment, data forms, communication with NPS personnel, and reporting. Field crew members will assist the Crew Lead in completing post season field tasks.

Inventory, Clean, and Store Field Equipment

1. All equipment should be checked in following the Klamath Network property guidelines maintained by the Program Assistant. Electronic equipment (GPS units, rangefinders, laptop computers, etc.) should be checked in with the Data Manager.
2. Record broken or missing equipment on the Network's equipment inventory sheet. Label the equipment with sufficient information so that someone else will understand the specific problem.
3. Report missing or faulty equipment and/or equipment needing repairs to the Crew Lead so that equipment can be repaired or replaced before the following field season. It is the Crew Lead's responsibility to account for all equipment and have it repaired or replaced at the end of the field season.
4. All equipment should be cleaned, in working order, and stored in the proper storage location. Equipment should be prepared for winter storage, which will include removing batteries, emptying fluids, and winterizing trailers when applicable.

Vehicles

Vehicles should be full of fuel and the inside and outside thoroughly cleaned. Mileage reports and vehicle maintenance forms should be submitted to the Program Assistant. Any damage, needed repairs, or required maintenance should be reported at the time the vehicle is checked into the Network. Before signing off on the vehicle, one of the core Network staff should inspect the vehicle.

Interviews

Prior to ending the field technician's seasonal employment, the Crew Lead (or Project Lead if the Crew Lead is not available) should meet with the seasonal employees to discuss the field season. The following should be discussed:

- Determine how the field season went overall.
- Review what was accomplished and what did not get completed.
- Discuss options to improve upon any aspect of the protocol.
- Determine whether the field crew has any concerns that should be addressed prior to the next field season.
- Discuss field equipment (e.g., repairs needed, software updates, additional equipment, etc.).
- Review the training schedule and see if there are any areas for improvement or if there is additional training the field crew desires.

This information should be summarized and included in the briefing report. In addition to the field crews, the Crew Lead should contact the Park Contact to accomplish the following:

- Discuss the field season and determine if the park staff had any concerns or areas for improvement.
- Ensure all park keys have been returned.
- If park housing was used, make certain it was left in proper order.
- Examine ways to improve Project Lead, Crew Lead, Park Contact, and Field Crew relationships (e.g., improved communication, periodic meeting, etc.).

It is the Project Lead's responsibility to follow the check-out procedures developed by Redwood National Park when ending the employment of seasonal employees. At the end of the field season, 2 weeks prior to the end of the seasonal employee's employment, the Crew Lead should inform the Project Lead about an end date for each employee. The Project Lead should then work with Redwood National Park staff to complete the final paperwork.

Raw Data and Deliverables

There are a variety of deliverables associated with this project that should be stored in their proper location by the end of the field season. See SOP #8: Data Transfer, Storage, and Archive for a list of deliverables, when they should be stored, and who is responsible completing this task.

Appendix A. Prioritization of Non-native Plants in the National Park Service Klamath Network using Weighted Criteria and Measures of Uncertainty

Appendix A is a USGS report on the selection of non-native species for monitoring in the Klamath Network and the associated procedures that accompany this selection.

This appendix was not included because the report is only in PDF form. A copy of this appendix can be obtained through the USGS web page, at: http://www.pwrc.usgs.gov/brd/invasiveHandbook.cfm. In addition, the document is posted on the KLMN Intranet, which can be accessed by NPS staff.

Appendix B. Annual report – Invasive species early detection monitoring (pilot study) 2007.

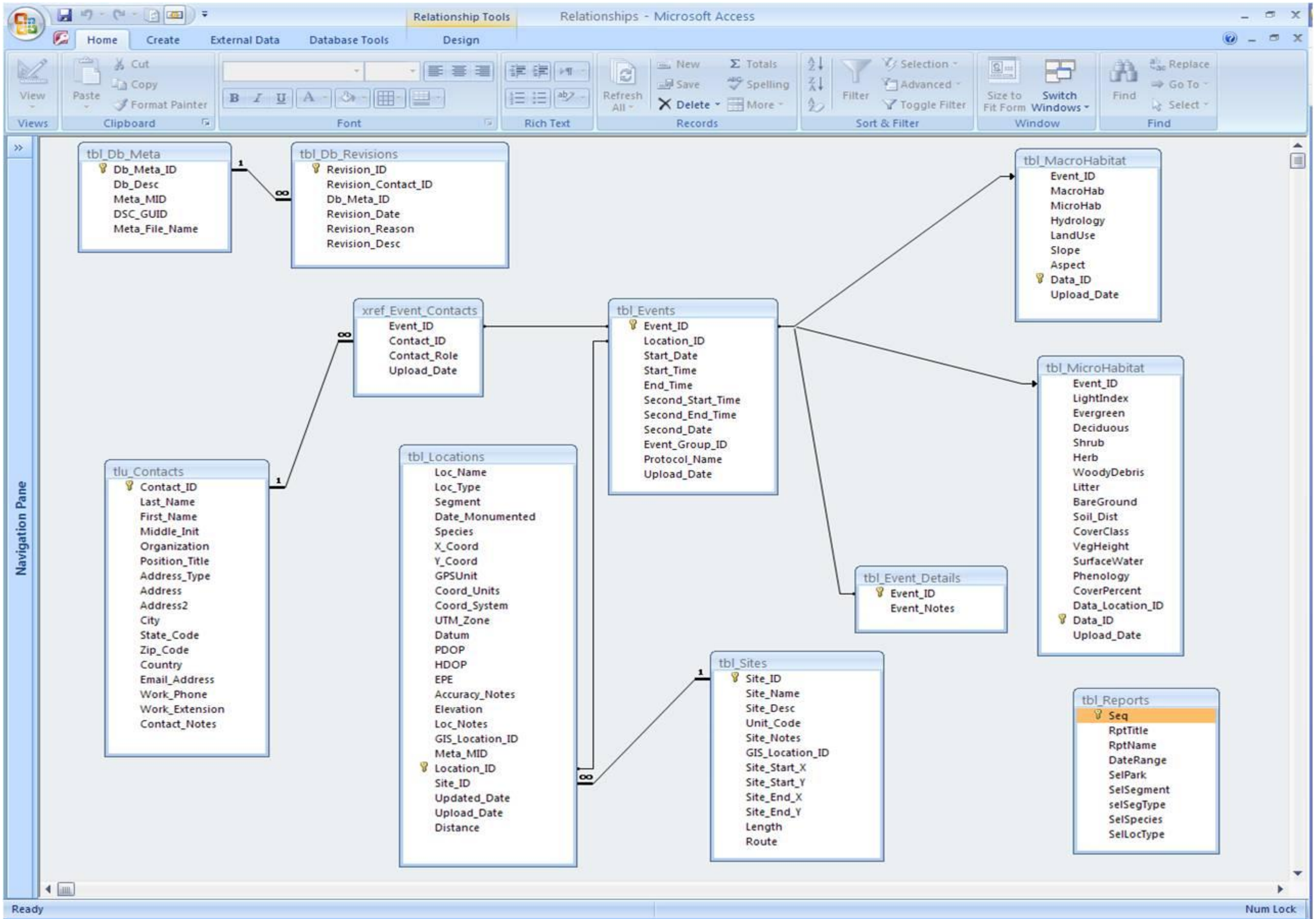
The Klamath Network completed a pilot study to test the Invasive Species Early Detection Protocol at Redwood National and State Parks in the fall of 2007. This appendix is the report resulting from that study. This report also serves as a template for future annual reports on invasive species monitoring. In general, the pilot study confirmed that the approach would be feasible, with some unsubstantial modifications. The data collected, however, are not likely to be sufficient in and of themselves for modeling individual invasive species habitat relationships. However, the data may be supplemented with data from the vegetation protocol or data collected by parks.

The report is available through the Klamath Network web site, specifically at: http://science.nature.nps.gov/im/units/klmn/Monitoring/vs/Invasives/documents/KLMN_ISED_PilotStudy_AnnualReport_2008_Final.pdf

Appendix C. Step by step invasive alien plant mapping methods for the Klamath Network, NPS.

This appendix is a report prepared by Andrew Duff on using general linear models and ordinary kriging to map species distribution. This report was prepared for the Klamath Network and is available on the Klamath Network web sites and by contacting Network personnel.

Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database.



Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database (continued).

Figure 1. Relationship diagram for main tables in the database.

Table Description: tbl_Sites: This table contains the general information about the survey area.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Site_ID	Y	Text	50	NA				Unique site identifer
Site_Name	Y	Text	100	NA	See list of roads and trail segements for each park			Name of the 3 kilometer segment
Site_Desc	Y	Text	9	NA	Trail, Road, Powerline			Category of the 3 kilometer segment
Unit_Code	Y	Text	4	NA	CRLA, LABE, LAVO, ORCA, REDW, WHIS			Park where the site occurs
Site_Notes	N	Memo	NA	NA				General notes about the segment
GIS_Location_ID	Y	Text	50	NA				Unique ID that links the site to the GIS Feature Class
Site_Start_X	Y	Number	6	0				Easting for the starting point of the transect
Site_Start_Y	Y	Number	7	0				Northing for the starting point of the transect
Site_End_X	Y	Number	6	0				Easting for the endpoint of the transect
Site_End_y	Y	Number	7	0				Northing for the endpoint of the transect
Length	Y	Number	NA	2				Length of the segment

Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database (continued).

Route	Y	Text	100	NA	See list of trails, roads, or powerline in the sampling frame			Name of the road, trail or powerline.

Table Description: tbl_Locations: This table contains the general information about the infestations and random plots surveyed along each segment.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Site_ID	Y	Text	50	Na	Na			Unique site identifer
Location_ID	Y	Text	50		Na			Unique location identifer
Loc_Name	Y	Text	100					Unique name for the location
Loc_Type	Y	Text	11		Infestation, Random			Category for location
Segment	Y	Text	50		See sampling frame			Subsegement surveyed
Species	Y	Text	100		See priority species list for each park			Scientific name of the species observed
Date_Monumented	Y	Date/Time	Na					Date the species was monumented
X_Coord	Y	Number	6					Easting for the locations
Y_Coord	Y	Number	7					Northing for the locations
Coord_Units	Y	Text	2		m			Coordinate Unit
Coord_System	Y	Text	3		Geo, UTM			Coordinate System
UTM_Zone	Y	Text	3		10N			UTM zone where the location was found
Datum	Y	Text	6		NAD83, WGS84			Datum of the location
GPS_Unit	Y	Text	20		Garmin 76CSx, Garmin 60CSx, Trimble XT, Trimble XM, Trimble XH			GPS Unit used to collect the location
PDOP	Y	Number	Na	1				Accuracy of the Trimble
HDOP	Y	Number	Na	1				Accuracy of the Trimble
EPE	Y	Number	Na	1				Accuracy of the Garmin
Elevation	Y	Number	Na					Elevation of the location
Loc_Notes	N	Memo	Na					General notes
Upload_Date	Y	Date/Time	Na					Date the electronically collected data was

Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database (continued).

								uploaded.

Table Description: tbl_Microhabitat: This table contains the general information about the infestations and random plots surveyed along each segment.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Event_ID	Y	Text	50	NA				Link to tbl_Events
Data_Location_ID	N	Text	50	NA				Optional link to tbl_Data_Locations
Data_ID	N	Text	50	NA				Field data table row identifier
LightIndex	N	Number	3	0		0	100	Light index measured with a densiometer
Evergreen	N	Number	3	0		0	100	Percent evergreen tree cover in the plot
Deciduous	N	Number	3	0		0	100	Percent deciduous tree cover in the plot
Shrub	N	Number	3	0		0	100	Percent shrub cover in the plot
Herb	N	Number	3	0		0	100	Percent herbaceous cover in the plot
WoodyDebris	N	Number	3	0		0	100	Percent woody debris in the plot
Litter	N	Number	3	0		0	100	Percent litter in the plot
BareGround	N	Number	3	0		0	100	Percent bareground in the plot
Soil_Dist	N	Number	3	0		0	100	Percent disturbance in the plot
CoverClass	N	Text	6	NA	< 1, 1 - 25, > 25			Estimated size of the infestions
VegHeight	N	Text	10	NA	0.5 -5, 5.1 - 10, 10.1 - 20, 20.1 - 30, >30			Estimated height of most dominant 3 species of canopy trees
SurfaceWater	N	Number	3	0		0	100	% of Surface Water within the Plot
Phenology	N	Text	10	0	Bolting, Bud, Dead, Flowering, Mature, Rosette, Seed Set, Seedling.			Maturity of the weed species

Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database (continued).

CoverPercent	N	Text	3	0		0	100	% of the Plot Covered by the weed
Upload_Date	y	Date/Time	NA	NA				Data the data was uploaded or entered into the database

Table Description: tbl_Macrohabitat: This table contains the general information about the infestations and random plots surveyed along each segment.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Event_ID	Y	Text	50	NA				Link to tbl_Events
Data_ID	N	Text	50	NA				Field data table row identifier
MacroHab	N	Text	5	NA	Top, Up, Mid, Low, Bottom			Macro Topography at the plot
MicroHab	N	Text	10	NA	Convex, Concave, Straight, Undulating			Micro Topography at the plot
Hydrology	N	Text	40	NA	Flooded Permanently / Semi-permanently, Seasonally / Temporary Flooded, Seep, Upland			Water source closest to the plot
LandUse	N	Text	20	NA	Campground, Cultivation, Ditch / Diversion, Graded, Homestead, Logging, Mining, Pasture, Road / Trail			Landuse at the plot.
Slope	N	Text	2	NA		0	90	Slope of the site in % measured using a Clinometer.
Aspect	N	Number	3	NA		1	360	Aspect of the site in compass degrees facing out from the site.
Upload_Date	Y	Date/Time		NA				Data the data was uploaded or entered into the database

Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database (continued).

Table Description: tbl_Reports: This table contains the information needed to make the reporting tool for this database function.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Seq	Y	Number	NA	0				A sequence so you can sort the reports
RptTitle	Y	Text	100					Title of the report, analysis, or raw data
RptName	Y	Text	100					Name of the report, analysis, or raw data
DateRange	Y	Yes / No	NA					Makes the date field visible
SelPark	Y	Yes / No	NA					Makes the park field visible
SelSegment	Y	Yes / No	NA					Makes the segment field visible
selSegType	Y	Yes / No	NA					Makes the segment type field field visible
SelSpecies	Y	Yes / No	NA					Makes the species field visible
SelLocType	Y	Yes / No	NA					Makes the location type field visible

Table Description: tbl_Contacts: This table provides the contact information for people working on this project.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Contact_ID	Y	Text	50	NA				Unique ID for each individual
Last_Name	Y	Text	50	NA				Last name of the individual
First_Name	Y	Text	50	NA				First name of the individual
Middle_Init	N	Text	1	NA				Middle initial of the individual
Organization	Y	Text	20	NA				Organization the individual is working for
Position_Title	Y	Text	20	NA				Postions they hold on the project
Address_Type	Y	Text	25	NA	Physical, Mailing, Physical and Mailing			Type of address entered

Appendix D. Data dictionary and relationship diagram for the KLMN EDIS database (continued).

Address	Y	Text	255	NA				Their contact address
Address2	N	Text	255	NA				Their contact address
City	Y	Text	50	NA				City where they live
State_Code	Y	Text	2	NA				State where they live
Zip_Code	Y	Number	5	NA				Zipcode where they live
Country	Y	Text	3	NA				Country where they live
Email_Address	N	Text	100	NA				Email address of the individual
Work_Phone	Y	Text	14	NA				Work phone number
Work_Extension	N	Text	10	NA				Work extension number
Contact_Notes	N	Memo	NA	NA				General information

Table Description: tlu_Enumeration: This table provides the contact information for people working on this project

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Enum_Code	Y	Text	50	NA				Code for lookup values
Enum_Description	N	Memo	NA	NA				Lookup value description
Enum_Group	Y	Text	50	NA				Category for lookup value
Sort_Order	Y	Number	NA	0				Order in which to sort lookup values

Appendix E: Job Hazard Analysis for the KLMN Invasive Species Early Detection Monitoring Protocol

Version 1.00 (February 2010)

The Klamath Network (KLMN) will make every effort to comply with the NPSafe program and with local park safety programs. KLMN takes safety seriously, and it is the number one priority when developing and implementing these protocols. Crews are expected to be trained on all safety aspects of this project prior to entering the field.

The vision of the NPSafe program is:

> *"The NPS is widely recognized for providing world-class resource stewardship and visitor experiences. Just as the NPS excels at protecting natural and cultural resources and serving park visitors, the NPS can excel in providing our employees with a safe work environment. All employees deserve the opportunity to do their jobs safely and effectively so they can go home healthy at the end of the day to fully enjoy their lives and families."*

The beliefs of the NPSafe program are:

- We believe that healthy, productive employees are our most important resource, and employee safety is our most important value.
- Injuries and occupational illnesses are unacceptable and all are preventable.
- At risk behaviors can be eliminated.
- Operating hazards and risks can be controlled.
- Safety is everyone's responsibility.
- Managing for safety excellence can enhance employee productivity, save millions of dollars in workers compensation costs, and improve overall management effectiveness.

The goals of the NPSafe program are:

1) The NPS becomes the safest place to work in DOI.
2) Safety is integrated into all NPS activities.
3) The NPS organizational culture values employee safety as much as it values protecting resources and serving visitors.
4) Employees, supervisors, and managers demonstrate unwavering commitment to continuous improvement in employee health and safety.

To meet these goals, the KLMN has included several Job Hazard Analyses (JHA) in this appendix that should be followed while implementing this protocol.

JOB HAZARD ANALYSIS (JHA)		Date: 1/21/2010	
Park Unit: KLMN	Division: IMD	Branch: NRPC	Location: Ashland, Oregon
Task Title: Driving vehicles in the course of one's job		JHA Number: KLMN JHA 1	Page: 1 of 3
Job Performed By: ALL	Analysis By: Daniel Sarr	Supervisor: Daniel Sarr	Approved By: Daniel Sarr
Required Standards and General Notes:	Employees driving as part of their duties must have a valid state issued driver's license.		
Required Training:	Standard drivers training. Also need to know how to change tires and jump start vehicle.		
Required Personal Protective Equipment:	Seatbelts must be used.		
Tools and Equipment:	Vehicle		

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Starting vehicle, basic operation	• Lights not functioning, visibility impaired • Low tire pressure • Low fluid levels • Spare tire not in vehicle or deflated • Low gas	• Test headlights, turn signals, brake lights, breaks, tire pressure and all fluids • Check status of spare; insure that jack, properly sized lug wrench and all necessary tools are present in vehicle • Check gas
Using 4 wheel drive, if applicable.	• Not knowing how to engage, getting stuck in the field • Unsafe driving procedures due to perceived safety of 4 wheel drive	• Practice engaging 4 wheel drive • Engage 4 wheel drive prior to rough conditions • Use 4 wheel drive when increased traction is necessary; e.g., steep slopes, slick conditions, snow • Even in 4 wheel drive, do not assume safety is enhanced. Use cautious and defensive driving practices.
Driving in reverse	• Hitting objects, people, wildlife	• Check area behind vehicle prior to leaving site • Use a person outside the vehicle (other crew member) to direct traffic • Back into parking spots, so leaving sites after long field day is easier and less likely to result in fatigue related mishap

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 1	Page: 2 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Transporting gear and heavy equipment	• Gear flying around, hitting driver and passenger in accident • Damage to gear during turns or stops	• Ensure that gear is adequately stowed. • If the gear comes with protective gear (e.g., electrofisher), properly stow in container. • Do not put gear on top of vehicle; stow inside.	
Passenger/driver safety	• Distracted driving	• Wear seatbelts at all times while driving. • Practice safe and defensive driving habits. • Obey traffic laws. • Do not text. Pull over and stop to use phone. • Keep windshields clean. • Drive with both hands on the wheel at 10 o'clock and 2 o'clock. • Do not pick up hitch hikers. • Use turn signals/indicators. • Plan route in advance. • Make sure seat and mirrors are properly adjusted for driver • Use headlights, even during day time driving.	
	• Driving on narrow, single lane roads with bumpy or "washboard" surfaces.	• Maintain a safe speed (this may be below the legal limit). • Stay to the right, especially on curves, and be aware for oncoming traffic. • If turning around, "face the danger," in other words, turn towards a steep slope, instead of backing into a steep slope cliff.	
	• Driving with limited visibility, as in heavy rain, fog, or dust.	• Slow down. • If possible, wait for conditions to imporve. • Drive with lights on. In some conditions, low lights may penetrate better than brights.	

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 1	Page: 3 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Passenger/driver safety	• Fatigue driving	• Be aware of signs of fatigue. Pull over and catnap if necessary, eat a snack, or have a partner drive. If in doubt, do not drive.	
	• Storm conditions (snow, mud, wind)	• Keep informed of the weather. • If excess wind (tree top swaying, twigs falling) consider postponing trip. • Avoid wet clay roads as much as possible.	
	• Road obstacles	• Get out and move rocks in the road as necessary. If large amounts of rockfall or trees, report to the park staff. • If you hit rocks, stop and check tire conditions (wear, sidewall, and inflation) for damage. • If obstacle is an animal, slow down! Be aware of high animal traffic areas and drive appropriately. It is better to "ride out" an impact than suddenly swerve. This is true for animals of all sizes, from squirrels to cattle.	
Working/Parking on or near a roadside	•Being hit by a car	• Stay off of the road. • Use pullouts or secondary road when parking. • Be aware of the traffic. • Walk on the side of the road facing traffic. • Always set out safety triangles or flares behind the vehicle before starting any maintenance. • Never go under the vehicle while it is up on a jack.	
Working/Parking on or near a roadside	•Running into objects, parking too far off the road, getting stuck, rolling vehicle	• Park on stable surface. • Don't park on a blind corner or a solid striped road area. • Set parking break.	

Description of Task When it is Done Safely

Crew returns safe from the field day/season, with no injuries, damages, or law suit.

JOB HAZARD ANALYSIS (JHA)		Date: 1/21/2010	
Park Unit: KLMN	Division: IMD	Branch: NRPC	Location: Ashland, Oregon
Task Title: Remote field site access/ trail travel/ cross-country travel		JHA Number: KLMN JHA 2	Page: 1 of 3
Job Performed By: ALL	Analysis By: Daniel Sarr	Supervisor: Daniel Sarr	Approved By: Daniel Sarr
Required Standards and General Notes:	Crew members should be physically fit		
Required Training:	None required.		
Required Personal Protective Equipment:	Footwear appropriate to terrain (probably hiking boots); pants if hiking through brush or poison oak; Tecnu poison oak pre-exposure lotion, park radio with charged batteries, GPS units, eyewear, first aid kit.		
Tools and Equipment:			

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Hiking on and off trails	• Getting lost	• Use and be trained in navigation techniques using both maps and GPS units. • Allow ample time to access site and return. • Bring safety gear (e.g., radio); extra clothes, water, food, etc. • Look at notes from crews that previously accessed this site.
	• Physical injury (e.g., twisted ankle, broken bones)	• Wear appropriate footwear, preferably boots with vibram soles and tops above the ankle, broken in prior to field season. • Walk cautiously and don't run. • Take breather breaks as necessary. • Stay physically fit. • Know basic first aid. • Be trained in radio SOP. • Avoid talus slopes. On steep slopes, avoid walking directly below others. • Take care walking on wet or slippery ground, especially bridges.
	• Getting hit with tool, implement, or vegetation branch	• Maintain 6 foot spacing • Warn people behind of "snap-back" from vegetation branches; wear safety glasses (or other glasses).

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 2	Page: 2 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Hiking on and off trails	• Blisters	• Wear broken in and proper fitting boots. • Bring moleskin and use if blisters develop.	
	• Carrying heavy loads	• Use backpack appropriate to load; do not carry heavy items in arms or hands; make hands available to break a fall. • Properly fit backpack. • Use crew member to assist in putting pack on. • Be physically fit. • Report problems or issues to supervisor. • Stay hydrated.	
	• Loose footing; falls, broken bones, etc.	• Avoid steep slopes. • If unavoidable, walk at angle up slope; not straight up. • Wear good boots. • Do not go up hazardous slopes. • Watch for branches, wet, slick rocks, etc. Avoid as necessary. • Take your time, ascending and descending. • Plan your route so that hazardous terrain is minimized and the use of trails is maximized. • Do not travel alone (e.g., if one crew member is faster, only travel as fast as your slowest person).	
	• Branches and trees, other dangerous obstacles	• Examine for the safest way around. • Do not jump off trees. • Avoid going underneath large trees that could shift and crush a person.	

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 2	Page: 3 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Wildfires	• Exposure to smoke and fire	• Don't panic. Be alert. Keep calm. Think clearly & act decisively. Get out of the area immediately. • Maintain communication with other crew members and with dispatch. Follow local district policies regarding reporting fire.	
Water Crossing	• Loose footing; falls, broken bones, etc.	• Choose stream crossing routes by scouting the area first • Avoid crossing when water levels are higher than knee height. Avoid crossing on logs whenever possible. • Use a stick or pole to secure footing. Place it upstream at a slight angle. Use pole to test for depth & walk to the pole. • Stay out of areas with swift current, especially after heavy snowfall, rain, or spring melt. • Use footwear with non-slip soles while walking in streams. Do not wear sandals in streams. • When possible, step on streambed proper instead of the tops of boulders that may be slippery.	

Description of Task When it is Done Safely

Crew returns safe from the field day/season, with no injuries, damages, or law suit.

JOB HAZARD ANALYSIS (JHA)		Date: 1/21/2010	
Park Unit: KLMN	Division: IMD	Branch: NRPC	Location: Ashland, Oregon
Task Title: Environmental Exposure		JHA Number: KLMN JHA 3	Page: 1 of 3
Job Performed By: ALL	Analysis By: Daniel Sarr	Supervisor: Daniel Sarr	Approved By: Daniel Sarr
Required Standards and General Notes:	Field crew members in the field are expected to use common sense in dealing with exposure to elements or wildlife. Ideally, they have experience in outdoor work prior to initiating the field season.		
Required Training:	None required.		
Required Personal Protective Equipment:	Appropriate clothing for conditions.		
Tools and Equipment:			

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Being outdoors, far from facilities for long time periods	• Hypothermia	• Consult First Aid book for treatment. • Seek assistance. • Recognize the signs: Shivering; Numbness; Drowsiness; Muscle Weakness; Dizziness; Nausea; Unconsciousness; Low, weak pulse; Large pupils. • Practice prevention: stay dry; wear appropriate clothing; cotton kills; wear layers, shed layers as needed (don't overheat as sweat can cause hypothermia); watch or listen to the weather forecast, and plan accordingly; stay hydrated, cover head with warm clothing, stay active. • Be aware of the role that wind-chill can play in hypothermia; under certain conditions, hypothermia can occur without any rain or being wet.
	• heat exhaustion; heat stroke	• Consult First Aid book for treatment but generally get the victim to cooler conditions. NOTE: HEAT STROKE IS A LIFE THREATENING CONDITION. • Recognize signs: above normal body temps; headaches, nausea, cramping, fainting, increased heart rate, pale and clammy skin, heavy sweating, etc. • Practice prevention: Stay hydrated: in the midst of the summer, it may be necessary to drink 1 liter of water per hour; wear a broad brimmed hat; take rest stops in shade. • Reschedule work day to do hot, heavy work in cooler hours of the day, or during cooler weather

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 3	Page: 2 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Being outdoors, far from facilities for long time periods	• Electrical Storms – lightning	• Watch the sky for signs of thunderstorms and seek shelter before the weather deteriorates. • Stop work in streams and lakes. • If caught in electrical storms, seek shelter inside a vehicle or building; keep away from doors and windows, plugged in appliances, and metal. Avoid contact with metal objects in vehicles.	
	• Electrical Storms – lightning	• Do not use telephones. • If outside with no shelter, do not congregate. In case of lightning strike, someone must be able to begin revival techniques (e.g., CPR). • Do not use metal objects. • Avoid standing near isolated trees. • Seek lower elevations such as valleys or canyons; avoid being on peaks and trees. • If you feel your hair standing on end and your skin tingling, this is a sign that lightning might be about to strike – crouch immediately (feet together, hands on knees).	
	• Sunburn	• The risk of sunburn is higher when working at high elevations, or when working around water (from reflection). In these conditions, you can be burned even in overcast conditions. • Wear protective clothing and use sunscreen.	
	• High wind events	• Severe wind events can create “windthrows” where strong winds can blow down trees, causing hazardous conditions to field personnel. Crews should avoid areas during high wind, exhibiting obvious previous wind damage.	

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 3	Page: 3 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
	• Altitude sickness	• Know and recognize signs of "acute mountain sickness:" headaches; light-headedness; unable to catch your breath; nausea; vomiting. • Practice prevention: acclimate to high elevations slowly and stay hydrated. • If symptoms progress and include: difficulty breathing, chest pain, confusion, decreased consciousness or loss of balance, descend to lower elevations immediately and seek medical attention.	
	• Giardia	• Treat, filter, or boil all drinking water. Do not drink untreated water from streams, lakes, or springs.	

Description of Task When it is Done Safely

Crew returns safe from the field day/season, with no injuries, damages, or law suit.

JOB HAZARD ANALYSIS (JHA)		Date: 1/21/2010	
Park Unit: KLMN	Division: IMD	Branch: NRPC	Location: Ashland, Oregon
Task Title: Wildlife and Botanical Exposure		JHA Number: KLMN JHA 4	Page: 1 of 3
Job Performed By: ALL	Analysis By: Daniel Sarr	Supervisor: Daniel Sarr	Approved By: Daniel Sarr
Required Standards and General Notes:	Field crew members in the field are expected to use common sense in dealing with exposure to elements or wildlife. Ideally, they have experience in outdoor work prior to initiating the field season.		
Required Training:	None required.		
Required Personal Protective Equipment:	Appropriate clothing for conditions.		
Tools and Equipment:			

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Driving to the site	• Animal in the road	• Slow down! Be aware of high animal traffic areas and drive appropriately. It is better to "ride out" an impact, rather than a sudden swerve. This is true for animals of all sizes, from squirrels to cattle.
Being in the field	• Rattlesnakes	• Be alert • Do not put your feet or hands where you cannot see • Do not pick up rattlesnakes • Give a wide berth • Avoid stepping over logs, when you cannot see the other side • If bitten, seek immediate professional medical attention if possible send someone for aid. • Lower bitten extremity below your heart, cover wound with sterile bandage while en route to medical attention.
	• Bears	• Be alert and stay calm. • If you encounter a bear, give it as much room as possible. • Try to leave the area but DO NOT RUN. Back away slowly, but if the bear follows, stop and hold your ground. • Wave your arms, make yourself look big, and talk in a normal voice • If the bear makes contact, surrender! Fall to the ground and play dead. Typically, a bear will break off its attack once it feels the threat has been eliminated. If the bear continues to bite after you assume a defensive posture, the attack is predatory and you should fight back vigorously.

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 4	Page: 2 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Being in the field	• Mountain Lions	• Be alert, calm, and do not panic. • If you see a mountain lion, do not run; you may stimulate its predatory nature. Shout and wave arms to let it know that you are not prey. FIGHT BACK.	
	• Ticks	• Use DEET based repellants on exposed skin. • Check for ticks during and after field work. • Remove with tweezers within 24 hours, preferably immediately. • DO NOT leave the head imbedded. • DO NOT extract with matches, petroleum jelly, or other coatings (e.g., motor oil).	
	• Roughskin newts (*Taricha granulosa*)	• Avoid handling Roughskin newts; their skin contains a potent neurotoxin. If necessary for the protocol, handle only when wearing gloves. Do not "lick" for "killer buzz." People have died from attempting to eat roughskin newts.	
	• Insect Sting	• Do not provoke insects by swatting at them. Remain calm and move away from the area. • Be alert for buzzing insects both on the ground and in the air. Walk around any nests you encounter. Inform others of nests. • Flag if necessary. Wear long sleeved shirt and pants. Tuck in shirt. Wear bright colors. Perfumes & metal objects may attract bees. • If stung, scrape stinger off skin. Cold can bring relief. Do not use tweezers. Tweezers can squeeze venom sac and worsen injury. • If you are allergic, carry an unexpired doctor prescribed bee sting kit (EpiPen) with you at all times. • Know the allergic reactions of co-workers as well as the location of the bee sting kit. If victim develops hives, asthmatic breathing, tissue swelling, or a drop in blood pressure, seek medical help immediately. Give victim antihistamine (Benadryl or chol-amine tabs). Use EpiPen. • Prevent bug/mosquito bites by using repellent. Spray on clothing to avoid prolonged exposure to skin. Wear long sleeved shirts and pants. • Be aware of insect transmitted diseases (West Nile Virus, Lyme Disease, Plague).	

JOB HAZARD ANALYSIS (JHA)		JHA Number: KLMN JHA 4	Page: 3 of 3
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**	
Being in the field	• Rabies	• Be aware of animals acting strangely. If bitten by a wild or domestic animal get medical attention and report to local health authorities or animal control officer. Locate animal if possible. Follow accident procedures for animal bites.	
Encountering irrigation pipes, marijuana plantation, or grow operations.	• Unfriendly encounters with criminal elements	• Do not wear uniforms. • Carry radio in backpack, not visible. • Act like tourists (i.e., act unsuspicious). • Work in pairs or larger groups. • If working in areas likely to contain operations, check in with park staff when leaving vehicle and returning to vehicle. • Do not confront strangers. • Watch for suspicious vehicles and people and report to rangers. • Watch for black piping or other signs. • If finding a definite grow operation, LEAVE IMMEDIATELY, note location, and report to park ranger.	
Travel, movement or work in area with Poison Oak	• Allergic reaction to poison oak plants	• Learn to recognize Poison Oak. • Avoid contact and wear long pants and long-sleeve shirts if travelling in dense areas. • If skin contact is made, flush with cold water as soon as possible. • DO NOT flush with warm water or use soap. This can open your pores and increase the reaction. • Use Tec-nu or similar product to wash and rinse with cold water to remove oils (follow label instructions).	

Description of Task When it is Done Safely

Crew returns safe from the field day/season, with no injuries, damages, or law suit.

JOB HAZARD ANALYSIS (JHA)		Date: 1/21/2010	
Park Unit: KLMN	Division: IMD	Branch: NRPC	Location: Ashland, Oregon
Task Title: Communication		JHA Number: KLMN JHA 5	Page: 1 of 2
Job Performed By: ALL	Analysis By: Daniel Sarr	Supervisor: Daniel Sarr	Approved By: Daniel Sarr
Required Standards and General Notes:			
Required Training:	Radio / Spot use		
Required Personal Prospective Equipment:			
Tools and Equipment:	Professional Grade Radio, SPOT Monitoring System		

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Radio communication	• Communication not possible	• Make sure radio is working before you leave the office or field station. Make sure batteries are changed. Carry a second rechargeable battery as back up. • Check in mornings and evenings. If in a dead zone, try to check in from a better location throughout the day. Be prepared to relay messages in an emergency. If you are working alone, be sure to check in and out with dispatch. • Make sure that your supervisor knows your planned itinerary before you leave in case your radio fails. Follow crew-specific safety check in/checkout procedures. • Know which radio frequencies to use and which to monitor. Know who to call in case of an emergency. Know how to reach repeaters. • Carry a list of employee call numbers. Be prepared to relay messages in an emergency. • Keep messages short, less than 30 seconds per transmission. If a longer message is necessary, break every 30 seconds. • Conserve batteries. Carry a spare and don't leave scanner on. Turn radio off over night. Your life may depend on it.
Spot System	• Communication not possible	• Make sure system is working before you leave the office or field station. Make sure batteries are changed. Carry a second rechargeable battery as back up. • Make sure that your supervisor knows your planned itinerary before you leave in case your system fails. Follow crew specific safety check in/checkout procedures. • Make certain system is setup properly and includes an accurate contact list.

Description of Task When it is Done Safely

Crew returns safe from the field day/season, with no injuries, damages, or law suit.

NPS 963/105042, July 2010

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov