National Park Service
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Natural Resource Program Center

Upper Columbia Basin Network
Sagebrush Steppe Vegetation Monitoring Protocol

Narrative Version 1.0

Natural Resource Report NPS/UCBN/NRR—2009/142

ON THE COVER
Sagebrush steppe vegetation in City of Rocks National Reserve
Photo courtesy of NPS Upper Columbia Basin Network

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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

1. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.

2. Notify the UCBN Data Manager of any changes to the Protocol Narrative or SOPs so that the new version number can be incorporated in the Metadata of the project database.

3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOPs. A list will be maintained in an appendix at the end of this document.

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This appendix is available from the Upper Columbia Basin Network website (http://www.nature.nps.gov/im/units/UCBN) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM).

Executive Summary

The mission of the National Park Service is "to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations" (National Park Service 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation's natural heritage through science, natural resource inventories, and expanded resource monitoring (National Park Service 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The Upper Columbia Basin Network (UCBN) has identified 14 priority park vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Our intent has been to develop a balanced and integrated suite of vital signs that meets the needs of current park management, and that also will accommodate unanticipated environmental conditions and management questions in the future. Sagebrush steppe is a high priority vital sign for five UCBN parks: City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), and Lake Roosevelt National Recreation Area (LARO). Sagebrush steppe occupies over 50% of land cover in CIRO, HAFO, and JODA, and over 90% of the vegetated area of CRMO. At LARO, sagebrush steppe is present and significant in the southern half of the Park and represents an important park ecosystem. Historic and current land use practices both within and adjacent to UCBN parks continue to fragment and alter steppe ecosystems, and accelerated climate change predicted to occur in the region will likely exacerbate these changes.

This protocol details the why, where, how, and when of the UCBN's sagebrush steppe monitoring program. As recommended by Oakley et al. (2003), it consists of a protocol narrative and a set of standard operating procedures (SOPs) which detail the steps required to collect, manage, and disseminate the data representing the status and trend of sagebrush steppe ecological condition in the Network. The protocol is a "living" document in the sense that it is continually updated as new information acquired through monitoring and evaluation leads to the refinement of program objectives and methodologies. Changes to the protocol are carefully documented in a revision history log. The intent of the protocol is to ensure that a scientifically credible story about the ecological condition of park sagebrush steppe communities and their responses to park management actions, changing precipitation patterns, and other stressors can be told to park visitors and managers alike. Pilot data collected from each park during 2008 and 2009 have answered preliminary questions about current park sagebrush steppe condition and resolved outstanding logistical and methodological questions for the monitoring program. From here, the focus will now shift toward status and trend analysis, in which baseline conditions of sagebrush steppe ecological condition will be described for each park, and biologically meaningful declines or increases in indicators of sagebrush steppe ecological condition will be detected over longer time intervals. These long-term data can contribute to the development of informative models of relationships between sagebrush steppe community conditions and key environmental factors and management actions specific to each park.

Acknowledgements

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Servicewide Inventory and Monitoring Program. We thank the Park superintendents and resource staff who met with us in the field to discuss park management objectives and information needs, and who provided invaluable feedback on this protocol. Matt Rauch, University of Idaho, assisted in the development of the draft Microsoft Access database for this protocol. Dr. Kirk Steinhorst, University of Idaho, provided guidance on sampling design and data analysis. Jannis Jocius and Eric Starkey, University of Idaho, provided helpful comments and formatting edits, and ensured timely completion of the final protocol document. We thank Dr. Penny Latham, NPS Pacific West Region Inventory and Monitoring Coordinator, for facilitating peer reviews and providing their own rigorous review of this protocol. Finally, we thank the anonymous reviewers who provided thorough and constructive comments on this protocol.

Background and Objectives

This document presents a protocol for monitoring the status and trends of indicators of sagebrush steppe ecological condition in five Upper Columbia Basin Network (UCBN) parks: City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), and Lake Roosevelt National Recreation Area (LARO). The protocol details a sagebrush steppe community sampling strategy, including a sampling design and field methods, which will enable the UCBN to achieve monitoring and sampling objectives identified in this document and in the network monitoring plan (Garrett et al. 2007).

Rationale for Monitoring Sagebrush Steppe in the Upper Columbia Basin

Prior to European colonization, sagebrush steppe covered approximately 44 million ha of the Intermountain West (West and Young 2000). Since then the sagebrush steppe ecosystem has experienced extensive changes (USDA Forest Service 1996, West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). Substantial portions of the region have been converted to agriculture and development (West and Young 2000, Bunting et al. 2002). Much of the remaining sagebrush steppe has been degraded through overgrazing by livestock, altered fire regimes, and invasion of introduced plants (Reid et al. 2002). These changes have had significant impacts on the ecological condition of the sagebrush steppe, including a decline in native flora and fauna, decreased soil stability, and reduced hydrologic function (Mack and D'Antonio 1998, Wisdom et al. 2000, Keane et al. 2002, Knick et al. 2003, Dobkin and Sauder 2004). Sagebrush steppe today is one of the most threatened ecosystems in the Intermountain West (Noss et al. 2005). Biological invasions, altered fire regimes, and other stressors continue to cause major, possibly irreversible, changes to steppe ecosystem structure and function (e.g., Knick et al. 2003, 2005, Brooks et al. 2004, Dobkin and Sauder 2004).

The degradation of sagebrush steppe so widespread throughout the Intermountain West has also occurred within UCBN parks. Sagebrush steppe is the most extensive ecosystem type in the Upper Columbia Basin Network (UCBN), occupying over 50% of land cover in CIRO, HAFO, and JODA. At CRMO, where bare lava rock comprises 81% of the total land cover, sagebrush steppe represents over 90% of the vegetation cover. At LARO, sagebrush steppe is present and extensive in the southern half of the Park. Historic and current land use practices both within and adjacent to UCBN parks continue to fragment and alter steppe ecosystems (e.g., Knick and Rotenberry 1997, Hanser and Huntly 2006), and predicted climate change scenarios for the region will likely exacerbate these changes with potential outcomes including increased frequency of drought and wildfire, increased ability of non-native species to invade sagebrush steppe, and altered phenology (Smith et al. 2000, Wagner et al. 2003). Long-term vegetation trends at the Idaho National Laboratory (INL) near CRMO provide substantial evidence of the importance of climate patterns on sagebrush steppe vegetation dynamics (Anderson and Inouye 2001). A half century of monitoring at INL has shown a multi-decadal plant community response to prolonged drought during the mid-20th century that has important implications for management within the context of varying and changing climate.

The UCBN has identified the ecological condition of sagebrush steppe vegetation as a high priority vital sign and monitoring of steppe condition will be a central element to the UCBN monitoring program (Garrett et al. 2007). Community response to fire and drought, vulnerability to invasion, and the potential for restoration and recovery can differ significantly among sagebrush steppe communities (Reid et al. 2002, Bureau of Land Management 2002). The heterogeneity of sagebrush community types (e.g., alliances and associations defined by *Artemisia* subtaxa) in the UCBN, the complexity of ecological threats to sagebrush steppe ecosystems, and the substantial variability of vegetation change that has been reported among years and decades emphasizes the uncertainty that managers face. Understanding the complexity of change at the park level is critical for effective management strategies to be developed. These challenges underscore the need for a long-term monitoring program that provides for routine evaluation of the status of UCBN steppe communities, and for identification of trends over time within parks and across the network. This information will provide the feedback required for effective adaptive management.

Prior to settlement of the west, infrequent fires in sagebrush steppe typically killed sagebrush and other shrubs but native grasses and forbs quickly recovered by sprouting of surviving plants or from seed. With the advent of livestock grazing, introduction of non-native plants, and fire suppression, the simple cycle of infrequent fire and natural recovery was broken. We developed a basic state and transition model that encapsulates current knowledge and management assumptions of cause and effect in the sagebrush steppe ecosystems of UCBN parks (Figure 1). The model highlights the principal disturbance factors currently driving ecosystem change: natural disturbances such as drought and wildfire, which may be exacerbated by accelerated climate change, and anthropogenic disturbances such as livestock grazing, introduction of invasive plants, and fire suppression. We've chosen a subset of indicators of sagebrush steppe ecological condition to implement an effective monitoring program that addresses the fundamental attributes biotic integrity, soil stability, and hydrologic function:

- Canopy cover of sagebrush, native grasses & forbs
- Canopy cover of non-native invasive annual grasses & forbs
- Cover of exposed soil

This protocol will provide considerable information on established invasive grasses and forbs, contributing to the UCBN invasive/exotic species vital sign, and will complement early detection monitoring that will be addressed in a separate protocol. Additionally, information on sagebrush-steppe habitat conditions at CIRO and CRMO obtained through this protocol will complement sage grouse (*Centrocercus urophasianus*) lek monitoring data being collected by Idaho Department of Fish and Game in and near these parks. Finally, this protocol will complement vegetation plot data being collected in JODA by the NPS Fire Effect Monitoring Program.

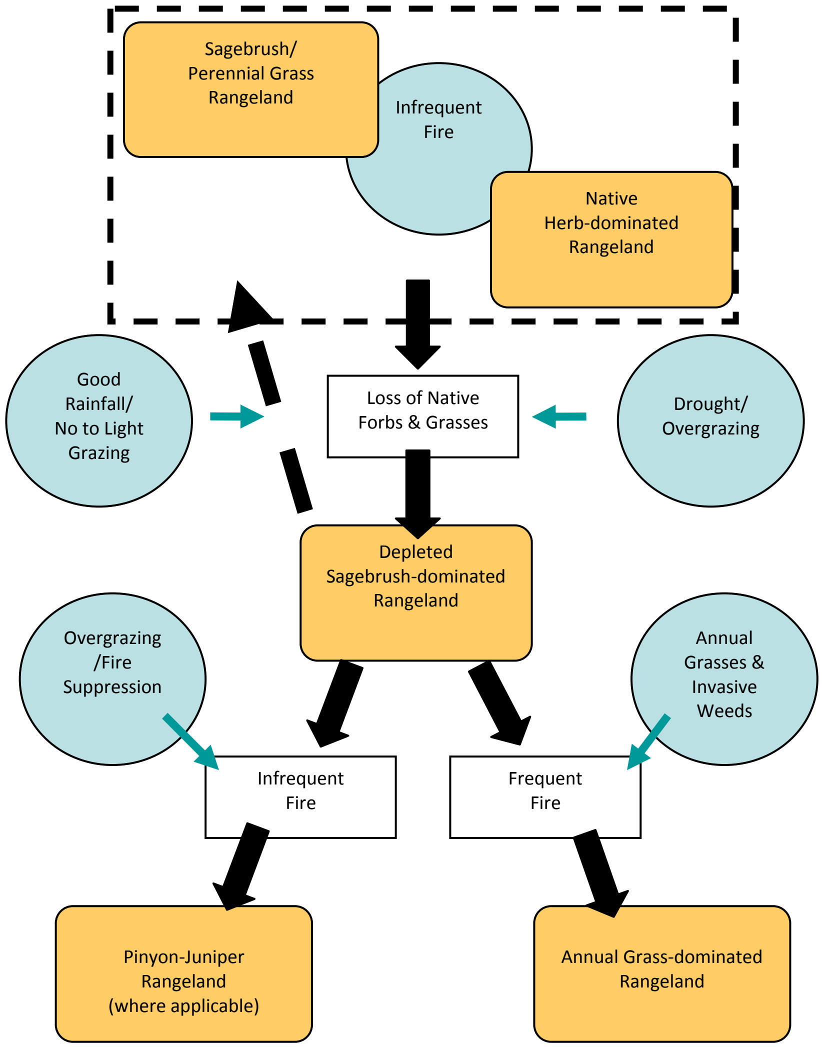

Figure 1. State and transition model for sagebrush steppe communities in UCBN parks in response to principal disturbance factors. States are represented by orange boxes and transition conditions between states are represented by white boxes with principal disturbance factors depicted by blue circles. The states and transition within the dashed box at top are those within historic ranges of variability, and which are the most desired conditions for UCBN sagebrush steppe communities.

Objectives

All of the parks addressed by this protocol share a common goal to maintain and restore native ecosystems and ecological processes (i.e., ecosystem integrity/health). The five parks are affected by biological invasions, fire, past or current grazing on parklands or surrounding lands, and climatic trends and fluctuations. Plant invasion, altered community composition, and altered species abundances are the principal concerns for UCBN park managers (Garrett et al. 2007). This protocol will focus on these central concerns and will provide managers with the information necessary to evaluate progress in their efforts to maintain and restore native plant communities.

Our monitoring objectives respond to park management concerns and desires for maintaining and restoring ecosystem health of sagebrush steppe. The objectives focus on the status and trends of key indicators of biotic integrity, soil stability, and hydrologic function in UCBN sagebrush steppe communities. The protocol addresses the following monitoring objectives:

- Determine the status (current condition) and trends (change in condition over time) in the composition and abundance (cover) of principal native plant species in UCBN sagebrush steppe communities.
- Determine the status and trends in composition and abundance (cover) of principal invasive plant species, including annual grasses, in UCBN sagebrush steppe communities.
- Determine the status and trend in the amount of exposed soil (cover), a fundamental indicator of soil stability.

Sampling Design

Sampling Design Rationale

Our monitoring design involves random sampling in UCBN park sagebrush steppe communities with 1 m^2 quadrats in temporary locations (a "never revisit" design [1-n] *sensu* McDonald 2003) using ocular estimation of cover (in classes) for principal indicator species and exposed soil (bare ground). Monitoring large landscapes poses unique challenges that require compromises among (1) the accuracy and precision of measurements needed to detect meaningful change, (2) the large sample sizes and extensive sampling required to reflect the high natural variability in sagebrush steppe vegetation across large landscapes, and (3) the logistical constraints posed by rugged and often inaccessible terrain. As a result, our criteria for selecting a design for long-term monitoring are:

- An efficient response design that permits rapid measurements thus allowing for large sample sizes and good dispersion of sample units
- Rapid quantification of principal indicators of ecological condition with sufficient precision to detect meaningful estimates of status and trend
- Accessible and easily learned field methods that can be consistently applied among observers

Sampling design development is an exercise in cost-benefit trade-offs, and given the large and highly variable sagebrush steppe landscapes in the UCBN, we have placed a premium on obtaining large and truly representative samples, and have accordingly reduced the amount and precision of information gathered at individual sampling units (Bonham 1989, Elzinga et al. 2001, de Gruijter et al. 2006). The benefits of measuring less precise information on key indicators of community condition gathered from many locations across each park far outweigh the added costs of gathering detailed information from only a few locations in each park. Sagebrush steppe systems are subject to high inter-annual variability, largely driven by seasonal precipitation patterns (Beatley 1974, Schwinning and Sala 2004), and we have increased our sampling frequency in order to accommodate this natural variability.

Rather than attempting to monitor many ecosystem attributes that may be useful to know but that require an expense of time and personnel that is not practical for monitoring large landscapes (i.e., surveillance monitoring *sensu* Nichols and Williams 2006), this protocol will focus on measuring a few key attributes that are indicators of conditions fundamental to the health of the sagebrush steppe ecosystem (i.e., targeted monitoring). The National Research Council (1994) recommended key indicators of rangelands that should be the basis for monitoring rangeland condition and trend. Subsequent to these recommendations, Pellant (1999), Pellant et al. (2005), Pyke et al. (2002), O'Brien et al. (2003), and Herrick et al. (2005) developed assessments using specific indicators of key attributes of rangeland condition and we have adopted a subset of those indicators for monitoring.

The selected monitoring indicators of sagebrush steppe ecological condition for the UCBN are:

- Canopy cover (foliar cover) of *Artemisia* species
- Canopy cover of principal native grasses (see SOP # 10 for a list of species)
- Canopy cover of principal non-native invasive grasses e.g., crested wheatgrass (*Agropyron cristatum*, cheatgrass (*Bromus tectorum*), and medusahead (*Taeniatherum caput-medusae*).
- Canopy cover of principal perennial forbs, by genera or species (see SOP # 10 for a list of species)
- Canopy cover of principal non-native forbs, including state-listed noxious species (see SOP # 10 for a list of species)
- Cover of exposed soil

These indicators are readily and efficiently measured, and address our objectives for monitoring sagebrush steppe biotic integrity, soil stability, and hydrologic function. The extent of bare ground is directly tied to hydrologic and soil stability (National Research Council 1994, Van Haveren 2001, Pellant et al. 2005). Abundances of *Artemisia* species and subspecies are considered key indicators of sagebrush ecosystem condition, and, in combination with native grasses and forbs, are fundamental to the character of sagebrush steppe and are crucial to the function of sagebrush steppe ecosystems providing forage and cover for wildlife such as sage grouse, another UCBN vital sign (Hironaka et al. 1983, Rosentreter 2005, Hanser and Huntly 2006, Beck et al. 2009). Native forbs may provide critical resistance to invasion by non-native invasive weeds (Pyke 2000, Germino et al. 2004, Chambers et al. 2007). Cheatgrass and other non-native invasive plants are an increasing and widespread problem in the sagebrush biome (D'Antonio and Vitousek 1992, Knick et al. 2003, Brooks et al. 2004). Medusahead is of particular concern at JODA, where the species was estimated to occur in 27%, 9%, and 1% of the Clarno, Painted Hills, and Foree Units of the Park, respectively, during 2008 pilot sampling (Rodhouse 2009). During initial stages of planning for vital signs monitoring, all five sagebrush steppe parks noted the presence and effects of exotic plants as a significant management concern, and exotic plants were the top priority stressor identified by park resource managers. Crested wheatgrass, a non-native perennial bunchgrass, has been planted widely in degraded sagebrush steppe to stabilize soils and provide forage for livestock (Young and Evans 1986, Jones 2000), and occurs in all five parks. Crested wheatgrass resists the re-colonization by native bunchgrasses (Lesica and DeLuca 1996). This protocol will therefore contribute to monitoring of invasive plants, another UCBN vital sign.

Multiple permanent sample frames will be sampled within each park. The boundaries of the sample frames are defined by criteria that include management boundaries or other permanent features such as roads or topographic barriers, potential sagebrush steppe vegetation as identified through ecological site descriptions developed by the Natural Resources Conservation Service (NRCS), where available, and when necessary, manual identification of accessible target areas based on park vegetation maps and high resolution aerial photography. These discrete frames will enable status and trend estimates to be explicit to areas of management importance and will facilitate greater spatial resolution in monitoring data. Within each frame, temporary sampling unit locations will be used despite the benefits that permanent locations might provide. The advantage of using permanent sample locations is the higher statistical power gained to detect trend with fewer observations (Bonham 1989, Elzinga et al. 2001). However, marking and relocating permanent sample locations in subsequent sample years is extremely time consuming and carries the very real risk of loss of sampling location markers. Sampling permanent locations also poses the risk of substantial site disturbance from repeated visits (i.e. "conditioning" or "response burden" *sensu* McDonald 2003, Miller et al. 2006). UCBN sagebrush steppe environments are particularly prone to conditioning (e.g., xeric unstable soils); especially if a 2-year alternating sampling revisit schedule is adopted as discussed in the next section. In addition, park superintendents have raised concerns about compromised safety and the visual impact of raised permanent markers. Therefore sampling will proceed with non-permanent quadrats and any loss in statistical power will be mitigated by increasing the number of locations sampled each year, a feasible option in this case given the efficient response design.

Sampling Frames and Allocation of Samples

We chose to establish multiple independent sampling frames so that spatially-explicit status and trend estimates for discrete areas of park management interest could be made with adequate sample sizes. We used a series of criteria, sometimes differing among parks, to define permanent sampling frame boundaries within each park unit. Ecological sites, where NRCS soil survey spatial data were available and currently mapped vegetation where soil survey data were not available, defined the preliminary boundaries of existing and potential sagebrush steppe communities. JODA is composed of multiple park subunits which were treated independently, and ecological site descriptions were used as the basis for independent sampling frames within each subunit. An ecological site is "a type of land with specific physical characteristics that differs from other types of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management" (Pellant et al. 2005). Ecological site boundaries are defined by soils, slope, aspect, and elevation. We modified these preliminary boundaries to remove additional areas of non-target vegetation and other inappropriate land cover (e.g., roads, development, ash badlands, rock outcrop) not already excluded by soil and vegetation maps through analysis of high-resolution (1-2 m resolution) color aerial photography (National Agricultural Imaging Projects [NAIP]). Steep (>30°) or unstable slopes, identified using digital elevation models in GIS and NAIP imagery and our knowledge of park topography, were excluded from the sampling frame, as well as barren lava rock and non-vegetated fossil-bearing badlands, which comprise substantial areas in CRMO, HAFO, and JODA. Traversable areas that were isolated by steep slopes and cliffs were also excluded. Riparian zones generally are narrow in all five parks, and a 30 m buffer was used along riparian-upland boundaries to exclude riparian vegetation. A 10 m buffer also was placed along park boundaries and in between adjacent strata boundaries at JODA to account for mapping errors and minimize the problems associated with fence lines and adjacent ownership. Because CRMO is so large and inaccessible, we also restricted sampling frames to occur within 1 km of reliable roads in that Park. Some kipukas and other areas of special interest in CRMO that occur beyond the 1 km buffer will also be included as separate sampling frames. Kipukas are islands of vegetation surrounded by lava that are particularly important to CRMO park management, as some of these areas have been isolated from grazing and may support quasi-pristine vegetation.

The distribution of sample frames across parks is intended to depict both the current condition of existing or potential sagebrush steppe communities as well as to detect changes resulting from perceived threats: ongoing livestock grazing, noxious weed invasion, and fire. Livestock grazing is extensive within the boundaries of CIRO including Castle Rocks State Park, and occurs on substantial portions of sagebrush steppe ecosystems at LARO. Invasive forbs and annual grasses occur in all parks, and new invasions threaten along park borders and along roadways within parks. Fire, both wildfire and managed fires, impact all parks. Additionally, there are quasi-intact native sagebrush steppe communities in several parks: kipukas at CRMO, some bunchgrass communities on north-facing slopes at JODA and HAFO, and higher elevation sagebrush communities in northerly portions of CIRO and CRMO. These communities deserve particular attention from monitoring as reference areas of community integrity. Our approach involving subdivision of parks into multiple discrete permanent sampling frames provides spatially-explicit estimates of sagebrush steppe community status and trend that can increase the immediate utility of the monitoring program for park management. Sampling frame errors arising from map inaccuracies will be addressed iteratively over the first two years of implementation and documented in an updated version of this protocol.

A spatially-balanced sampling design of non-permanent locations within each permanent sample frame, distributed across the entire extent of mapped target communities, will be drawn for each sampling occasion using the generalized random-tessellation stratified (GRTS) design described by Stevens and Olsen (2004). Sample sizes will be allocated proportionally to each frame according to area. A minimum sample size allocated to each frame was determined through power analysis to ensure sufficient power to estimate status and trend with adequate precision within sampling frames. A GRTS sample design is a flexible, efficient, and statistically robust approach that accommodates many of the difficulties commonly encountered in field sampling (e.g., sample frame errors, inaccessibility), allows inclusion of new sample locations in response to these difficulties, maintains spatial balance, and, through a modified variance estimator developed for GRTS samples, increases precision of status estimates (Stevens and Olsen 2004).

Sample frame delineations specific to each park follow:

CIRO

CIRO contains 2 geographically distinct subunits: City of the Rocks National Reserve and Castle Rocks State Park (which is managed cooperatively by NPS and Idaho State Parks and Recreation). City of the Rocks contains large private land in-holdings and both units of CIRO are grazed by cattle. City of the Rocks was divided into 7 permanent sample frames following the boundaries of potential or current sagebrush steppe vegetation as described by NRCS ecological site descriptions, private in-holdings, and grazing allotments or pastures within allotments (Figure 2). We separated the southern pasture of the Circle Creek allotment from the remainder of the Circle Creek allotment because park managers terminated livestock grazing there beginning in 2008, and therefore management differs from the rest of the allotment. Private lands within CIRO were excluded from monitoring as were areas of rock outcrops, riparian communities, and pinyon-juniper woodland communities defined by NAIP imagery and the NRCS ecological site descriptions. The array of 7 sample frames within CIRO allows inference specific to sagebrush steppe within each grazing allotment as well as providing inference to specific areas across the spatial extent of the Park. A total of 940 hectares are included in sampling areas in City of the Rocks, and individual frames range in size from 66-252 ha.

Castle Rocks was divided into 3 permanent sample frames following the boundaries of potential or current sagebrush steppe vegetation as described by NRCS ecological site descriptions and grazing pastures (Figure 2). Rock outcrops, wetlands, and irrigated meadows (northeast portion of unit) were excluded. Sampling frame size range from 74 to 137 ha.

CRMO

CRMO is a large expansive park with limited access and lengthy travel times across many sections of the park making subdivision of the park into discrete sample frames a necessary and more efficient monitoring approach. Of particular importance at CRMO is the elevation gradient that occurs in a north-south pattern, and the arrangement of independent sample frames has been made along this gradient. Accessible regions in CRMO were defined as all sample locations ≤ 1 km from a reliable vehicle access point. Special areas of interest beyond the 1 km buffer have also been included as sampling frames. Park managers have noted that weed invasion threatens from southwest of the park as well as along the Highway 20 corridor through the northern portions of the park. Sample frames were positioned to monitor these areas (Figure 3). The ecological site description data available from NRCS for CRMO was insufficiently detailed to guide sampling frame development. The new park vegetation map produced by the NPS Inventory and Monitoring Vegetation Mapping Program was used to delineate existing and potential target vegetation. Our approach for CRMO entails monitoring a combination of sagebrush steppe communities around the perimeter of the park (vegetated lava), and areas of special management interest identified by Park resource managers. The perimeter of the park is the interface between BLM-managed lands with greater likelihood of disturbance from livestock grazing, public access, wildfire, and noxious weeds, and the more protected, less accessible interior portions of the park. The special interest areas include three research natural areas, a proposed National Natural Landmark area, and areas of recent wildfires. Three sample frames occur within designated wilderness. A total of thirty-four 12 ha sampling frames and one 17.5 ha sampling frame are arrayed across CRMO for the sagebrush steppe monitoring program (Figure 3).

HAFO

The HAFO landscape is comprised of a series of benches at different elevations above the Snake River that are deeply dissected by steep, unstable terrain. Five permanent sample frames were positioned to monitor the majority of sagebrush steppe that is safely accessible at HAFO (Figure 4). Some benches, although relatively flat, can only be reached across steep, unstable terrain or across private lands so these benches were excluded from sampling. NRCS ecological site descriptions were used to identify areas of potential and current sagebrush steppe within HAFO. Exclusions included shadscale (*Atriplex* spp.) and greasewood (*Sarcobatus vermiculatus*) communities, riparian or wetland zones, woodlands, and areas mapped as bare rock or sand. A total of 630 hectares are included in sampling areas, and individual frames range in size from 45-153 ha.

JODA

The Sheep Rock, Clarno, Painted Hills, and Foree subunits of JODA are geographically separate, with sometimes different management issues so we developed sampling frames independently for each of these areas (Figures 5-8). We split the Sheep Rock subunit further into east and west sections, separated by the John Day River, because Sheep Rock is the largest subunit of JODA, it has the largest area of inaccessible terrain, and because these two sides of the river can have distinct management issues and prescribed fire boundaries do not cross the river. Within each park subunit, we identified three independently sampling frames based on potential and existing vegetation from NRCS ecological site descriptions: mesic grasslands, xeric grasslands, and sagebrush steppe. JODA contains substantial amounts of bunchgrass steppe that we have chosen to include for monitoring within the sagebrush steppe vital sign. Prescribed fire has been widely used in JODA as a management tool to reduce populations of juniper and sagebrush, particularly within the Sheep Rock, Foree, and Painted Hills units. Prescribed fire boundaries were not used to influence sampling frame or strata boundaries, but will be addressed through analysis of status and trends in burned and unburned areas using a post-stratification approach. We excluded steep slopes and areas of gentler terrain isolated by steep slopes, the extensive shadscale communities in the Painted Hills Unit, rocky outcrops and barren fossil-bearing ash badlands. We also excluded the area of private use within the congressional boundary south of Rattlesnake Creek in the Sheep Rock – West subunit A total of 3565 hectares are included in sampling areas, and individual frames range in size from 49-406 ha. Each frame will be sampled with sufficient intensity so as to support inference to frames as well as to park subunits.

LARO

Sagebrush steppe and bunchgrass communities in LARO occupy a narrow band along the southwestern shoreline of Lake Roosevelt. Livestock grazing occurs across a substantial portion of these communities. Five permanent sample frames were developed to facilitate sampling from both within grazed (3 sample frames) and ungrazed (2 sample frames) portions of sagebrush steppe potential or existing vegetation (Figures 9 and 10). Our sample frames also overlap several Park weed management areas as well. Steep unstable terrain and areas ≤ 30 m from the shoreline were excluded from sampling frames. A total of 148 hectares are included in sampling areas, and individual frames range in size from 8-40 ha.

Sampling Frequency and Timing

Each park sampling frame will be sampled every other year (i.e., an alternating revisit schedule), with park visits scheduled for alternate years (Table 1). In 2008, HAFO, CIRO, and several units of JODA (Clarno, Painted Hills and Foree) were sampled as part of the initial 2 years of protocol testing and revision. CRMO, HAFO, JODA (Sheep Rock) and LARO were sampled in 2009 to continue testing of the protocol. In 2010, all frames within CIRO, JODA, and LARO will be sampled. In 2011, all frames in HAFO and CRMO will be sampled. This two-year alternating revisit approach will provide sufficient frequency of data collection in each park and balance the substantial logistical and financial constraints of fielding personnel in five parks spread across three states.

Timing of sampling within seasons will be important and may vary between years depending on weather and plant phenological variation. The UCBN will remain flexible in the scheduling of field work and will be as responsive as possible to local park conditions in any given year. Generally, sampling will begin in spring at low elevations and proceed to higher elevations following plant phenology (e.g., JODA followed by CIRO, or the southern portion of CRMO then proceeding to the higher elevations in the northern part of CRMO). Sampling should occur in the spring after principal perennial grasses have achieved sufficient growth to be identifiable, and continue until principal forbs are no longer identifiable. This period generally extends from May through early July.

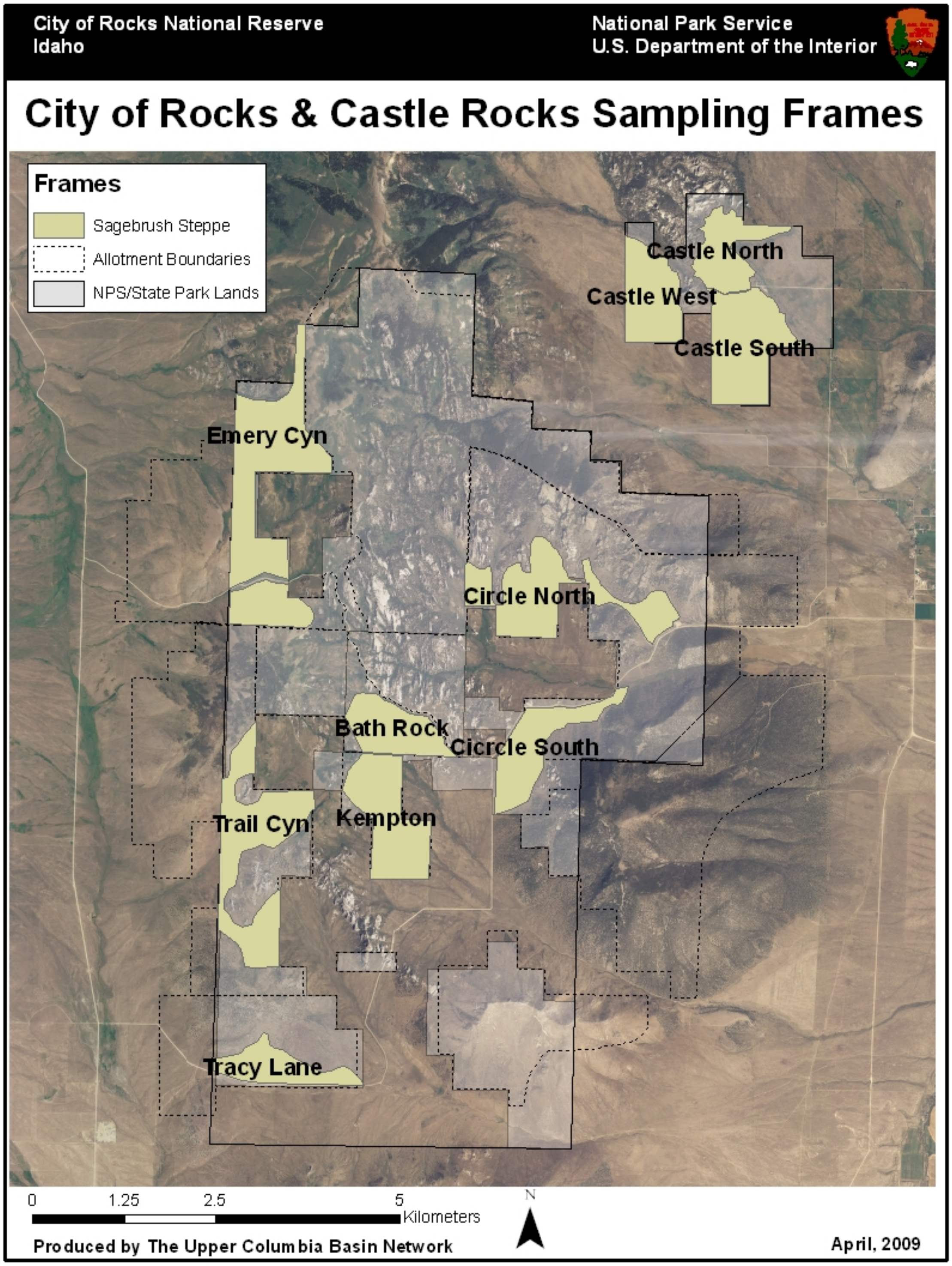

Figure 2. Sampling frames for City of Rocks National Reserve and Castle Rocks State Park.

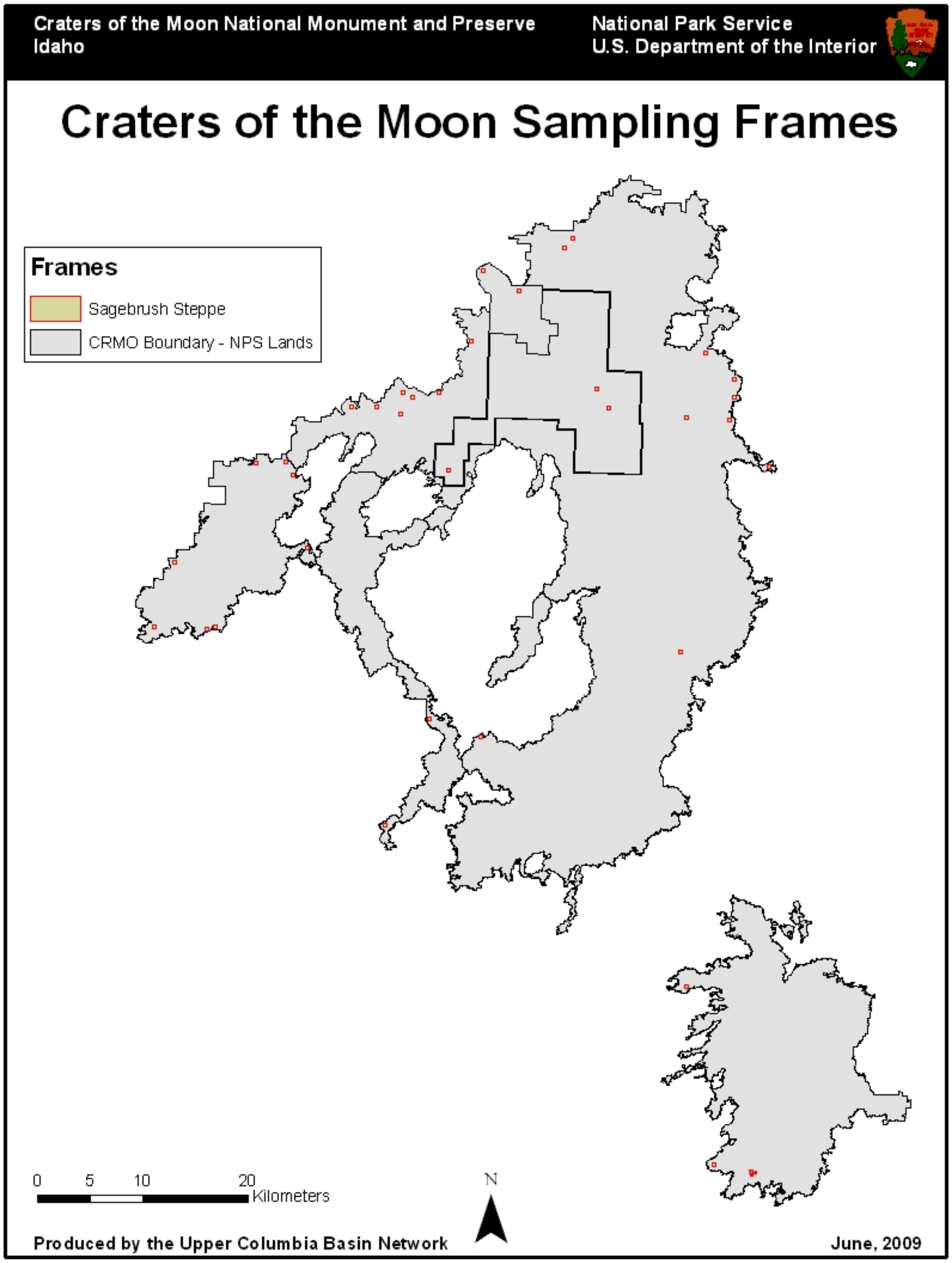

Figure 3. Sampling frames for Craters of the Moon National Monument and Preserve.

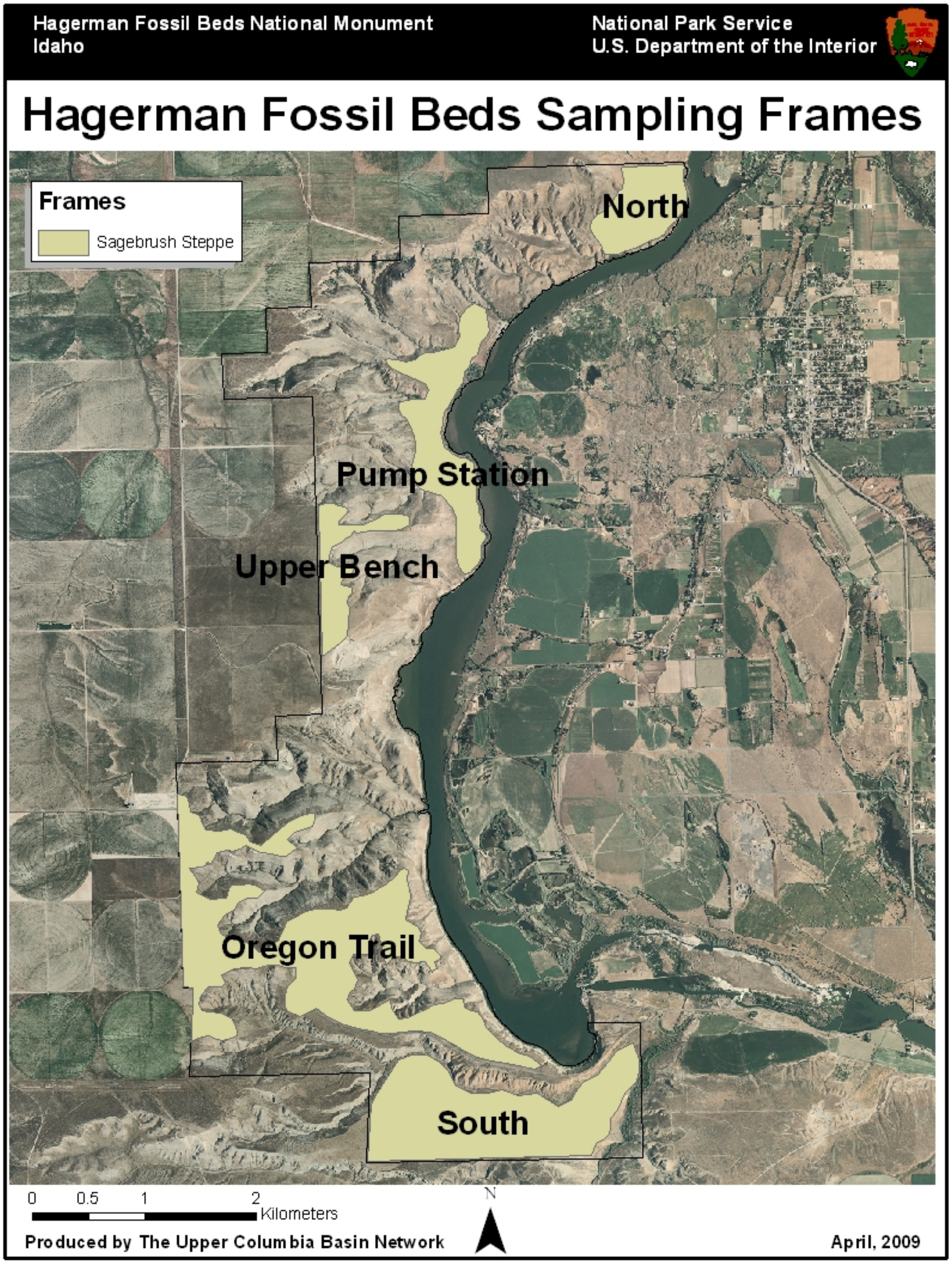

Figure 4. Sampling frames for Hagerman Fossil Beds National Monument.

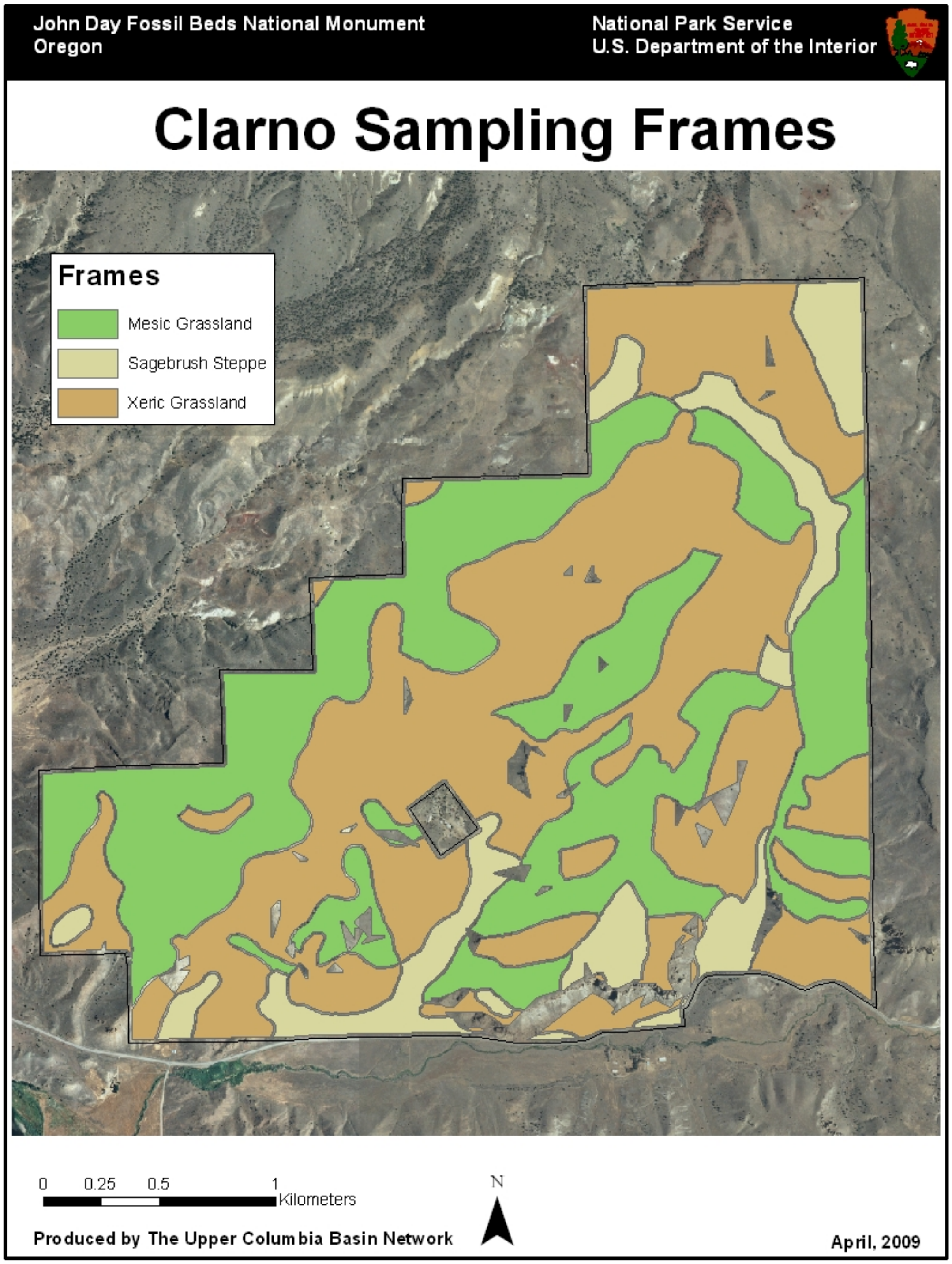

Figure 5. Sampling frames for the Clarno Unit, John Day Fossil Beds National Monument.

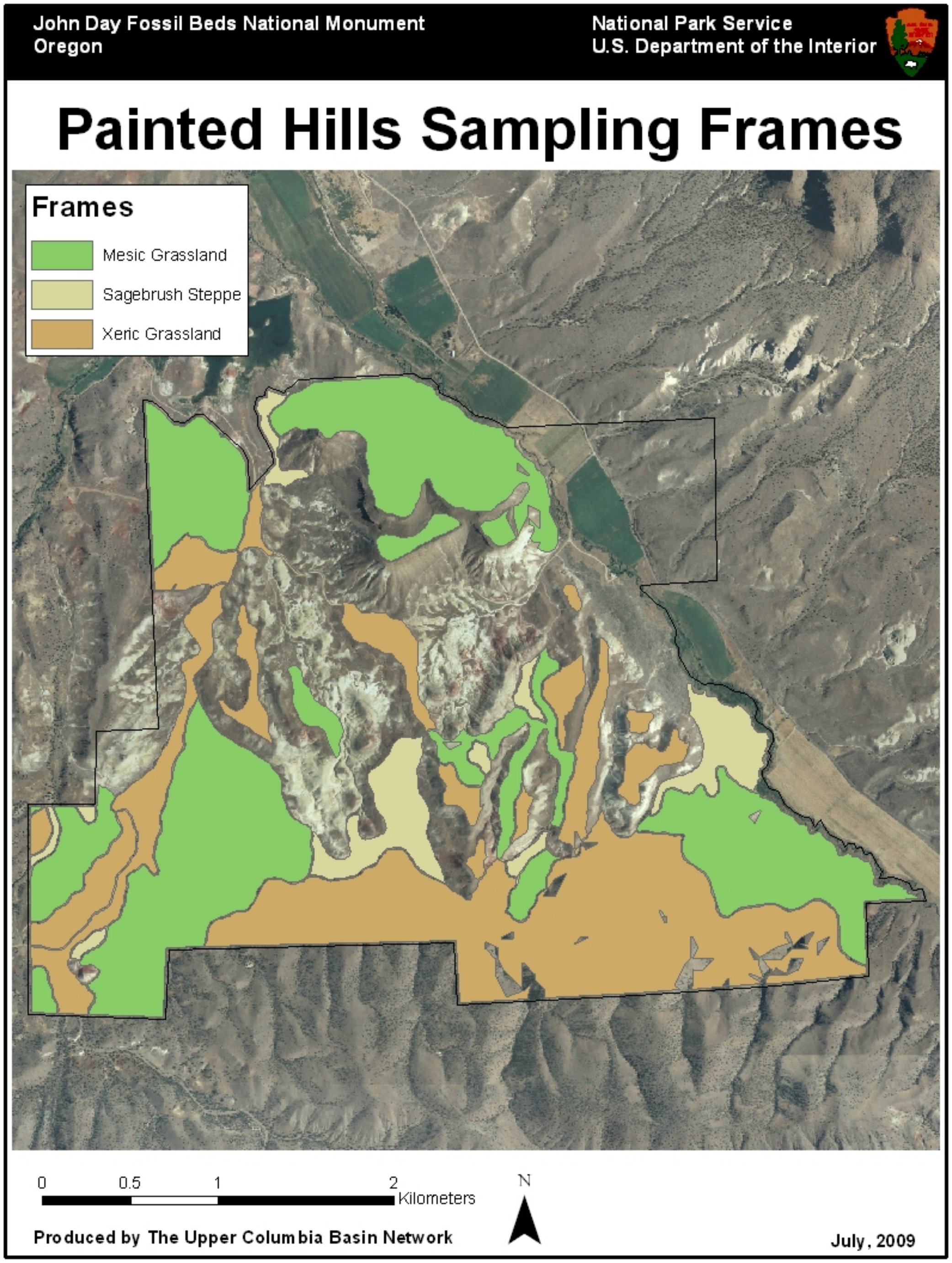

Figure 6. Sampling frames for the Painted Hills Unit, John Day Fossil Beds National Monument.

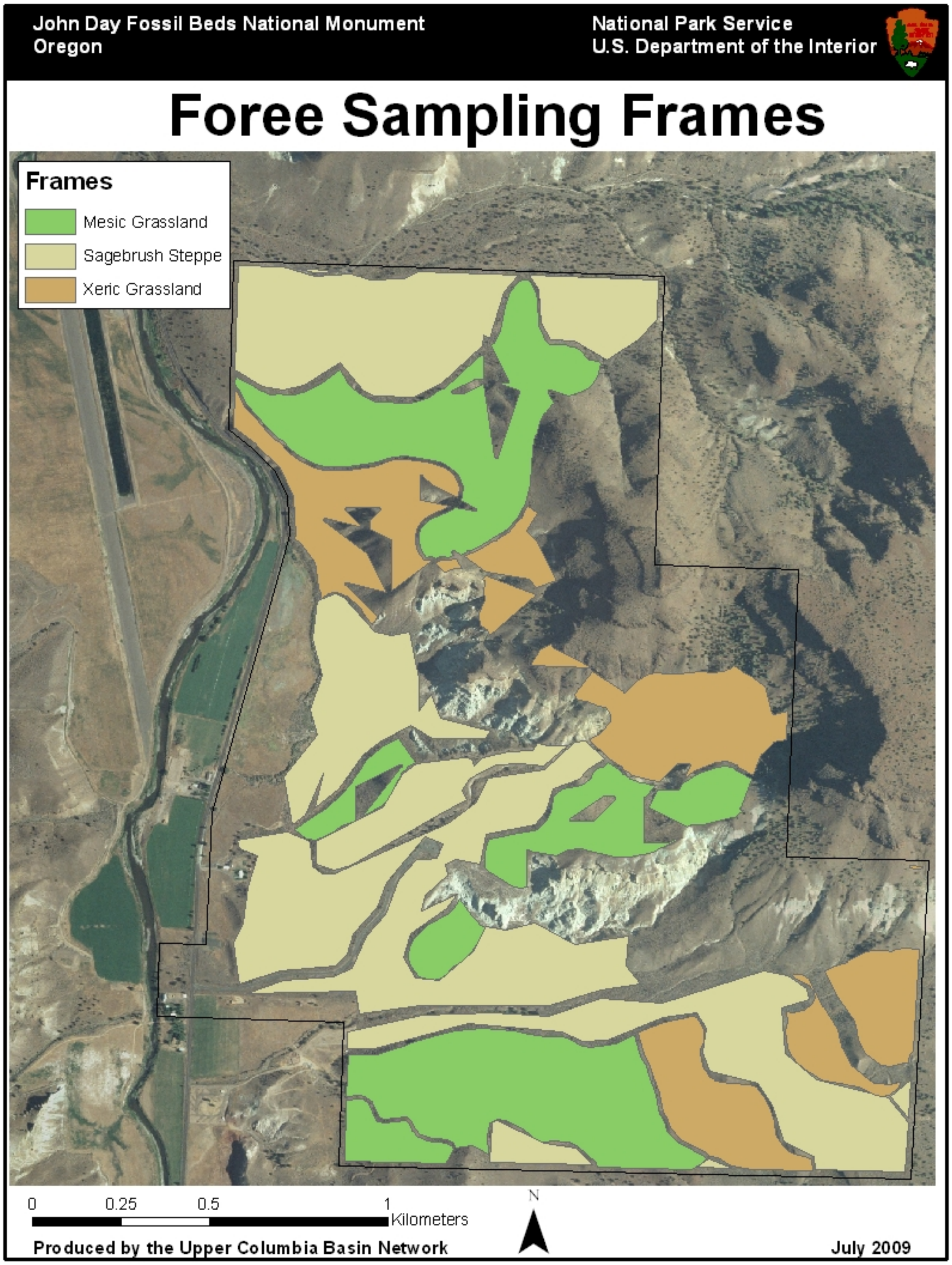

Figure 7. Sampling frames for the Foree Unit, John Day Fossil Beds National Monument.

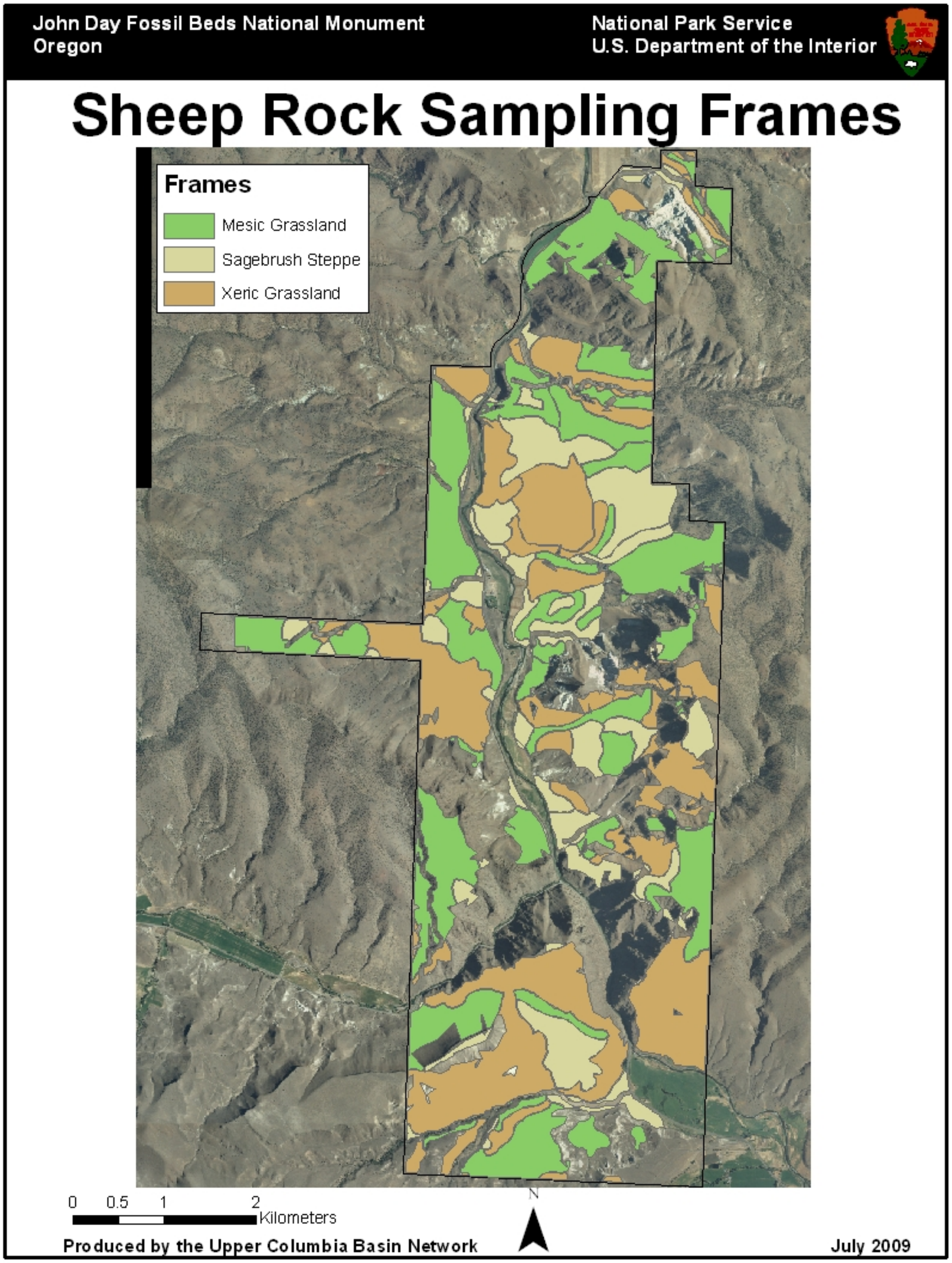

Figure 8. Sampling frames for the Sheep Rock Unit, John Day Fossil Beds National Monument.

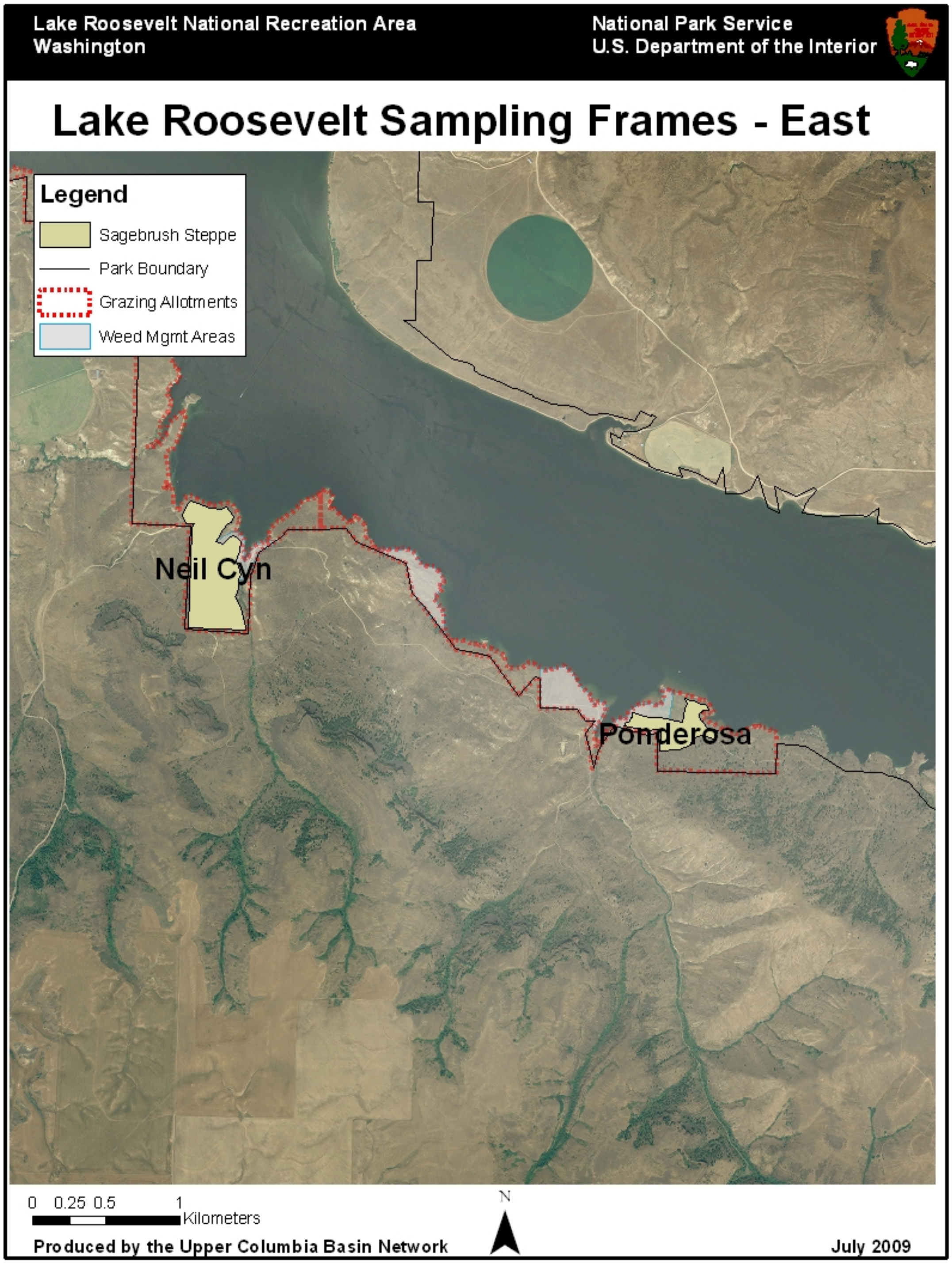

Figure 9. Sampling frames for the eastern portion of the sampling area along the southwestern shore of Lake Roosevelt, Lake Roosevelt National Recreation Area.

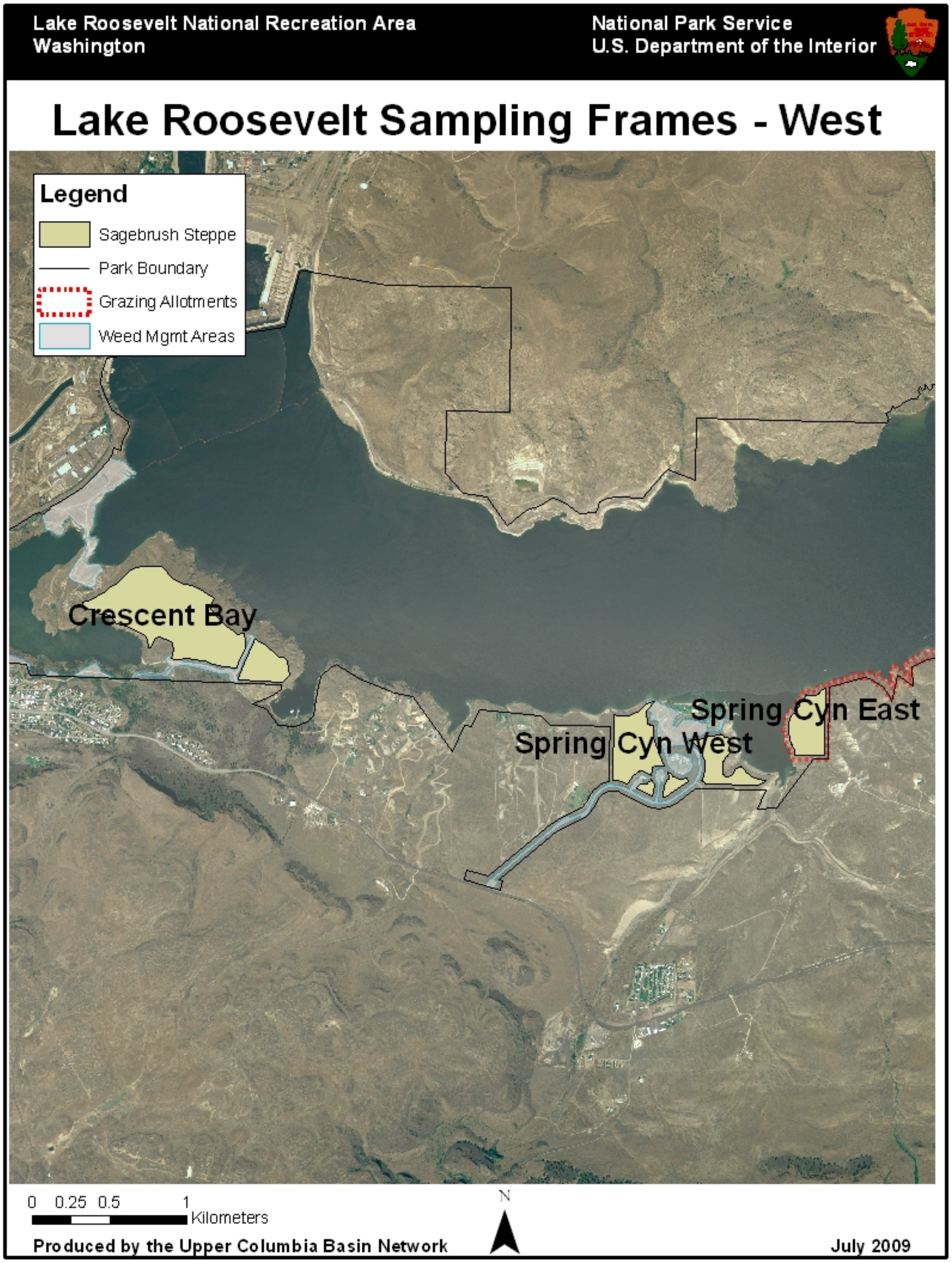

Figure 10. Sampling frames for the western portion of the sampling area along the southwestern shore of Lake Roosevelt, Lake Roosevelt National Recreation Area.

Table 1. Proposed revisit design for two groups of parks in the UCBN sagebrush steppe monitoring program. Note that a new sample is drawn for each park frame for each alternate-year sampling occasion.

	Sampling Occasion								
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	JODA, HAFO, CIRO								
2		CRMO, HAFO, JODA, LARO							
3			CIRO, JODA, LARO						
4				CRMO, HAFO					
5					CIRO, JODA, LARO				
6						CRMO, HAFO			
7							CIRO, JODA, LARO		
8								CRMO, HAFO	
9									CIRO, JODA, LARO

Response Design

To monitor landscapes efficiently, a technique is needed that allows rapid and reliable estimation of the monitoring parameters and a sample unit that is practical, large enough to encompass the average community patch size to reduce sample variance, but small enough to be quickly measured. This is particularly important in the rough terrain and dense vegetation encountered within the five parks.

Sample Metrics

The principal monitoring metric used in this protocol is the estimated canopy cover class (Daubenmire 1959; Table 2) of live or current year foliage of principal sagebrush steppe plant species and exposed bare soil, estimated in 1 m^2 quadrats. Canopy cover is defined as the percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants (Society of Range Management 1999). Openings within an individual plant's foliar canopy are included in cover estimation (Pellant et al. 2005). Although canopy cover estimation is sensitive to seasonal variation in precipitation and plant phenology, and visual estimates can differ among observers, cover estimates can be readily visualized by managers and is more sensitive to species occurring in low abundance, such as invasive forbs and incipient infestations of annual grasses (Elzinga et al. 2001). Visual estimation of plant cover has been widely used and recommended (Daubenmire 1959, Grieg-Smith 1983, Mitchell et al. 1988, Bonham 1989, Peet et al. 1998, Elzinga et al. 2001, McCune and Grace 2002, Beck et al. 2009). Visual estimates of plant cover can be assessed rapidly, and can be equal to or more accurate and precise than estimates obtained through more intensive (and seemingly more "objective") means such as line or point intercept methods. This is especially true when a cover class scheme is used that is narrow at the extremes and broad in the middle, and when consistent training and calibration exercises are conducted (Hatton et al. 1986, Meese and Tomich 1992, Dethier et al. 1993, Brakenhielm and Qinghong 1995, Murphy and Lodge 2002, McCune and Grace 2002). Daubenmire's (1959) ranked cover categories satisfy the need for narrow cover classes at the extremes with broad cover ranges in the middle (Table 2), and the distinction between cover classes can be readily learned by a wide range of field people with training. The large sample sizes, acceptable precision, and the quadrat size utilized by this protocol are also likely to mitigate problems inherent in the visual estimation of cover classes (Mitchell et al. 1988).

Table 2. Daubenmire's cover classes used for visually estimating vegetation cover in 1 m^2 square quadrats.

Cover Class	Range	Midpoint
(0	0%	0%)
1	1-5%	2.50%
2	>5-25%	15%
3	>25-50%	37.50%
4	>50-75%	62.50%
5	>75-95%	85%
6	>95%	97.50%

Frequency of invasive species occurrence, measured as the proportion of quadrats with cover >0%, will not be directly measured in the field but can be easily obtained by querying the project database for all quadrats with cover >0%. This approach will not be restricted to rooted plants, however, and therefore differs from other programs that use measures of rooted plant frequency (Elzinga et al. 2001). Frequency complements cover estimates by providing additional information on spatial distribution and is particularly useful in monitoring rangeland invasions by annual grasses and forbs where annual fluctuations in cover can be extreme due to precipitation patterns (Elzinga et al. 2001, McCune and Grace 2002). In 2008 UCBN pilot sampling, for example, Rodhouse (2009) noted that in some park areas, cheatgrass frequency was very high but annual grass cover was low, suggesting that the species was widespread but in low abundance. This kind of information can be useful to managers evaluating the risk of invasion by noxious weeds.

Precipitation and temperature will be obtained from the nearest weather stations for each park unit or subunit. Table 3 identifies the closest cooperative weather stations with long records that are the best sources of weather data for each park based on an inventory of weather stations in the UCBN (Davey et al. 2006). Additional stations of interest exist, including a Remote Automated Weather Station (RAWS) 20 km southeast of the CRMO visitor center that is well situated for sagebrush steppe monitoring. An additional station for CIRO is currently being considered by NPS and the Western Regional Climate Center (WRCC) and will provide a significant contribution to the UCBN's ability to address effects of weather and climate on trends in sagebrush steppe vegetation. Protocol details for precipitation and temperature data collection, management, and analysis are forthcoming from the WRCC/NPS joint effort to develop a cooperative climate data system for the entire I&M program (i.e., "NPClime"; J. Gross, personal communication). SOP # 7 provides interim guidance on acquiring and analyzing these data. After 10 years (five biennial samples) of sagebrush steppe vegetation data collection (2016 and 2017), an analysis of the influence of annual and seasonal (e.g., winter and spring totals) variation in weather patterns on trends in indicators will be made. A revised SOP will be written at that time detailing the collection, management, and analysis of weather data within the context of sagebrush steppe vegetation monitoring. Climate data for these stations are currently housed and served by the WRCC (available at: http://www.wrcc.dri.edu/Climsum.html). Thirty-year monthly mean precipitation totals from the Craters of the Moon station illustrate the pattern of summer drought and winter/spring precipitation maxima typical of the sagebrush steppe parks in the UCBN (Figure 11; Davey et al. 2006). In some sagebrush steppe parks, precipitation maxima occur later in the spring (Mar-June; Davey et al. 2006). We will use this information to organize station data into winter dormancy (Oct-Mar), spring emergence (Mar-May), peak precipitation (Nov-May or Mar-June), and annual (preceding growing season) periods for analysis.

Table 3. Location of weather stations with data available for use in sagebrush steppe monitoring in UCBN parks. Additional stations are available in CRMO.

Park	Station	Name	Distance
CIRO	106542	Oakley	40 km
CRMO	102260	Craters of the Moon	Within Park
HAFO	103932	Hagerman 2 SW	2 km
JODA - Sheep Rock	352173	Dayville 8 SW	Within Park
JODA - Clarno	353038	Fossil	20 km
JODA - Painted Hills	356411	Mitchell	10 km
LARO	451767	Coulee Dam	Within Park

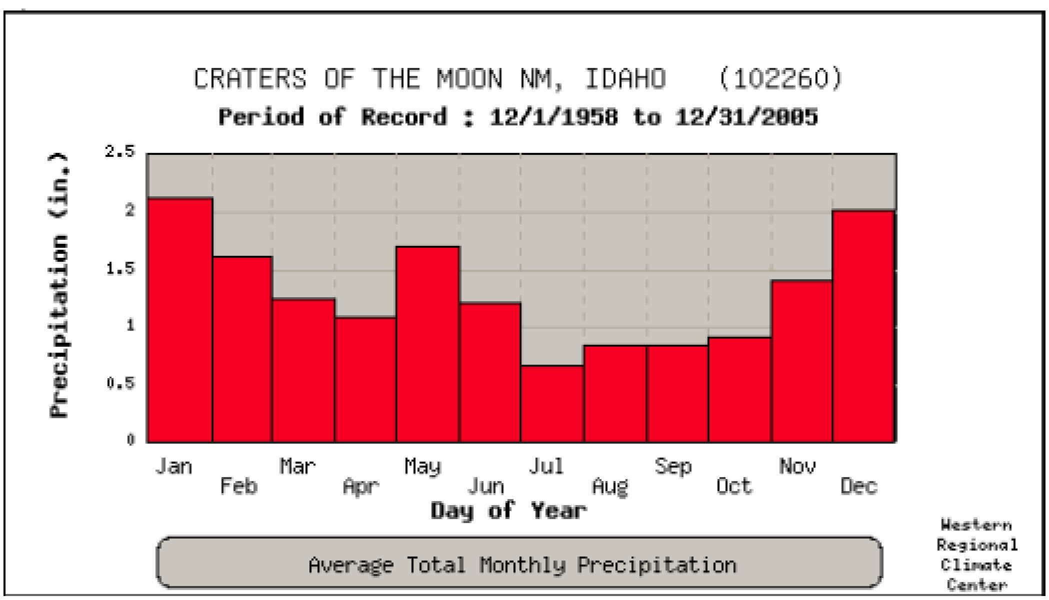

Figure 11. Monthly average precipitation for the period of record 1958-2005 at Craters of the Moon National station located within the park. Reproduced from Davey et al. (2006).

Sample Unit

Kenkel and Podani (1991) recommended that for visual estimation of cover that quadrats be as large as possible within the constraints of efficient sampling because larger quadrats generally are more efficient relative to estimates of variance. They also recommended that quadrats be large enough to encompass average patch size within the sampled community. Recommendations for quadrat sizes to sample grassland and shrub steppe vegetation range from 0.5 m^2 to 4 m^2 (e.g., Curtis and McIntosh 1950, Daubenmire 1959, Meurk 1989, Brummer et al. 1994). In 2008, we sampled HAFO, CIRO, and several subunits of JODA (n > 500 quadrats; Rodhouse 2009) with nested quadrats in 4 sizes: 0.01 m^2, 0.1 m^2, 1.0 m^2, and 10 m^2. We estimated percent cover in Daubenmire cover classes from the 10 m^2 quadrats and percent frequency from each of the 4 quadrat sizes. Our experience clearly demonstrated that the 10 m^2 quadrat was too large to estimate cover for many situations encountered. Within predominantly bunchgrass communities as found at Clarno, the 10 m^2 quadrat was efficient. The quadrat was easily established and readily viewed from 1 location. However, in denser shrub cover encountered many times at CIRO and HAFO, and in the broken lava fields found at CRMO, the boundaries of the large quadrats were difficult to establish, and the boundaries and area of the quadrat were compromised by the inability in many cases to establish straight, flat lines. Elzinga et al. (2001) recommend that quadrats used for visual estimation of cover be small enough to be viewed without moving the head. We tested 10 m^2, 4 m^2, and 2 m^2 quadrats and found that we were unable to view the entire quadrat without moving our heads, and in dense cover much of the quadrat can be obscured from view. We found that a 1 m^2 quadrat can be viewed without moving the head, and that the entire quadrat can be viewed from above rather than at an angle which biases perceived cover estimation. We were concerned that a 1 m^2 quadrat would be too small to encompass average patch size but analysis of 2008 data showed that the frequency of occurrence of principal indicators in 1 m^2 quadrats was in almost all cases identical to frequency of occurrence within 10 m^2 quadrats, suggesting that 1 m^2 quadrats will capture average patch size adequately. In 2009 we compared variance estimates and time required to sample 70 quadrats in JODA with a 1 m^2 and a 2 m^2 quadrat frame. We compared estimates for representative shrub, sub-shrub, bunchgrass, and annual grass life-forms. The larger frame required a 25% increase in sampling time but resulted in only negligible reductions in variances. The 1 m^2 quadrat size is easily placed at a sampling location even in broken terrain or dense vegetation. The 1 m^2 quadrat is easily delineated using a folding 2-m ruler which creates 90° corners, and is marked with visual cues to estimate foliar cover and ground cover (Figure 12).

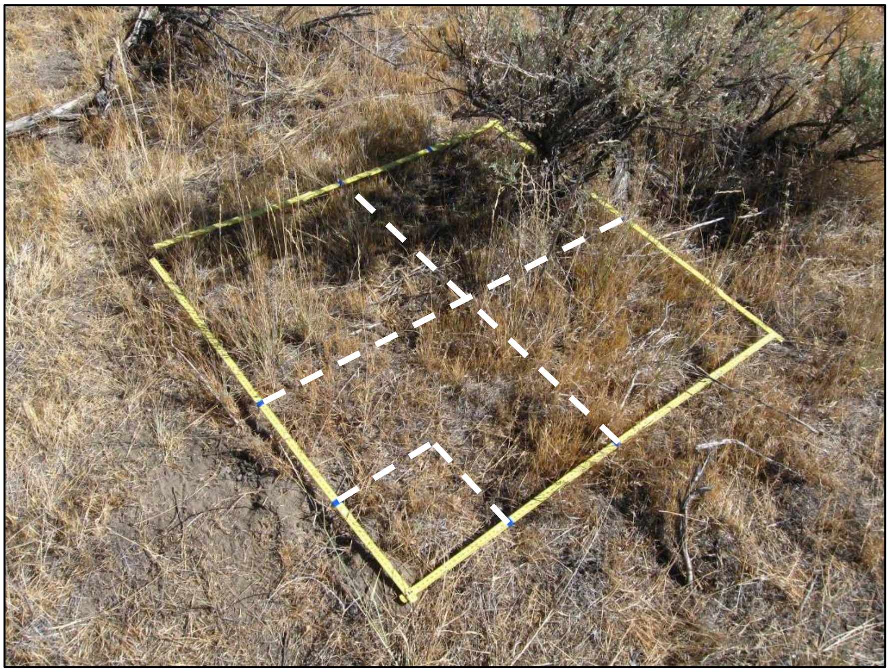

Figure 12. The 1 m² quadrat sample unit used for UCBN sagebrush steppe vegetation monitoring. Dashed white lines depict 5% area (smallest square in lower portion of quadrat), and 25% areas (larger 4 squares covering quadrat).

Sample Size and Power Analysis

We developed the following sampling objectives to guide sample size decisions:

- Estimate the proportion of sampling strata and frames covered by principal plant species and exposed soil, for each Daubenmire category, within 15% of true proportion values with 90% confidence.
- Detect differences of >25% in the proportion of quadrats assigned to a given cover class or classes between any two sampling periods for each stratum or frame during the first 10 years of the monitoring program (five biennial samples per park sampling frame) with ≥90% power and ≤10% false-change error (type I or α).
- Detect linear trends in cover proportions ≥50% after 10 years (five biennial samples per park frame), and ≥25% after 20 years (10 biennial samples per park) for each sampling stratum with ≥90% power and ≤10% false-change error.

These objectives are expressed in terms of cover, our principal monitoring metric, which will be collected in cover classes and analyzed as ordinal categories. Specifically, we will estimate the proportion of sampling quadrats within each Daubenmire cover class and trends in those proportions over time. These objectives serve as guidelines for ensuring that this monitoring effort has the capability to detect ecologically meaningful status and trends in core cover metrics for discrete areas of management interest and across ecological sites within parks. These objectives include both short-term and long-term status and trend monitoring goals, and address the statistical reality that many years of sampling are required before trends, if present, can be detected. It is important to underscore that considerable status information of importance will be available to park managers immediately after the first year of sampling, as has already been demonstrated with the sagebrush vegetation monitoring annual report following 2008 pilot sampling (Rodhouse 2009). Changes will be detected long before 20 years of sampling have elapsed, particularly if evidence of change with lower confidence levels (e.g., 80%) will be accepted (a lower "conservationist's risk" and higher "polluter's risk"; Morrison 2007; Irwin 2006)

The values for change between years were arrived at through review of the literature, consideration of the magnitude of change meaningful to park management, and consideration of the cost-benefit tradeoffs inherent in these decisions. The sampling objectives capture conservative yet biologically meaningful management thresholds or "assessment points" (Bennetts et al. 2007). We believe that a 25% difference in cover is biologically meaningful and will reflect more than just the "noise" inherent in fluctuations of steppe vegetation abundances. The threshold for irreversible change from native rangeland to cheatgrass dominance is not known (Pellant 1999), but a shift to ≥25% cover (Daubenmire class 3 or more) summed across a sample frame likely indicates greater risk to the stability (integrity) of the sagebrush steppe community because of increased risk of fire, and loss of native plants. Van Haveren (2001) suggested that >30% cover of bare ground is detrimental to soil stability in xeric sagebrush steppe, which is represented in our cover class scheme by class 3. A change from class 2 (5-25% cover) to class 3 (25-50% cover) would indicate a substantial increase of bare ground and increased risk of soil instability. Similarly, a decline to <25% cover (classes 1 and 2) for *Artemisia* shrubs and native bunchgrasses certainly warrants attention and represents an important *a priori* assessment point. We anticipate that as information from monitoring is gained and as further research clarifies the disturbance ecology of sagebrush steppe, that these assessment points will be revised.

A 2-sample "step trend" (*sensu* Helsel and Hirsch 1991; sampling objective 2 above) requires the ability to detect differences in proportions between any two non-overlapping sampling periods. This will initially involve changes between consecutive years, but will eventually be used to test for changes at greater intervals. The appropriate parametric test for a step trend involving proportions of categorical data is a test for equivalent odds (H_0: odds ratio = 1; Ramsey and Schafer 1997). The form of this test involves estimating the log odds ratio ($\hat{\Phi}$), and dividing $\hat{\Phi}$ by its standard error to obtain a z score for comparison with the critical value from the standard normal distribution. This test will allow testing of specific hypotheses about shifts across threshold proportions. For example, we may be interested in our ability to detect a 25% increase in the proportion of quadrats $\geq$ class 3 for bare ground. Given the uncertainty in the inter-annual variability of sagebrush steppe vegetation cover in UCBN parks, we have focused on step trend as a reasonable starting point for our program. We will refine and revise power analyses and sample size estimates required to address our second sampling objective for long-term linear trend after 3 years of data become available. Our response design enables us to acquire large samples and we will be able to adjust sample sizes and allocate Network resources accordingly.

Sample Size for Status and Trend

We considered sample sizes for both status and for a 2-sample comparison of proportions (e.g., proportion of quadrats within cover class 1) between years ("step trend"). Because GRTS sampling allows for a more efficient variance estimator (Stevens and Olsen 2004), a simple random sampling formula for sample size to achieve a desired confidence interval will be conservative. For status, we used the simple random sampling formula, $n_o = 1.64^2/(4e^2)$, to determine the sample size required for a specific margin of error (confidence interval half-width), where 1.64 is the 90% confidence interval multiplier from a standard normal distribution, e is the margin of error, 1/4 is the binomial variance when the estimated proportion, *p*, is equal to 0.5. This provides the most conservative estimate of needed sample size. For example, a sample size of 50 yields a 90% confidence interval with margin of error (confidence interval half-width) approximately 0.11 when p = 0.5, but a margin of error of 0.093 when p = 0.2. A minimum sample size of 50 will allow us to meet our first objective and obtain adequate precision within years. Additional information on this procedure, including estimates based on 2008 pilot data from JODA are available in SOP # 7.

We also used a formula for estimating required sample sizes for comparing two proportions or odds estimated from categorical data (Ramsey and Schafer 1997; SOP # 7). We used pilot cover estimates from 2008 sampling in the Clarno Unit of JODA and from 2009 sampling in the Foree Unit of JODA to provide the necessary proportion inputs to the formula (Rodhouse 2009; SOP # 7). We included estimates of cover for bare ground, annual grass, bunchgrass, and shrub group data from 2008 and for *Artemisia tridentata*, *Gutierrezia sarothrae*, *Pseudoeregneria spicata*, and *Bromus tectorum* species-specific cover data from 2009, which provided a wide range of skewed and relatively symmetric empirical distributions to consider. Sample size estimates ranged from 18-69 for a fixed effect size of ±25% cover (multiplicative change) and an α level (type I error) of 10%. For the species data, a 25% increase in *Bromus tectorum* cover classes $\geq$ 3 resulted in the highest sample size estimate of 49.

Based on these two exercises, we settled on 50 as a minimum sample size, but adjusted sample sizes upward proportionally for larger strata and frames, with an upper limit of 100 (Thompson 2002). Sample sizes for each park stratum are presented in Table 5. We will re-estimate sample size requirements and address power to detect long-term trends with generalized linear models after 3 years of data have been collected.

Summary of Benefits of the Selected Design

- The sampling design allows estimation of key indicators of rangeland health across large landscapes requiring just a few personnel.
- The sampling design facilitates rapid collection of cover class data with sufficient spatial extent and intensity (sample size) to obtain adequate precision in estimates of important community indicators for managers to detect meaningful changes in rangeland health.
- The alternate year sampling design incorporates the ability to calibrate data with inter-annual variation in weather without the time, personnel, and financial commitment of annual sampling.
- The use of temporary sample locations avoids the potential bias from trampling effects and promotes quick field sampling.
- The field techniques are easy to learn allowing for the use of observers from diverse academic backgrounds to be employed, and the use of GPS technology provides an objective approach to locating sample locations.
- The GRTS spatially balanced sample design provides the ability to add new sample locations without affecting the spatial balance of the sample, and minimizes the effects of spatial autocorrelation relative to other random sampling schemes.

Field Methods

Field Season Preparation and Field Schedule

The first step in field preparation is to revise procedures based on the experiences and results from the previous year. After any revisions are completed, preparation involves determining quadrat locations, gathering equipment, and fulfilling permitting and compliance requirements. All study areas are NPS units, and permits will be provided through the NPS research permit and reporting system (http://science.nature.nps.gov/research/ac/ResearchIndex). These preparations should begin in January preceding each sampling occasion. Hiring and scheduling of field personnel should also be initiated no later than January. For each park unit to be sampled in a given year, a new sample of GRTS locations will be drawn using R software and ArcGIS, mapped, and loaded onto project GPS units. Some of this GIS preparation can be completed during the previous season's close-out period, which is efficient and reduces the work load in the subsequent year. Field training should be conducted in late April or early May during the week preceding initiation of field sampling. The field team will be able to practice identification and sampling techniques outdoors with vegetation in similar phenological condition to what will be encountered during sampling. Complete descriptions of pre-season preparation and training are in SOP # 1 and SOP # 2.

Locating and Establishing Quadrats

Driving directions to park study areas are included in SOP # 4. Travel times can be substantial, particularly in CRMO, and should be carefully planned. Once on site, access to sampling areas will require hiking across rugged terrain, and field teams must be prepared for challenging weather conditions, including extreme heat, cold, rain, and snow. Each team member should maintain a supply of warm clothes and rain gear, sun hats, and plenty of water. Safety procedures outlined in SOP # 9 should be adhered to, including maintaining close communication with office-based park points-of-contact, such as park resource managers, regarding field schedules and check-in/check-out times. Park hazards, including emerging threats such as extreme weather or fire hazards, should be discussed with park staff during a debriefing prior to initiation of field work, and throughout the duration of sampling, as necessary. First aid and other safety equipment must be kept in project vehicles and easily available at all times. Before the start of each field session, quadrat locations will be organized into convenient and efficient routes through the study area according to the sample layout and topography. Each park has impassable barriers, such as cliffs and rugged lava flows that will interrupt travel between the sample locations. These routes will be illustrated on hard copy maps, developed and annotated during close-out of the previous season, drawing on accumulated field experience. Absolutely precise quadrat locations are not crucial, but are important to strive for. GPS units employed by the UCBN typically allow navigation accuracies of 1-3 m.

Quadrats will be located using GPS, following procedures outlined in SOP # 3. This protocol is designed for individual observers to measure sample quadrats alone, although field teams will be composed of 2 individuals for safety and logistical efficiency. Team members will work independently, but within close proximity of one another, maintaining regular visual contact. Two-way radios will be used for ease of communication. When a field technician navigates with the GPS unit to the waypoint location, the person will focus on the coordinates and ignore the vegetation. Once the GPS unit registers "zero" (or otherwise shows that the coordinates have been reached exactly), the person stops immediately. The location is marked with a surveyor's pin midway between the locator's boots. This will fix the lower right-hand corner of the quadrat. The quadrat will be oriented along the line of travel to avoid trampling vegetation in that area before the quadrat frame is established.

Measuring Community Indicators

Field training will be conducted at the start of each season. Training is detailed in SOP # 2 and will include calibration exercises for ocular cover estimation, as well as review of plant identification for each target species and similar species subject to misidentification. Each sample unit will consist of a 1 m^2 quadrat (Figure 12). The cover of target species (i.e., sagebrush, key grasses, annual grasses, perennial native and non-native forbs) within or overhanging the quadrat will be estimated visually using Daubenmire cover categories. Unknown plants can be photographed, or, if common, collected for later identification.

Once the quadrat is established with folding rulers, the basic field sampling procedure involves (1) visual estimation of cover of indicators, (2) enter and review data entries into hand-held PDA data logger, and (3) select and navigate to the next sample waypoint.

Training, Calibration and Consistency

The protocol is designed to be readily learned by individuals with some field experience identifying plants. It does not depend on individuals with expertise in plant taxonomy or sagebrush steppe ecology. All field teams will have a week of training in the sampling techniques, identification of sagebrush steppe community indicators, and use of GPS for locating sample locations at the start of each season. Each field team member will be provided with a Field Reference Manual that gives clear descriptions of field methods and principal species lists for each park (SOP # 10). Graphical cover estimation guides will be included in the manual. The 1 m^2 quadrat will be marked into quarters along the edges providing visual cues for 25% cover, and 1 corner of the quadrat will be marked for 5% cover area. During the week-long training, team members will practice visual estimation of plant cover using known cover values within quadrats and under field conditions. Team members' cover estimates will be compared to achieve consistency among team members. Cardboard cutouts in different shapes, sizes, and colors will be employed during training to facilitate visualization of various permutations of plant cover patterns (SOP # 2). These cutouts will have known quadrat coverages and will facilitate consistency among observers across years. Team members will calibrate with each other and record results of comparisons at periods throughout the sampling season, typically during the start of a new park sampling session, when a morning will be dedicated to orienting to the new park environment and searching for new species.

Data Entry and Management

The UCBN will use DataPlus Professional software for mobile personal digital assistant (PDA) handheld computers. DataPlus is a Microsoft Windows-based application that runs on Windows CE mobile operating systems and supports the development of custom data entry forms and error checks. The DataPlus data entry form resembles the layout of a paper field sheet, is intuitive, and will have built-in quality assurance components such as pick lists for principal species and form controls and warnings to prevent missing data or illogical entries (e.g., 2 cover entries for bare ground). Warning messages are generated when fields are not completed on individual subforms.

Data entry should be viewed as an important step in the overall QA/QC process, and care should be taken to review both the input during field work and the resulting entries in the Access database following imports.

Data will be downloaded to project laptops at the end of each field day and double-checked. This is a key QA/QC step and will mitigate against catastrophic data loss from accidents and malfunctioning PDAs. Laptops will be backed up to external storage devices after each QA/QC session. An import function will allow the project leader to upload field data from laptops into the project Microsoft Access working database.

The preferred order of field operations and data entry steps are as follows:

1. Quadrat location using GPS
2. Placement of 1 m^2 quadrat
3. Enter park unit, observer name, date, and quadrat ID number into PDA
4. Enter cover data
5. Add comments in notes columns
6. Take photographs or collect plant specimens for later identification if necessary
7. Review data entry and be sure that all fields are filled appropriately, unambiguously, and clearly before moving to the next sample location

After the Field Season

Following field work, all equipment will be stored in the UCBN headquarters in labeled bins. Electronic equipment, including GPS units and PDAs, will have batteries removed during winter months to prevent corrosion and leaking. Waypoints will be deleted at the end of each field season prior to storage. Data entry into the project database will begin as soon as possible after data collection in order to address outstanding QA/QC problems before memories fade and personnel change. Also, it is extremely important that locations of targeted invasive weeds requiring management and control action are delivered to parks immediately upon completion of field work (or during field work as time permits).

Data Handling, Analysis and Reporting

The following section outlines procedures for sagebrush steppe vegetation data handling, analysis, and report development, additional details and context for this chapter may be found in the UCBN Data Management Plan (Dicus and Garrett 2008) and SOPs # 6 and # 7. The UCBN monitoring plan also provides a good overview of the Network's information management and reporting plan (Garrett et al. 2007).

Overview of Database Design

A customized relational database application, implemented in Microsoft Access, has been designed to store and manipulate the data associated with this project. The design of this database is consistent with NPS I&M Natural Resource Database Template version 3.2 and UCBN standards (http://science.nature.nps.gov/im/apps/template/index.cfm; (Dicus and Garrett 2008). The database will continue to undergo revisions, which will be reflected in both this protocol narrative and the data management SOP # 6. The general database strategy is to use a blank version of the protocol database (a "working copy") to import, error-check, and validate a given season's data, then migrate that data to the read-only "master version" of the protocol database. This strategy protects validated data from corruption, and the master version will facilitate multi-year analyses. The underlying data structure (tables, fields and relationships) will always remain the same in both versions, and they will have very similar front-end database applications ("user interface" with forms, queries, etc.) accessed through a user-friendly "switchboard" (Figure 13). The user interface of the working copy database will serve data import, quality control, and validation needs. The user interface of the master database application will serve analysis and summarization needs, including specific reporting and exporting format needs. Details of the database, including a description of core and peripheral tables and a logical model of table relationships, are presented in SOP # 6.

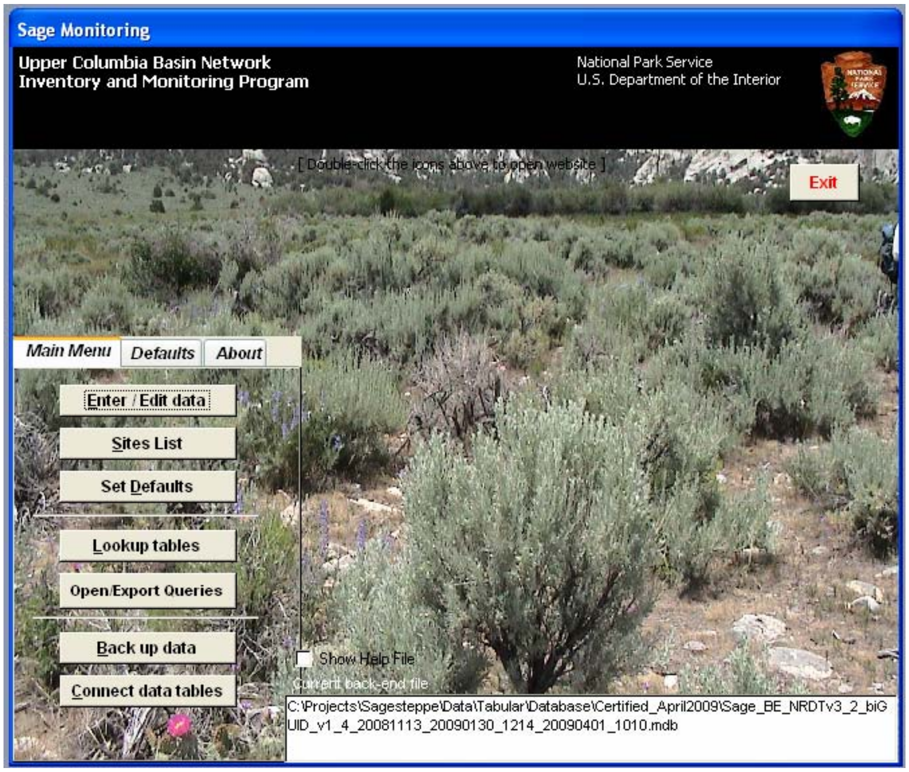

Figure 13. View of the UCBN Sagebrush Steppe database user interface.

Data Entry

Uploading of data from PDAs to project laptops will occur on a daily basis. The DataPlus data forms use pick lists to minimize the time required to accomplish digital data entry and use validation rules to reduce potential data entry errors as much as possible. Regular backups will be created for each laptop following QA/QC checks. Data will be imported to the working copy of the project Microsoft Access database on a regular basis. Project leaders will be trained in database use and troubleshooting, and will be expected to import batches of new records into Access daily and no less frequently than weekly. The DataPlus data entry form resembles the layout of a paper field sheet, is intuitive, and will have built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Data entry should be viewed as an important step in the overall QA/QC process, and care should be taken to review both the input from the PDA forms and the resulting entries in the database.

Paper data sheets will be available to field crews for use in the event that the computer equipment fails to work. All paper data sheets will be printed on Rite-in-the-Rain paper and will be archived in the Network office at the end of each field season.

Quality Review

After the data have been entered and processed, they will be reviewed by the project leader for quality, completeness, and logical consistency. The working database application will facilitate this process by showing the results of pre-built queries that check for data integrity, data outliers and missing values, and illogical values. The user may then fix these problems and document the fixes. If all errors and inconsistencies cannot be fixed, the resulting errors will be documented and included in the metadata and certification report. A season-end close-out report and checklist will be completed by the project leader with a data quality assessment included.

Metadata Procedures

Data documentation is a critical step toward ensuring that datasets are useable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog datasets within intranet and internet systems, making data available to a broad range of potential users. Metadata for all UCBN monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the UCBN Data Management Plan. In general, the Project Lead and the Data Manager (or Data Technician) will work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The Project Lead should update the metadata content as changes to the protocol are made, and each year as additional data are accumulated. Edits within the document should be tracked so that any changes are obvious to those who will use it to update the XML metadata file. At the conclusion of the field season, the Project Lead will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager. The Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to national clearinghouses as described below.

Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Lead and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager. We do not anticipate that sensitive information will be present in the sagebrush steppe monitoring program at this time.

Data Certification and Delivery

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

To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Lead is primarily responsible for completing certification. The completed form, certified data, and updated metadata should be delivered to the Data Manager according to the timeline in Table 7 in the Operational Requirements section. Additional details of the certification and delivery processes, including a season close-out form, are included in SOP # 6.

Data Analysis

Annual Status Analysis

Status results will be summarized after each year of data collection. Graphical representation of data as well as standard summary statistics will be presented. Ordinal cover data can be analyzed as if continuous by taking the midpoints of cover classes, or with categorical analytical methods by estimating the proportions of sample quadrats in each cover class. For example, Figure 14 shows the distribution of annual grass cover class proportions for each of three JODA subunits sampled in 2008, represented as bar graphs. Margins of errors, computed with a “local” and more efficient GRTS variance estimator, are represented by vertical lines. The sampling design, with its emphasis on large and well-distributed samples will make this immediately feasible after year 1 of implementation, as has been demonstrated through the 2008 annual monitoring report following pilot sampling in CIRO, HAFO, and JODA (Rodhouse 2009). An analysis can be conducted to compare status estimates for areas that undergo different management “treatments” such as grazing allotments in CIRO and LARO, or burned and unburned areas in JODA. Rodhouse (2009) demonstrated this for CIRO allotments using non-parametric Kruskal-Wallis tests.

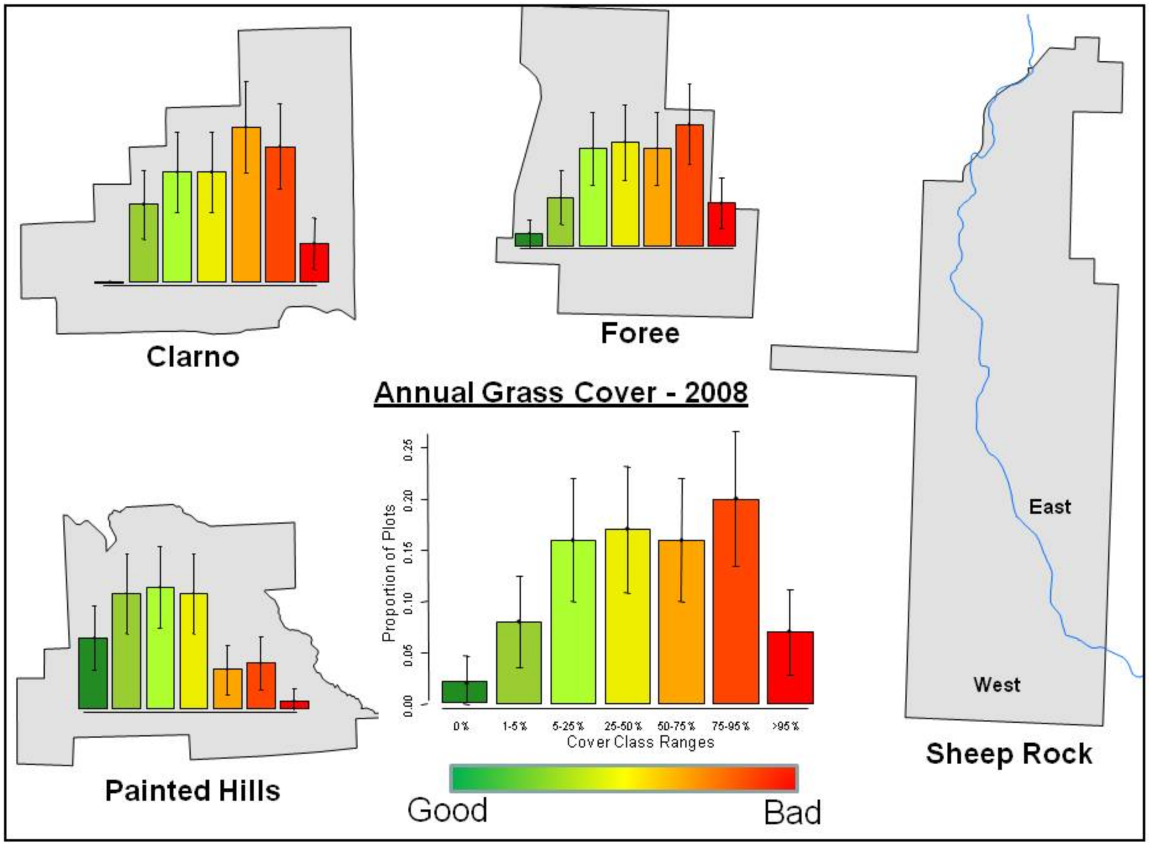

Figure 14. A bar graph of the distribution of annual grass Daubenmire cover class proportions in three of the five subunits in JODA, using 2008 pilot data. Sheep Rock was not sampled in 2008. Bar height represents the proportions of quadrats in each cover class, with margin of errors represented by vertical lines. Annual grass cover was greater in the Clarno and Foree Units than in the Painted Hills Unit. The color scheme is intended to quickly draw attention to problems such as high annual grass cover.

Change Detection and Trend Analysis

The detection of change between 2 sample periods will be evaluated by comparing odds ratios from categorical cover estimates (Ramsey and Schafer 1997, Elzinga et al. 2001, Higgins 2004). As an accumulation of results from five or more sampling periods (10 years) become available for each park, we will evaluate trend through the use of generalized linear models appropriate for categorical data. The use of ordinary least squares using cover category midpoints has been shown to be effective and is generally common practice (Peet et al. 1998, McCune and Grace 2002). However, other approaches, such as a proportional odds logistic regression model, may prove more efficient and would be more consistent with the status and step-trend procedures previously outlined (Guisan and Harrell 2000, McCune and Grace 2002). Trend analysis methods will be developed in conjunction with our power analysis for long-term trend after three years of data become available for a representative park.

Reporting

A summary report will be produced after each year of data collection, with a more detailed report produced every five years. The annual report will:

- Provide a summary history of the samples taken during each year of the study, tabulating numbers of samples for each sampling frame and showing these locations on maps of the parks
- Provide summary status statistics and interpretation of the results relative to management goals.
- Provide a summary table or "scorecard" for use in park reporting and resource stewardship strategies.
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretation.
- Evaluate and identify suggested or required changes to the protocol.

An annual report was produced following the 2008 pilot season and can be used as a template to guide future reports (Rodhouse 2009). A 1-2 page resource brief will also be prepared from this annual report that will be provided to superintendents, park interpretive staff, and resource managers. A template for the resource brief is included in SOP # 7. An NPS template for producing maps with ESRI ArcGIS or ArcView software is available at http://imgis.nps.gov/templates.html. Information from the annual summary report will also be provided to parks in time for park Government Performance Results Act (GPRA) goals reporting and for informing and evaluating park resource stewardship strategies. Table 4 presents an example status summary report of indicators for the Oregon Trail frame within HAFO from 2009 sample data. Finally, invasive weed locations should be reported to the UCBN park resource managers immediately following completion of field activities. Reported information should include GPS locations and maps of quadrats with weeds present both within quadrats and as noted during travel between quadrats.

A more in-depth trend report will be produced every five years. This report will provide greater analytical and interpretive detail, and will evaluate the relevance of findings to long-term management and restoration goals. The report will also evaluate operational aspects of the monitoring program, such as whether sample frame boundaries need to be changed or whether the sampling period remains appropriate (the optimal sampling season could conceivably change over time in response to climate change). The report will also evaluate the monitoring protocol. For instance, does allocation of samples among parks appear to be adequate for all parks, are there new management concerns that might dictate some reallocation of effort or additions to the indicator metrics that are routinely examined annually, is the sampling time still appropriate, etc.

Annual reports and five-year analyses of status and trend will use the NPS Natural Resource Publications Natural Resource Technical Report series template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Template guidelines and documentation of the NPS publication standards are available at the following address: http://www.nature.nps.gov/publications/NRPM/index.cfm.

Current versions of the protocol, resource briefs, and annual and five-year technical reports will be made available on the UCBN website (http://science.nature.nps.gov/im/units/UCBN/index.cfm). The protocol and technical reports will also be available from the national NRPM website (http://www.nature.nps.gov/publications/nrpm/nrr.cfm). All NPS protocols are available from (http://science.nature.nps.gov/im/monitor/protocoldb.cfm).

Table 4. Summary information for the sagebrush steppe vital sign in the Oregon Trail sampling frame of Hagerman Fossil Beds National Monument, 2009.

Current Condition - % Cover of Principal Species		
Species	Cover Range	Proportion (%) ± margin of error (%)
Artemisia tridentata	0	81.3±7.2
(Big sagebrush - a	1-5%	1.3±2.2
principal native shrub)	>5-25%	9.3±5.8
	>25-50%	4.0±3.9
	>50-75%	1.3±2.1
	>75-95%	2.7±3.2
Bromus tectorum	0	6.7±4.9
(Cheatgrass – an	1-5%	2.7±3.1
invasive annual grass)	>5-25%	16.0±7.5
	>25-50%	20.0±7.4
	>50-75%	21.3±8.3
	>75-95%	29.3±8.3
	>95%	4.0±4.0
Poa secunda	0	38.7±9.6
(Steppe bluegrass – a	1-5%	33.3±9.1
principal native grass)	>5-25%	16.0±7.1
	>25-50%	9.3±5.6
	>50-75%	2.7±3.2
Sisymbrium altissimum	0	70.7±8.7
(Tumble mustard – an	1-5%	16.0±7.4
invasive annual forb)	>5-25%	9.3±5.6
	>25-50%	2.7±3.3
	>50-75%	1.3±2.2

Data Archival Procedures

Paper data sheets, if used, should be archived for 3 years, which will allow ample time to complete QA/QC and certification steps for digital data. Long-term archiving will only be used for digital data. Upon certification, data and reports will be archived on the UCBN Network Attached Storage (NAS) unit, posted to the UCBN website, and posted to the national web-accessible secure databases hosted by the NPS Washington Areas Support Office (WASO) or National I&M program. These include:

- *NatureBib* – the master database for natural resource bibliographic references
- *NPSpecies* – the master database for biodiversity information including species occurrences and physical or written evidence for the occurrence (i.e., references and observations)
- *NPS Data Store* – a centralized data repository with a graphical search interface.

Protocol Testing and Revision

Data was collected at CIRO, HAFO, and JODA in 2008 and at CRMO, HAFO, JODA, and LARO in 2009 using the draft version 1.0 of this protocol. Data will be collected at CIRO, JODA, and LARO during 2010 using the final version 1.0 of this protocol. Updated methods and data management strategies, including revised DataPlus data entry forms and species pick lists, will be implemented during this time. Over time, revisions to both the protocol narrative and specific SOPs are expected. Careful documentation of any changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate summary analyses. The database for each monitoring component will contain a field that identifies which version of the protocol was used when the data were collected.

The protocol narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide the methodological details. The protocol narrative will only be revised if major changes are made to the protocol.

The SOPs, in contrast, are specific, step-by-step instructions for performing tasks. They are expected to be revised more frequently. It will only rarely be necessary to revise the protocol narrative to reflect specific changes in an SOP. All versions of the protocol and SOPs will be archived in a sagebrush-steppe project digital library on the UCBN Network Attached Storage (NAS) server. Current versions will be served off of the UCBN website and the national I&M protocol database.

The steps for changing the protocol (either the narrative or an SOP) are given in SOP # 8, “Revising the Protocol”. Each SOP contains a change log that should be filled out each time an SOP is revised to explain why the change was made and to assign a new version number to the revised SOP. The new version of the SOP or Protocol Narrative should be archived in the project library under the appropriate folder. A revision history log in SOP # 8 will also document revisions over time.

Personnel Requirements and Training

Personnel Requirements

Minimum requirements for this protocol include a team of 2 biological technicians with substantial college-level training in biology or related subjects. A degree is desired but not necessary. Technicians will be carefully trained in the sampling techniques and in the identification of sagebrush steppe plant species and community condition indicators. A capable project leader is required who will train the technicians, oversee their work, and verify, summarize, analyze, and interpret data each year. The project leader may also double as one of the two technical team members. The UCBN ecologist and/or coordinator may serve as the project leader in the absence of other qualified available personnel. Table 6 provides a general outline for the roles and responsibilities of personnel involved in this monitoring protocol.

As currently planned, sampling will require two technicians, one of which continues to serve as a field leader responsible for protocol testing, staff training, and field oversight. Sampling will follow the presumed advance of plant phenology with the team beginning at LARO and JODA and then proceeding to CIRO in even numbered years. In odd numbered years, the field team will begin sampling at HAFO and then proceed to CRMO. A team can sample 50-75 sample quadrats per day, or about one strata or sampling frame every 1-2 days. Approximately ten weeks of sampling time after training will be required to complete each season's field work. Teams completing approximately 50 quadrats per day, 250 per week, and approximately 2000 per season, will enable the UCBN to easily complete its goal each year. This number provides ample time to accommodate travel, foul weather, and unanticipated contingencies. Table 5 provides a summary of the number of quadrats per park and days required for each park.

Table 5. Sample sizes and estimated time to sample each park unit (based on two 2-person teams). A 2-person team can complete approximately 50 quadrats in a day. Approximately five days are required to sample 250 quadrats.

Park Unit	Sample Size	Sample Days
CIRO TOTAL	600	15
CIRO-Bath Rock	55	1
CIRO-Circle Cr. South	55	1
CIRO-Circle Cr. North	65	2
CIRO-Emery Cyn.	75	2
CIRO-Tracy Lane	55	1
CIRO-Kempton	60	2
CIRO-Trail Cyn.	65	2
CRSP-West	55	1
CRSP-North	60	2
CRSP-South	55	1
CRMO TOTAL	1750	35
Hwy 20 (13 frames)	650	13
Laidlaw Park Rd. (12 frames)	600	12
Minidoka-Arco Rd. (7 frames)	350	7
Wapi Flow (3 frames)	150	3
HAFO TOTAL	300	7
North	50	1
South	65	2
Upper Bench	55	1
Pump Station	55	1
Oregon Trail	75	2

Table 5. Sample sizes and estimated time to sample each park unit (based on two 2-person teams; continued). A 2-person team can complete approximately 50 quadrats in a day. Approximately five days are required to sample 250 quadrats (continued).

Park Unit	Sample Size	Sample Days
JODA TOTAL	1070	25
Clarno	215	5
Painted Hills	210	5
Sheep Rock East	250	5
Sheep Rock West	230	5
Foree	165	5
LARO TOTAL	260	5
Crescent Bay	55	1
Spring Cyn. West	50	1
Spring Cyn. East	50	1
Neil Cyn.	55	1
Ponderosa	50	1

Roles and Responsibilities

Table 6. Roles and responsibilities for implementing the sagebrush steppe monitoring program in the UCBN.

Role	Responsibilities	Name / Position
Project Leader	• Project oversight and administration • Track project objectives, budget, requirements, and progress toward meeting objectives • Facilitate communications between NPS and cooperator(s) • Coordinate and ratify changes to protocol • Acquire and maintain field equipment • Assist in training field teams • Perform data summaries and analyses • Maintain and archive project records • Project operations and implementation • Certify each season's data for quality and completeness • Complete reports, metadata, and other products according to schedule	UCBN Ecologist
PI/Field Lead	• Direct training and safety of field teams • Plan and execute field visits • Oversee data collection and entry, verify accurate data transcription into database • Complete a field season report	Park, Cooperator, and/or UCBN staff persons
Technicians (2)	• Collect, record, enter and verify data	Seasonal UCBN, Park, University employees, or interns (e.g. SCA)

Table 6. Roles and responsibilities for implementing the sagebrush steppe monitoring program in the UCBN (continued).

Role	Responsibilities	Name / Position
Data Manager	• Consultant on data management activities • Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule • Maintain and update database application • Provide database training as needed • Consultant on GPS use • Work with Project Lead to analyze spatial data and develop metadata for spatial data products • Primary steward of Access database and GIS data and products	UCBN Data Manager
Network Coordinator	• Project leader oversight • Administration and budget • Consultant on all phases of protocol review and implementation • Review of annual and 5-year reports	UCBN Coordinator
Park Resource Managers	• Consultant on all phases of protocol implementation • Facilitate logistics planning and coordination • Communicate management and restoration plans and associated information to Project Lead • Review reports, data and other project deliverables	UCBN Park Resource Managers or representatives

Qualifications, Training and Calibration

The technicians must become adept at all aspects of the sampling procedures, must be able and willing to travel and work independently at the five UCBN parks for which the sagebrush steppe protocol will be implemented, and must know or be able to learn quickly the principal plant species that will be encountered. They also must be careful and organized, giving attention to accurate sampling site location, sampling documentation, accurate plant identification, and oversight of data recording for accuracy, thoroughness, and clarity.

The project leader must have a basic understanding of sampling design and data management and analysis, knowledge of the sagebrush steppe flora and ability to identify plants, and must supervise training of the technicians and be available for consultation and oversight of their work during the sampling season.

The most important training elements are sampling procedures and indicator identification including plant identification. Many aids are available to assist in plant identification, including species lists for the five parks and standard taxonomic references including plant identification software (see SOP # 2). Plant species lists have been compiled for the five parks through the pilot testing process, in which park lists from NPSpecies are cross-checked against species lists accumulated through the sagebrush steppe pilot samples. These will be updated annually as the database of plant species present in the five focal parks grows and as knowledge is accumulated of the characteristics that best distinguish easily-confused species in the field. A field reference manual that includes abbreviated field methods, visual cover estimation guide, and a DataPlus quick reference guide will be an essential tool for each technician (SOP # 10).

Operational Requirements

Annual Workload and Field Schedule

Vegetation surveys will begin no earlier than late April or early May (for the lowest elevation parks) and be completed by no later than mid-late July, to reduce as much as possible differences in detection, identification, or cover estimates that are caused by changes in plant phenology over the growing season. At the beginning of the growing season, many plants are too immature for ready identification, and late in the season, many of the spring-growing plants that comprise a significant part of the biodiversity of sagebrush steppe vegetation are senesced and dried, often no longer identifiable. Thus roughly 3 months define the sampling time-frame. The annual workload for field personnel is 10-12 weeks, which includes 1 week of training, 8-10 weeks of sampling, and 2 weeks of preparation and close-out. Several additional weeks of preparation and analysis and reporting will be required from the UCBN project leader. Table 7 details the annual workload and schedule.

Table 7. Annual schedule of major tasks and events for the UCBN sagebrush steppe monitoring protocol.

Month	Administration	Field	Data Management/Reporting
January	UCBN annual report and work plan complete, Begin recruiting and hiring UCBN seasonal personnel	Hire seasonal staff and schedule field visits, housing, and vehicles	
February	Administer and modify existing agreements, if necessary	Provide GPS and other training to UCBN and park staff as needed	
March		Draw new samples, prepare maps and field data sheets	
April		Prepare field and GPS equipment and training manuals	
May		Begin training and field work	
June		Continue field work	
July		Complete field work; Report weed locations to parks; Clean and store equipment	Data entry and verification
August	Budget preparation for new fiscal year	Field season report complete	Metadata production, quality review
September	Close-out of fiscal year		Preliminary analysis of current year's results, Annual resource brief prepared for UCBN Science Advisory Committee meeting

Table 7. Annual schedule of major tasks and events for the UCBN sagebrush steppe monitoring protocol (continued).

Month	Administration	Field	Data Management/Reporting
October	UCBN annual report and work plan drafted		Data certification complete; Data archival and posting
November	Cooperative task agreements prepared, if needed		Analysis, reporting, and close-out
December			Close-out complete

Facilities and Equipment Needs

A list of necessary and recommended field sampling equipment is given in Table 8. It is desirable to have use of park housing, especially when working at the more distant parks or for longer sampling trips, although some camping should be expected. A UCBN pop-up camper is also available for longer field trips, for example in southern portions of CRMO. If digital equipment is to be used, access to power is essential for recharging batteries.

Housing must be arranged at or near each park well in advance of the field season. Housing options differ among the parks.

- CIRO – Housing must be arranged on the outskirts of CIRO, where there are several bed-and-breakfasts that may be available for weekly rental, or else the sampling team must arrange permission to camp within CIRO. Temporary trailer housing may be available through EPMT and other partner arrangements. The Castle Shadows Bed and Breakfast (208-431-1898) and has been most frequently used by the UCBN.
- CRMO – Housing must be arranged through NPS resource staff at CRMO, which has limited facilities at headquarters in the northern portion of the park, or else the sampling team must arrange permission to camp within or near CRMO. Housing at CRMO is limited, but is very useful to have for at least part of the time spent sampling CRMO, particularly during work in the northern half of the park. For work in the southern half, camping is a preferable option, as travel times back and forth to housing located at Park headquarters is prohibitively long, or there may be access to motels or other housing in Minidoka. Rental of a house in Arco is an option.
- HAFO – Housing may be available through NPS at the Giesler property and motels are available in Hagerman. Camping is limited.
- JODA – Housing should be sought at the Oregon Museum of Science and Industry's Hancock Station (541-763-4691), in the Clarno Unit of JODA. Because of the large travel times that could be involved in getting around JODA if the team is unable to stay within the park, it is very important to arrange housing at JODA well in advance of the field season. Apartment rental is available in Dayville from Christy Waldner, whose contact information is available from the UCBN office and the John Day Fossil Beds National Monument. Camping in the USFS Ochoco Summit Campground is the best option for the Painted Hills Unit. Camping options are limited elsewhere.
- LARO – Camping, and perhaps housing, is available in LARO and nearby areas. Housing requests of the park must be made prior to January. Alternatively, motels near the park can be used.

A minimum of 1 dedicated field vehicle, preferably 4-wheel drive, will be required to support each field season. Currently, the UCBN is dependent upon GSA motor pool availability for additional seasonal vehicles. The UCBN also has access to the University of Idaho motor pool via its cooperative task agreement through the Pacific Northwest Cooperative Ecosystem Studies Unit, and can also rent vehicles from private companies such as Hertz or Avis. Vehicle arrangements need to be made well in advance of field work. Seasonal technicians must be 25 years or older in order to rent and drive private rental vehicles.

Table 8. Equipment list for monitoring sagebrush steppe communities in the UCBN.

Measuring Equipment	Navigation and Recording Equipment	Misc. Equipment
2 m folding rulers	GPS units	2-way radios
Field Reference Manual	Weatherized data entry PDA with DataPlus software (e.g. Trimble JUNO unit)	Spare GPS and PDA batteries
Plant ID material	Compass with inclinometer	
10x Hand lens	Backup paper copies of data forms	
Surveyor's pin or screwdriver	Mechanical pencils and clip boards	
Labeled bags for collection of unknown plants (temporary ID purposes only)	Digital camera	

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Glossary of Important Terms

Canopy cover: The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Openings within an individual plant's foliar canopy are included in cover estimation. Canopy cover is typically restricted to live plants and live portions of plants with dead limbs, unless otherwise specified.

Forb: Herbaceous plants other than grasses, sedges, and rushes (graminoids).

Frequency of occurrence: A measure of the number of occurrences of an event in space or time. In plant sampling, frequency is the proportion of sample quadrats containing a species of interest.

Generalized Linear Model: A generalization of the ordinary least squares method of regression. A generalized linear model relates the random response component of the model, which may be non-linear, to the non-random predictor variables (e.g., year) through a link function.

Kipuka: An area of land completely surrounded by younger lava flows. Often kipukas have developed soils and late-successional vegetation. In CRMO, kipukas are ecologically important because they have been isolated from livestock grazing, and, in a few cases, still support quasi-pristine plant communities.

Odds ratio: A measure of effect size between two proportions that is calculated as the ratio of the odds of an event happening in one group (e.g., of a quadrat occurring in cover classes ≤ 3 in year 1) to the odds of an event happening in another group (e.g., of a quadrat occurring in cover classes ≤ 3 in year 2).

Ordinal data: A categorical data structure having naturally ordered ranks or scale, such as vegetation cover classes and ranked soil/site stability classes.

Perennial versus annual plants: Perennial plants live for 2 years or more and have structures such as tubers, rhizomes, and woody crowns that allow them to survive winters. Most native plants in UCBN sagebrush steppe communities are perennials. Annual plants live through a single season, and reproduce from seed. Very few native annuals occur in the UCBN.

Phenology: The time frame for any seasonal phenomena. Examples include the date of emergence of leaves and flowers, the first flight of butterflies and the first appearance of migratory birds.

Power analysis: The **power** of a statistical test is the probability that the test will reject a false null hypothesis, or in other words that it will not make a Type II error. As power increases, the chances of a Type II error decrease, and vice versa. The probability of a Type II error is referred to as β. Therefore power is equal to $1 - \beta$. Power is a function of effect size or minimum detectable change, variance of the parameter (e.g., standard error of the mean), and sample size. A power analysis determines the probability of correctly rejecting a false null hypothesis given fixed values of effect size, variance, and sample size.

Quadrats: In botany, a typical sampling unit is a quadrat. The purpose of using a quadrat is to enable comparable samples to be obtained from areas of consistent size and shape. Quadrats are often nested in order to capture scalar processes or to efficiently sample a range of species of different sizes and distributions.

Spatially-balanced sample: A probability sample that optimizes the location so sample locations in space so as to efficiently account for spatial auto-correlation. Such a sample typically has advantages over alternatives such as **simple random** and **stratified** samples in terms of statistical efficiency and logistical flexibility. The generalized random tessellation stratified (GRTS) approach is one important and widely used method of obtaining a spatially-balanced sample.

Status: Status is a measure of a current attribute, condition, or state, and is typically measured with population means.

Temporal variation: Variation in a population parameter, such as a mean, over time. For our purposes this typically refers to variation seasonally or annually.

Threshold: A threshold is a point "…in space and time at which one or more of the primary ecological processes responsible for maintaining the sustained equilibrium of the state degrades beyond the point of repair. These processes must be actively restored before the return to the previous state is possible. In the absence of active restoration a new state is formed (Stringham et al. 2001).

Trend: Trend is a measure of directional change over time and can occur in some population parameter, such as a mean (net trend), or in an individual member or unit of a population (gross trend).

Type I error: Is "false change" error or an error of commission in statistical hypothesis tests, in which a researcher declares a statistically significant difference when in fact no difference exists.

Type II error: Is a "missed change" error or an error of omission in statistical hypothesis tests, in which a researcher fails to detect a statistically significant difference when in fact a real difference exists.

Vital signs: A subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

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