

**Sagebrush-Steppe Vegetation Monitoring Protocol for Five Upper
Columbia Basin Network Parks**
(City of Rocks National Reserve, Craters of the Moon National Monument and
Preserve, Hagerman Fossil Beds National Monument, John Day Fossil Beds
National Monument, and Lake Roosevelt National Recreation Area)

Prepared by:

Nancy Huntly¹
Thomas J. Rodhouse²
Lisa Garrett²
Kathi Irvine

¹Department of Biological Sciences,
Idaho State University,
Pocatello, ID 83209-8007, USA

²NPS Upper Columbia Basin Network,
Department of Fish and Wildlife,
Moscow, ID 83844-1136, USA

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Former Version #	Revision Date	Revised By	Changes	Justification	New Vs. #

1. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02, ...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 sampling protocol consists of the Protocol Narrative and the following Standard Operating Procedures (SOPs):

- SOP 1: Preparations and Equipment Setup Before the Field Season
- SOP 2: Training Field Technicians
- SOP 3: Using the Global Positioning System
- SOP 4: Locating Sampling Sites and Sampling Vegetation
- SOP 5: Data Management (to be developed)
- SOP 6: Data Summary, Analysis, and Reporting
- SOP 7: Procedures and Equipment Storage After the Field Season
- SOP 8: Revising the Protocol
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Executive Summary

<<to be written when we are agreed on the final content of the review draft>>

Background and objectives

Rationale for Monitoring Sagebrush Steppe Vegetation in the Upper Columbia Basin

This document provides a comprehensive protocol for detecting and monitoring the status and trends of sagebrush-steppe vegetation 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]). This protocol provides a robust sagebrush-steppe vegetation sampling strategy, including a probabilistic sampling design and suitable field methods, which will enable the UCBN to achieve monitoring and sampling objectives identified in this document and in the network monitoring plan. This protocol draws from analogous monitoring manuals and data sets available from the research community to inform the UCBN monitoring protocol and to ensure that data collected by the UCBN are broadly applicable for use in larger regional analyses and applications.

Sagebrush-steppe is the most extensive ecosystem type in the Upper Columbia Basin Network (UCBN), occupying over 50% of land cover in City of Rocks National Reserve, Hagerman Fossil Beds National Monument, and John Day Fossil Beds National Monument. At Craters of the Moon National Monument and Preserve, where bare lava rock comprises 81% of the total land cover, sagebrush-steppe represents over 90% of the vegetation cover. At Lake Roosevelt National Recreation Area, sagebrush-steppe is present and significant in the southern half of the park. In the remaining parks of the UCBN, sagebrush-steppe is present as a transitional form in BIHO and occurs as minor relicts in MIIN, NEPE, and WHMI. The degradation of sagebrush-steppe resulting from biological invasion, altered fire regimes, and other factors so widespread throughout the intermountain West has also occurred within UCBN parks. 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 (Smith et al. 2000, Shafer et al. 2001, Wagner et al. 2003). Long-term vegetation trends from the Idaho National Engineering and Environmental Laboratory near Craters of the Moon provide substantial evidence of the importance of climate patterns on sage-steppe vegetation dynamics (Anderson and Inouye 2001). Monitoring on the Idaho National Laboratory 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 sagebrush-steppe region has undergone radical and extensive changes during the last 150 years (USDA Forest Service 1996, West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). Prior to European colonization, sagebrush-steppe covered approximately 44 million ha of the intermountain west (West and Young 2000). Significant portions of the region have since been converted to agriculture and heavily grazed rangeland (West and Young 2000, Bunting et al. 2002). Much of the remaining sagebrush-steppe has been degraded through 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. Biological invasions, altered fire regimes, and other stressors continue to cause major, possibly irreversible, changes in steppe ecosystem structure and function (e.g., Knick et al. 2003, 2005, Brooks 2004, Dobson and Sauder 2004) and create difficult challenges for UCBN land managers. Determining trends in sage-steppe communities is essential for understanding UCBN ecosystems and to conduct effective adaptive management. The UCBN has identified sagebrush-steppe vegetation as a high priority vital sign and monitoring of this ecosystem will be a central element to the UCBN monitoring program (Garrett et al. 2004, 2005, 2006).

The above-noted threats to sagebrush-steppe vegetation, the substantial variation in vegetation that has been recorded among years and decades, and the heterogeneity of sagebrush community types (i.e., soil conditions, topography, *Artemisia tridentata* subspecies) across the UCBN further underscore the necessity of long-term monitoring to enable adaptive management within the UCBN. The heterogeneity of sagebrush community types (i.e. alliances and associations defined by *Artemisia* subtaxa) in the UCBN present management challenges because community response to fire and drought, vulnerability to invasion, and potential for restoration and recovery can differ significantly among them (Reid et al. 2002, Bureau of Land Management 2002). Understanding these differences at the park level is critical for effective management strategies to be developed. This underscores the need for a long-term monitoring program that provides for periodic evaluation of the status of UCBN steppe communities and for identification of trends over time both within parks and across the network.

During initial stages of planning for vital signs monitoring, all 5 sagebrush-steppe parks noted presence and effects of exotic plants as a significant management concern, and exotic plants were the top priority stressor identified by park resource managers. All 5 UCBN sagebrush steppe parks have significant presence of non-native plants. Using the number of taxa on the current plant species lists that are posted on the web sites of each park, the proportion of plant taxa that are non-native ranges from lows of about 15% in CIRO and CRMO to 25% and more in JODA and HAFO (Table x). These estimates do not take into account abundances or distribution patterns of native and non-native taxa, but the high proportion of non-native taxa is nevertheless a cause for significant attention. Other stressors identified as priorities by park resource managers included by agriculture on adjacent lands (e.g., grazing, water diversion), fire management practices on NPS and adjacent lands, other NPS management (e.g., weed control, restoration, reintroductions), other historic human impacts (e.g., sagebrush removal, irrigation), NPS development, historic livestock grazing, visitation/recreation, historic fire suppression, and landscape fragmentation (Garrett et al. 2005). The protocol thus should include indicator metrics that are clearly related to the top priority stressors of concern, and should be sufficiently

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rich in content (in indicator metrics and in sample intensity and representation of overall sagebrush-steppe community structure) to be adaptable to future use to address the less common or immediate concerns, such as changes in park development or visitation patterns. Exotic plants, grazing, and fire are clear top priorities for monitoring.

Additionally, conceptual models were developed for the UCBN vital signs monitoring program for sagebrush steppe: the ecosystem control model and the altered fire regime submodel (Garrett et al. 2004). These models can be regarded as hypotheses that encapsulate current management assumptions of cause and effect and that can be tested by monitoring data. The tests will be of specified key linkages for which the values of the boxes (e.g., amount of grazing or fire) are changing or differ among parks or sample sites, and trends and effect sizes will be identified.

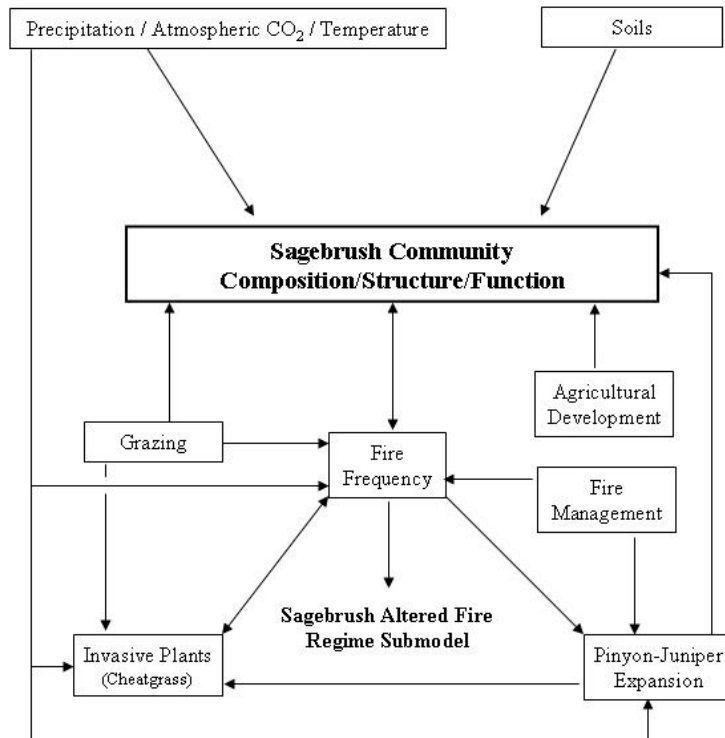


Figure x. Primary natural and anthropogenic controls on the composition, structure, and function of sagebrush-steppe in the UCBN. (Figure C.4, Sagebrush-Steppe Ecosystem Control Model, from [Garrett et al. 2006](#))

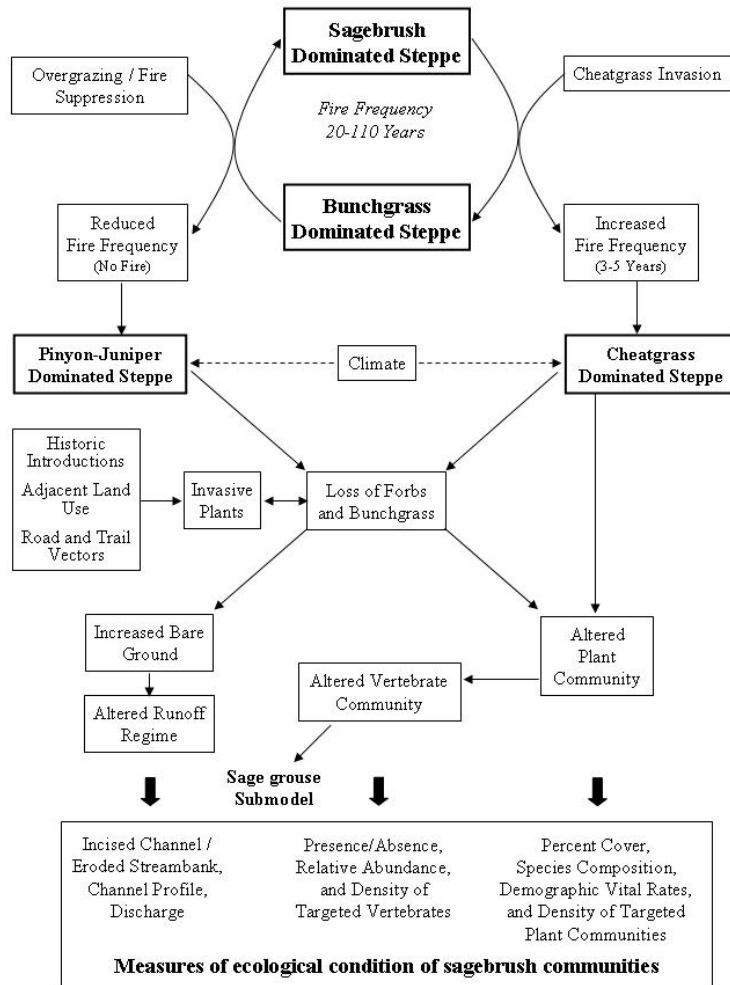


Figure x. Fire-driven community dynamics in sagebrush-steppe (Sagebrush-Steppe Altered Fire Regime Submodel). The dashed lines represent hypothesized relationships. (Fig C.5 from [Garrett et al. 2006](#))

Relating network monitoring objectives and park management objectives is important to ensure that the monitoring program provides relevant information to managers. Specific management objectives related to sage-steppe plant communities have not been explicitly articulated at this time. The 5 Parks that are to be monitored for

sagebrush steppe vegetation have somewhat different suites of central management issues, though all are affected by biological invasions, fire, past or current grazing on parklands or surrounding lands, and climatic trends and fluctuations. All of the parks addressed by this protocol share a common overarching management goal to maintain and restore native ecosystems and ecological processes. Plant invasion and shifting community composition and species abundance are the overarching concerns for UCBN park managers (Garrett et al. 2005). This protocol will focus on these central concerns and will provide managers with the information necessary to evaluate progress in their activities related to maintaining and restoring native plant communities.

Objectives

This protocol makes operational, in relation to park management concerns, the specific monitoring questions that were defined in the Protocol Development Summary for Sagebrush Steppe Vegetation. These motivating management questions were:

- *What are the trends in abundance and composition of species and horizontal strata (i.e. perennial grass, shrub, etc.) in UCBN sagebrush-steppe plant communities?*
- *Do trends differ among community types, as defined by *Artemisia* subtaxa?*
- *What are the trends in abundance and composition of invasive plant species in UCBN sagebrush-steppe communities?*
- *Are trends observed in sagebrush-steppe vegetation significantly correlated with trends in weather and climate?*

This monitoring protocol is designed to balance understanding of status with detection of trends and so include estimation of a suite of indicators that characterize sagebrush steppe community structure and condition. Additionally, this monitoring protocol is intended to generate a sufficiently rich description of sagebrush-steppe vegetation to be able to address specific management and monitoring questions that can be addressed with robust plant-community data and that may arise in future decades. Thus, the management questions and the background information reviewed above were used to define the following measurable objectives that will be addressed by this protocol:

- Estimate the status and trends in abundance of targeted plant species or groups (cover of *Artemisia* spp., *Bromus tectorum*, *Astragalus* spp., plus several native perennials and non-native species of concern that will be selected using information developed during protocol testing, and abundance and occurrence of trees) and horizontal strata (total vegetative cover, perennial grass cover, shrub cover, non-native species cover, total native legume cover) in UCBN sagebrush-steppe vegetation.
- Estimate the status and trends in species composition (i.e., dominance-diversity structure and diversity (i.e., total species richness [number of species in a sample],

tailored species richness [number of species in a sample that each comprise at least 2% of total cover]) of communities in UCBN sagebrush-steppe vegetation.

Each of the metrics defined in these objectives will be evaluated for status and for trend, with a sampling objective of ability to detect changes of a magnitude that are meaningful to management. This magnitude can reasonably be considered to be directional change of 3% per year, or 15% over 5 years (Urquhart et al. 1998, Elzinga et al. 2001, Rodhouse 2006), and . Additionally, this monitoring protocol will generate a sufficiently rich description of sagebrush-steppe vegetation to be able to address specific management and monitoring questions that may arise in future decades and can be addressed with robust plant-community data.

The parameters that have been chosen as indicators of sagebrush-steppe vegetation are:

- cover of *Artemisia* species
- cover of *Bromus tectorum*
- cover of *Astragalus* spp.
- cover of several other native and non-native species to be selected during protocol testing
- abundance and frequency of trees (e.g., pinyon pine and juniper)
- total shrub cover
- total covers of native and non-native species and proportional cover of non-native species
- total cover of native legumes
- community diversity (total species richness, species richness of native and non-native species, tailored species richness, tailored species richness of native species only, and proportional richness of non-native species)

These indicators are clearly measurable and address well the goals of the Vital Signs Monitoring Program, expressed in terms relevant to the most common and significant management concerns of the 5 sagebrush steppe parks: non-native plant species, grazing, fire, and various impacts of people (Garrett et al. 2004, 2005). Abundances of *Artemisia* species and subspecies are considered key indicators of sagebrush ecosystems (Hironaka et al. 1983, Rosentreter 2005, Hanser and Huntly 2006), and *Bromus tectorum* is a widespread problem in sagebrush (e.g., Knick et al. 2003, etc.) Total plant diversity and total and proportional numbers of non-native species are considered key integrative indicators of ecosystem condition (e.g., Heinz Centre 2002, 2004, 2005a, 2005b). *Astragalus* is a major and speciose native forb genus, with many species that characterize North American deserts, including sagebrush steppe, and that may play a role in nitrogen inputs to desert ecosystems. The borders of sagebrush and juniper or pinyon are dynamic, are known to be influenced by grazing, fire, and climate (Baker and other refs), and the movement of juniper into areas that recently were dominated by sagebrush is a current management concern.

The sampling objectives for this project follow those recommended for vital signs monitoring, as implemented in Rodhouse et al.(2007), emphasizing the high importance

of detecting changes in indicators of sagebrush-steppe vegetation. Detection of significant elevation or decline in an indicator of this magnitude and at this level of certainty will trigger action to examine likely causes, through further analysis of covariates in the monitoring data (e.g., temperature and precipitation) or in associated records (e.g., records of fire, grazing, etc., that can be used to post-stratify or correlate with vegetation indicators), or through other research efforts or, in some cases, will trigger management actions. The chosen sampling objectives are:

- Estimate with 90% confidence the sample means, within 25% of the true population means, for each sagebrush-steppe vegetation indicator for each park and for the aggregate of all parks.
- Detect with 90% certainty (power, $1-\beta$) a change of 20% or greater over 5 years with a 0.10 false-change (α) error rate for .

Each of the metrics defined in the objectives will be evaluated with analyses of both status and trend, with a sampling objective of ability to detect changes of a magnitude that are meaningful to management. The chosen target for trend detection is 80% power (β) to detect directional change of 15% over 5 years (3% per year) with error tolerance (α) of 10%. These parameters conform to UCBN requirements (Rodhouse, 2006 ms) and are within the range that is likely to be both achievable and useful to management (Urquhart et al. 1998, Elzinga et al. 2001).

Summary calculation of the vegetation indicators can be built into the data-base program that will be designed for the Sagebrush-Steppe Vegetation Monitoring Program (as was done, e.g., for the Heartland Vegetation Monitoring Program, Debacker et al. 2004). Other analysis will require use of additional software programs.

Climate data are available from <<Tom, please supply preferred data source(s) for this>>. Additionally, climate data for parks can be summarized as climatograms (refs) and changes in the patterns of these examined over time, or parks can be mapped into Holdridge's life zones (e.g., MacMahon and , Bailey)

Sampling Design

Rationale for the Chosen Sampling Design

The sagebrush-steppe vegetation monitoring protocol is based on a simple random sample drawn from grids of 100x100m cells laid over each Park. The sample will follow a split-panel rotational design, with allocation of half of the samples to a revisit panel that will be sampled annually and half to a new probabilistically-selected sample each year (a $(1 - 0) (1 - n)$ sample, in terminology of McDonald [2003]). The protocol was developed following National Park Service Inventory and Monitoring Program standards, as outlined by Oakley et al. (2003). It includes a probabilistic sampling design that balances the need for maximum scope of inference and statistical power with logistical and financial efficiency. Sampling design and methods that support these criteria have been

drawn from techniques in literature (e.g., Herrick et al. 2005, Elzinga et al. 2001, and Wilson 2006, McDonald 2004, Skalski 1990, Manly 2001), and they were chosen with attention to ensuring that UCBN sagebrush-steppe vegetation sampling methods produce results comparable with those used by other monitoring projects in the region (e.g., Idaho National Lab, Bureau of Land Management, NPS Fire Effects Monitoring Program) to increase the regional utility of the data. Power analysis and sample size requirements will be refined as a step during the initial three years of testing and implementation of the protocol, using data from the 5 Parks that will define the magnitude and structure of variation in the data for the metrics that are defined in the sampling objectives above.

There is broad agreement in the literature ([REDACTED], Manly 2001, ISRP 2005, McDonald et al. 2007) that sampling designs for monitoring long-term status and trends require first and foremost the probabilistic selection of sampling sites. Further, the sampling design should have as few complications and restrictions on randomization as are possible and should balance revisits, which provide the best ability to detect and understand causes of trend, with extensive sample inclusion, which both provide increasing overall power and also is necessary for on-going description of status (citations). Objectives may change over time, underscoring the need for a flexible protocol that can accommodate change. The protocol should generate a robust and representative data set that will be able to take advantage of advances in analytical techniques (ISRP and ISAB 2005, McDonald et al. 2007). Thus, we have concluded that probabilistic sample selection, with as few restrictions on randomization as possible, is the best sampling strategy. It is expected that the protocol sampling design and field methods will be refined during several years of implementation and testing following initial peer-review.

The design was chosen to give roughly equal attention to estimation of trend and status. Allocation of samples to a fixed panel, sampled annually, will facilitate good initial measures of trend, and the allocation of samples to the rotating panel will facilitate measures of status in an extensive landscape where among-sample variation and community composition are initially only poorly known, but assumed to be large (Anderson and Inouye 2000, Huntly unpubl. data). The fixed panel that is sampled annually improves ability to estimate effects of annual variations in weather and climate. Weather and climate conditions are known to have large effects on above-ground vegetation through their effects on relative favorability for plant growth and are thought to have substantial causative effects on the short- and long-term trends within a community (Chesson et al. 2004, Chesson and Huntly 1989, 1994, 1997). Additionally, directional trends in vegetation in sagebrush steppe are known to have substantial correlations with weather and climate (Anderson and Inouye 2000). Accounting for the direct influence of annual weather on plant cover allows better estimation of effects due to other factors, particularly the management concerns.

Sampling Frame and Allocation of Samples

Target Population

This protocol is intended to result in information that applies to sagebrush-steppe vegetation, broadly defined to include the zones of shifting balance between shrubland and woodland, and to address questions both within single parks and across the sagebrush regions of the 5 UCBN sagebrush-steppe parks that comprise the sample, CRMO, CIRO, HAFO, JODA, and LARO. Thus, the target population or sample frame will include the upland vegetation of JODA and HAFO; upland vegetation of LARO and CRMO, excluding lava; and upland vegetation of CIRO.

Samples will be drawn probabilistically within each park from a grid of sample units, each of cell size 100m x 100m. Sample grids will be laid over each park within the GIS database using the Sample Point Tool software that was written for this project. The Sample Point Tool establishes a grid of cells (potential sample units) over a designated geographic area (here, a park), beginning from a random starting point. Within each grid cell that is selected for sampling, vegetation will be sampled, using methods described below, from a transect that is randomly located within that grid cell. The Sample Point Tool also generates the specific sample points (100m transect locations) within each grid cell.

Selected samples will be restricted to accessible regions for CRMO, with accessibility limits defined to be as broad as possible without causing sampling times to be so large as to limit adequate sample sizes in CRMO and the other parks that share the annual sample-time budget. Also excluded from the sample frame at CRMO are lava flows, which do not harbor sagebrush steppe vegetation and which change to potential sagebrush vegetation on a geological rather than ecological time-scale. Accessible regions are initially defined as all sample locations that are no more than 1 km by foot from a reliable vehicle access point. Sample sites will be restricted to be below elevational limits of x, y, and z meters in CIRO, HAFO, and JODA, respectively.

Membership Design

It is desirable to minimize constraints on randomization, as fully probabilistic sampling has the broadest range of inference and is most flexible (Manly 2001, ISRP 2005). Thus, membership design will be a purely probabilistic sample of plots within each park, with plots designated systematically as a grid of 100m x 100m cells, originating from a random starting point, as described above. There will be no stratification within parks; grid cells will be selected randomly for sampling. The result of this will be a sample that is representative of the regional sagebrush-steppe habitat as a whole, as well as representative of habitat within each park, and the resulting data can be analyzed either in aggregate over all parks or in subsets for each park alone. In this design, all areas within the sampling frame have a positive probability of being included in the sample.

Sampling Frequency and Timing

Revisit Design

A split-panel rotational design will be used, with one panel being revisited annually and the other being a new probabilistically-selected sample each year. This is a

(1 - 0) (1 - n) sample, in McDonald's (McDonald 2003, Woodward 2005, Rodhouse ms) terminology, and is the basic design recommended by Skalski (1991) for status and trends monitoring. This design has been found to perform well for many monitoring applications (e.g., Overton and Stehman 1996, Lesser and Kalsbeek 1997, Urquhart et al. 1998, Manly 2001, Woodward 2005). The inclusion of a fixed panel with annual revisit was selected in order to be able to detect short-term responses to climate, but may also improve ability to detect shorter-term changes in general.

Sample Size(s)

Parks will be sampled with intensity roughly proportional to their sage-steppe vegetation area, but with proportionality modified to retain adequate minimum sample sizes in all parks. This initial allocation of sample sizes was selected to balance the needs for adequate inference both within and among parks and adequate power to detect changes in status or trends of sizes that are of use to management against the constraints of when sites can be sampled effectively (based on plant phenology), travel time and costs, and labor costs. Additionally, the sample needs to be sufficiently robust to be forgiving of changes that arise in management priorities and needs over the long time-frame during which the monitoring program is intended to work. Thus, it must be sufficiently extensive that sample plots will provide adequate representation of park areas that fall within the range of conditions that, over decades, are of interest for evaluation of the impacts of management and other forces. Retrospective power testing with data gathered during the first 3 years of protocol implementation will be used to refine total sample size and allocation of samples among parks to assure that sample sizes and dispersion meet the protocol's sampling goals. The sample size of 160 is based on estimated time needed to access and sample plots, based on limited testing of field methods in one park (CIRO) in summer 2006 and on experience sampling another park (CRMO) over several years.

The 5 parks for which sagebrush-steppe vegetation was selected as a vital signs indicator differ greatly in the extent of sagebrush-steppe vegetation, with CRMO having far larger area to be evaluated than any of the other parks (more than 80% of the total sagebrush-steppe vegetation in the 5 parks, based on initial information; Garrett et al. 2004; Table x.). Thus, the decision was made to adopt a minimum sample size of 10 fixed sampling sites allocated to each of the 4 smaller parks. Additionally, sample effort was partitioned equally to detection of trends vs description of status, so equal numbers of samples were assigned to the fixed versus rotating panels of sample sites. The balance of sample effort was allocated to CRMO, which will receive roughly 40% of total sample effort each year. This sample allocation is disproportionately low in comparison with the total area of sagebrush steppe within CRMO, but is justified because of the need to provide adequate data for management use within each of the other Parks and the need to have adequate overall ability to detect and describe overall network-wide patterns and responses of vegetation. The 4 other Parks, though smaller in total sagebrush steppe area, nevertheless collectively have far wider geographic representation (latitude, longitude, elevation, and soil types, and sheet distance of separation) than is found within CRMO alone. CRMO is also expected to be the most time-intensive to sample, given the remote nature and foot-only access of many areas of the park.

Park	total ha	proportion sagebrush steppe	ha sage steppe	proportion total sagebrush steppe in park	Total Samples	(1-0)	(1-n)
CIRO	5,708	0.21	1199	0.03	24	12	12
CRMO	190,081	0.18	34215	0.81	64	32	32
HAFO	1,760	0.53	933	0.02	20	10	10
JODA	5,688	0.68	3868	0.09	32	16	16
LARO	40,625	0.055	2234	0.05	20	10	10
Total			42448		160		

Table x. Initial Allocation of Sample Effort and Revisit Design for Sagebrush Steppe Parks. Park size (ha) and proportion sagebrush steppe are from Garrett et al. 2004 (Phase 1 Report), and the total number of samples is assumed to be 160, based on calculations of time needed to complete a sample, travel time, and the phenological window during which sampling must be completed. (1-0) indicates fixed samples, (1-n) indicates rotating samples

Response Design

Following recommendations in Elzinga et al. (2001), Herrick et al. (2005), and Miller et al. (2006), the primary vegetation metric will be percent cover, estimated using line-point intercept sampling. Abundance, relative abundance, and frequency of plant taxa and groups are the basic indicators that were chosen for monitoring, and percent cover was chosen as the primary abundance metric (excepting trees, for which density must be used, see below). Cover measurements are applicable for nearly all types of plants, including grasses, for which density estimates (whether based on ramets or genets) are difficult and unreliable, and cover allows reasonable comparisons of plants that differ greatly in size. Of the various measures of plant occurrence and abundance, cover is best related to biomass, which would be cost-prohibitive to sample. Frequency (proportion of samples in which a species or group is present) also will be used as an alternative metric to index spatial representation of species or groups.

Line-point-intercept sampling has been chosen as the basic sampling method because it is known to be a rapid and accurate method for quantifying vegetation cover and species composition in shrub and desert vegetation such as sagebrush-steppe, has been widely used in shrubland vegetation, and provides good measures of plant cover and relative abundance of taxa (Herrick et al. Elzinga et al. 2001, Miller et al. 2005). Line-point-intercept sampling provides a good balance of sample intensity, dispersion of observations over sample sites, and time required to gather a sample. It is more effective at giving representative estimates of total vegetation cover, species' absolute and relative abundances, and vegetation structure than are plot-based methods with the same sample

intensity or effort. The line-point-intercept method also allows less room for observer error than qualitative estimation of cover, and is quite repeatable, given well-trained observers (Elzinga et al. 2001, Herrick et al. 2005, Miller et al. 2006). Additionally, standard line-point-intercept sampling provides information on canopy and basal cover and on the amounts and forms of soil surface cover (e.g., bare, rock, lichen), which may be of use in comparing or interpreting monitoring results. Finally, line-point-intercept sampling was tested and found to be effective and efficient for sampling shrubland communities in the Southwestern NPS parks (Miller et al. 2006).

The sample unit for sagebrush-steppe vegetation monitoring will be a 100m x 100m grid cell, within which the actual sample taken will be of vegetation and soil surface from a; thus, the 100m line-point-intercept transect data will provide the estimate of vegetation abundance and composition of a grid cell. Plant cover will be estimated from point-intercept samples taken each 0.5 m along the transect. Data from the transect can be separated to 4 50-point segments (0-24.5, 25-49.5, 50-74.5, and 75-99.5 m spans) to allow estimation of within-site variance of vegetation metrics, as well as calculation of within/between sample sources of variance, but the primary sample unit is a grid cell, not a smaller element of the response design. This design follows procedures that have been tested and found effective in other shrubland vegetation (Herrick et al. 2005, Miller et al. 2006). Use of a single 100m transect was chosen because a long, linear sample generally provides a better characterization of vegetation over an area than a more spatially localized plot of equal sample effort, and use of a single response-sample unit reduces time needed to locate and establish sample transects.

Additionally, the sagebrush steppe vegetation monitoring data should provide information on encroachment by or reduction in woody species, for instance, juniper, which is the target of active fire management in JODA and also occurs at significant frequency in portions of CIRO. Thus, the number and species of trees greater than 0.5 m in height will be recorded from within a 10 m belt at each side of the 100m transects (forming a 2000m² belt transect to characterize each 100m x 100m grid cell in the sample). This will enable detection of changes in the occurrence and density of woody species such as juniper. Each sampled site also will be photographed (see below) using standard methods for photodocumentation (Rodhouse 2005). The resulting photographs can be used to broaden the sampled area from which trees are visible and recorded (e.g., Hastings and Turner 1965, Turner 1990).

Finally, sampling will be supplemented by photographs of each sample site in each year that it is sampled, following procedures described by Hall (2002) and Rodhouse (2005). Photopoints are landscape photographs taken from the same spot and filling the same frame to allow comparison between times. Photopoints are recommended for showing habitat conditions (e.g., overall physiognomy, cover, disturbance, or evidence of fire or presence of invasive plants), population conditions (e.g., flowering), and locations of study sites, transects, or plots (Elzinga et al. 2001). Photographs do not provide sufficient information for the quantitative objectives of the sagebrush steppe vegetation protocol, but they will provide a valuable and inexpensive long-term record of gross community physiognomy and phenology. Further, over the very long term,

Comment [NH2]: Tom, you may want to restrict photos of the fixed sites to be at some less frequent interval – say every 5th or 10th year? I think that would be perfectly adequate. Let me know what you think about this.

photographs have been useful in reconstructing vegetation dynamics and in associating them with probable causes of long-term changes (e.g. Hastings and Turner 1965, Turner 1990). A set of photopoint samples will be taken from the southwest corner of each 100m x 100m sampled grid cell, following procedures in Rodhouse (2005) as described for this protocol in SOP#4, Sampling Vegetation.

Power Analysis

Data collected during the first 3 years of protocol testing/implementation will be used to conduct power analyses (e.g., with which sample size and the allocation of samples to fixed and rotating panels will be refined as needed to best meet the protocol's sampling objective of ability to detect a directional change of 3% per year, or 15% over 5 years (Urquhart et al. 1998, Elzinga et al. 2001, Rodhouse 2006), with 90% certainty (power, $1-\beta$) and a 0.10 acceptable false-change (α) error rate. The allocation of equal sample effort to status and trend, or to rotating and fixed panels in the sample design, will provide critical needed data with which to do a meaningful power analysis for the UCBN sagebrush steppe parks; this initial allocation can be modified as needed when better measures of spatial and temporal variance in indicator metrics are better described.

Summary of Benefits of the Selected Design

The design directly reflects the study objectives.

Simple random sampling permits valid inference to larger populations.

The sample design provides positive probability of inclusion for all areas within the sample frame.

Use of a split panel design balances permanent samples (the fixed panel sites) to improve initial ability to detect trends) with extensive sampling (the rotating panel sites) to better represent the extensive sagebrush-steppe vegetation included within the 5 parks.

GPS technology allows easy location of random transect locations; there is no need for fixed transects.

Sampling of newly-selected transects within grid cells avoids impacts of repeated sampling over the long term, but retains a level of repeat visitation to grid cells.

The measurements are appropriate for structure, diversity, and phenology of sagebrush steppe vegetation.

The field techniques are easy to learn.

Field Methods

Field Season Preparation, Field Schedule, and Equipment Set-up

Preparation for field work should begin in January with inventory of field equipment and replacement or repair as needed, scheduling of the field work in each park, application for sampling permits, arrangements for use of a vehicle for travel and for lodging, and hiring of needed personnel for the field season. Personnel training should be conducted in April during the week preceding the first field sampling, at which time field workers will be able to practice identification and sampling techniques outdoors,

with vegetation in similar phenological condition to what they need to learn to identify with accuracy. Complete descriptions of pre-season preparation and training are in SOP #1 Preparations and Equipment Set-up Before the Field Season and SOP #2 Training Field Technicians.

Locating Sample Transects and Measuring Vegetation

The basic field sampling procedure involves location of a plot (100m x 100m grid cell) to be sampled, location of the point within the cell from which the sample transect is to be located, set-up of the line-point-intercept transect along the designated azimuth, photodocumentation of the sample location (both the grid cell and the transect), the vegetation sampling, and clean-up of sampling markers. The vegetation sampling includes (1) observation and recording of canopy and ground cover by species or ground cover category for a transect, and (2) recording of the number of trees (pinyon, juniper) 0.5 m or more in height within the 2000m² area defined by a 10 m belt transect along each edge of the 100m line-point-intercept transect. Sample locations will not be permanently marked, as the locations of the sample transects will be independently selected each year.

Permanent sample locations will not be used for several reasons. First, the long-term reuse of permanent plots can cause soil compaction, plant mortality and other inadvertent sampling impacts on plots (e.g., Miller et al. 2006), all of which are particularly problematic in long-term monitoring, where visits should be assumed to continue over many decades. Second, the basic sample unit of interest is a 100m x 100m grid cell. The sample taken in a year is to be regarded as a random sample of the vegetation characteristic of that grid cell. Third, the advantages to using permanently marked sample locations accrue primarily when the same population can be sampled year after year with accuracy, so that ability to detect change is, in theory, increased by effectively pairing or blocking the samples taken in different years for the same group of sampled individuals. For the plant community of sagebrush steppe, annual variation in both detectability and sizes of individual plants is high (Huntly unpubl. data), presumably primarily in response to variation in climate and weather. Thus, the advantages to resampling the same physical transect are modest in comparison with the substantial costs of cumulative direct impact of sampling on the vegetation and of effort required to relocate exact sample points and set up sampling transects in exactly the same location each year.

Data Entry and Management

The UCBN will move to paperless field data entry in all of its programs, but is currently in a period of transition as to preferred digital tools (e.g., Table PCs vs weaheerized PDAs) and does not yet have the ability to provide sufficient devices or training to assure data quality control. Paper data sheets will be used for initial testing and implementation of the sagebrush-steppe vegetation protocol. Paper data sheets prevent data loss and can be used easily by students and others untrained in use of digital tools.

This protocol is designed for paper data sheets, but will be revised once digital data entry is implemented by the UCBN.

Paper data entry is straightforward, and data sheet templates are included in Appendix A (or SOP#4 Sampling Vegetation?). The basic structure involves a spreadsheet of columns of

Blank data sheets also will be available to accommodate any late changes.

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

1. grid cell location
2. sample transect location
3. take photo-point images
4. enter line-intercept data onto data sheet
5. enter tree count data onto data sheet
6. add comments in notes columns
7. review data entry and be sure that all fields are filled appropriately, unambiguously, and clearly before moving to the next sample location

Data sheets will be inspected by team leaders and the project leader at the end of each field day, as a key step in quality assurance and quality control (QA/QC). Data entry from paper forms into the working copy of the sagebrush-steppe vegetation database, a Microsoft Access application, will be done by UCBN staff or field staff after completion of field work and will also be subject to QA/QC. Validation rules programmed into the database will help detect logical inconsistencies, such as out of range data. Paper data sheets will be archived by the UCBN for 3 years, which will allow time for all QA/QC problems to be resolved, at which time the archived database, including backup copies and versions off the NSP Data store, will be the sole repository for legacy data for this project.

After the Field Season

Following field work, equipment should be stored in the UCBN (or contractor) headquarters. Non-electrical equipment should be stored in labeled bins. Electronic equipment, including GPS units, should be stored at the UCBN or contractor offices. If not in use on other projects, batteries should be removed during winter months to prevent corrosion and leaking. Waypoints should be deleted at the end of each field season prior to storage.

Data Handling, Analysis ,and Reporting

Overview of Database Design

Data Entry

Entry of data from paper field sheets to the database will be accomplished each season shortly after completion of field work. A data entry form, developed within Microsoft Access, will be patterned after structure of a basic field form, 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 paper forms and the resulting entries in the database.

Quality Review

After data have been entered and processed, they need to be reviewed by the Project Lead for quality, completeness, and logical consistency. The working database application will facilitate this process by showing the results of pre-built queries that will check for data integrity, data outliers, missing values, and illogical values. Not all errors and inconsistencies can be fixed, in which case the resulting errors are then documented and included in the metadata and certification report.

Metadata Procedures

Data documentation is a critical step toward ensuring that data sets 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 data sets 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 Information 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 each year, as additional data are corrected, and as changes to the protocol are made. 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 locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Lead and the 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. Certain project information related to the specific locations of rare or threatened taxa may meet criteria for protection and as such should not be shared outside NPS except where a written confidentiality agreement is in place prior to sharing. Before preparing data in any format for sharing outside NPS – including presentations, reports, and publications – the Project Lead should consult the **UCBN Sensitive Information**. This document provides specific, up-to-date guidelines and procedures for:

- Determining which park resources (e.g., species of plants and animals) qualify as resources at risk,
- Identifying the specific types of information about these resources that constitute protected information, and
- Specifying the reduced level of resolution at which location information for particular resources can be shared outside NPS without a confidentiality agreement.

The Project Lead and Park Resource Managers have joint responsibility for ensuring adequate protection of sensitive information related to this project. Prior to accepting a report or publication, they will review all charts, figures, and location descriptions to ensure that the specific locations of sensitive natural resources are not compromised. All other data products that will be made public should be similarly screened for mention of sensitive information. Specifically, the following types of data should be retracted from all tables, figures, and descriptive narrative:

- All specific mention of observations of sensitive taxa at locations for which specific location information has already been made public. Species tallies and other types of data presentations that do not disclose the precise locations of sensitive taxa may be included.
- The coordinates or descriptive information that could be used to relocate the positions of sensitive resources observed incidentally and not associated with otherwise known locations (e.g., nesting observations and rare bird observations). In this latter situation, project personnel have the option of either omitting the record completely or applying a random offset to all qualifying observation coordinates, after which coordinates should be rounded or truncated so the UTM values end in zeros to give a visual cue that the values are not actual coordinates. These “public” coordinates are then the only ones to be shared outside NPS – including all published maps, reports, publications, presentations, and distribution copies of the data set – in the absence of a confidentiality agreement.

The Data Manager can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

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) they are appropriately documented and in a conditions for archiving, posting, and distribution. Certification is not intended to imply that 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 tables x and y in the Operational Requirements section. Additional details of the certification and delivery process are included in SOP#6.**

Data Analysis

This monitoring program is designed to balance understanding of status with detection of trends and includes analyses to characterize a variety of indicators of sagebrush steppe community structure and condition:

- a) cover of *Artemisia* species
- b) cover of *Bromus tectorum*
- c) cover of *Astragalus* spp.
- d) cover of several other species to be selected during protocol testing
- e) abundance and occurrence of trees
- f) total shrub cover
- g) total covers of native and non-native species and proportional cover of non-native species

Simple summary of means, standard errors, and ranges of the univariate indicator metrics (a through i, above) should be built directly into the database management to save time in routine annual data summary.

Annual Status Summary and Power Analysis

Status results will be summarized after each year of data collection. Standard summary statistics will be presented **with content similar to that shown in Table x**, and will include measure of central tendency (mean), dispersion (standard error), and frequency of occurrence.

Graphical representation of data is also important in exploratory data analysis, particularly in

Prospective power analysis, as described earlier, will continue to be used during the first 3 years of implementation (through 2010) in order to use knowledge of inter-annual variability to improve sample size estimation for future sampling.

Trend Analysis

Trend analysis will begin after the 2012 field season and will be conducted every five years thereafter. <<Tom, there is no good reason this can't be done annually. Once the program is up and running, data analyses can be automated and it will be easy to check out the appropriate trend metrics. What do you think is the best time interval?>>

Trend will be determined using route regression (Elzinga et al. 2001), a variant of linear regression that is used to assess aggregate trends over more than a single sample unit (here, over the annually sampled 100m x 100m grid cells). In route regression, a simple linear regression is calculated to establish the trend for each “route”, here a grid cell. Then the grid-cell-specific trends are combined to estimate a mean slope (trend) and associated variance over all locations. The mean and variance of slopes over all locations are then used to make confidence intervals and test whether trends, in aggregate, are significant (different from 0, no trend) overall the study area. For the sagebrush steppe vegetation data, route regression will be conducted for each indicator, both within each park and over all parks. The overall route regressions can be weighted, if desired, to account for effects of differences in sample sizes within parks.

Additionally, a non-parametric measure of trend will be calculated.

Reporting

A summary report will be produced annually, with a more detailed report produced every 5 years. The annual report should:

- List project personnel and their roles
- List grid cells and sample locations within grid cells that were measured during the current year
- Provide a summary history of the samples taken during each year of the study, tabulating numbers of fixed and rotating samples for each park and showing these located on maps of the parks
- Provide a summary of the indicator metrics for each park and for all parks in aggregate
- Provide summary status statistics and detailed trend results
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretation

A more in-depth analysis and report should be produced every 5 years. In addition to the above, the 5-year report should also summarize annual indicator estimates for all previous years of the monitoring program, assess spatial patterns in the density estimates, and identify any possible trends or distributional changes within the parks. The report should also evaluate the monitoring program. 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

Comment [Tom3]: I can pull this stuff directly from our monitoring plan – chapter 7 on reporting

routinely examined annually, is the sampling time still appropriate, etc. Reporting is described more thoroughly in SOP #7 Reporting and Presentation.

Annual reports and 5-year analyses of status and trend should use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports should use the Natural Resource Report template, and trend analysis and other peer-reviewed technical reports should use the Natural Resource Technical Report template, from which this protocol was also prepared. These templates, guidelines for their use, and documentation of the NPS publication standards are available at the following address:
<http://www.nature.nps.gov/publications/NRPM/index.cfm>.

Data Archival Procedures

Paper data sheets 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, vouchers, and observations)
- *NPS Data Store* – a centralized data repository with a graphical search interface.

Protocol Testing and Revision

Protocol Testing

Field work in summer 2006 was designed to test appropriateness of sampling methods in UCBN sagebrush-steppe field sites. To minimize costs of this basic data collection and testing step, field sampling was restricted to CIRO. On-going work in CRMO makes data from that park also available for protocol testing.

Protocol testing in summer 2008 will apply the protocol to CIRO, CRMO, JODA, and HAFO. Protocol testing will include assessment and refinement of power to detect a net trend in each of the indicator metrics (e.g., Elzinga et al. 2001). Field sampling and basic data management will be followed by extensive analysis of the data to optimize sample-size distribution among the Parks, and future sample sizes will be adjusted as needed, with final allocation of sample effort to fixed and rotating panels based on that information.

An additional objective of testing of the protocol during 2008 will be to assess the within- and among-park sample sizes that will allow the data to be used also to test new hypotheses that may arise over time and to address both deliberate management practices and uncontrolled occurrences for which exact spatial location of “treatments” cannot be

known in advance. This requires integration of field data and the GIS databases from each park to understand the likely sizes and occurrence in samples of various management-defined units. The long-term flexibility goal is to have a sufficiently large set of samples to be able to categorize them post-hoc (post-stratification) according to past land management or impact (e.g., wildfire) and be able to compare sufficiently large sets of plots to represent the outcome of shared (within-category, e.g., burned, or grazed, or with an invasive plant species) and divergent (between-category, e.g., grazed with different practices, managed burns vs. wildfires vs. unburned) land management practices or unplanned impacts. This analysis will require using the park GIS databases to explore the sample sizes that are likely to be available to address various evaluation scenarios (e.g., effects of wildfire; of limiting visitor access to an area or areas; of increasing visitor access through construction of trails, campgrounds, or parking lots).

Revising the Protocol and Archiving Previous Versions of the Protocol

Over time, revisions to both the Protocol Narrative and specific SOPs are to be 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 and analysis of data. 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 give the history and justification for doing the work and an overview of the sampling methods, but hat 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 Protocol Library.

The steps for changing the protocol (either the Narrative or an SOP) are given in SOP #10, “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 LTEM Protocol Library under the appropriate folder.

Personnel Requirements and Training

Personnel Requirements, Roles, and Responsibilities

The sagebrush-steppe vegetation monitoring program requires coordination among many, only a small number of whose roles are decribed in detail in this Protocol,

which describes field work, primary data management, analysis, and reporting activities. Thus, the coordinated roles of the full team, including the UCBN personnel (including the designated UCBN Project Lead), Park personnel, the project contractor (Project Lead/Field Lead), and technicians are detailed in Appendix E.1. This Protocol describes in detail the roles and responsibilities for only the Project Lead, which may be the UCBN lead or may include an additional contractor, and Field Personnel.

The sampling protocol defined here requires, minimally, a crew of 2 biological technicians trained in identification of sagebrush-steppe species and in the basic sampling techniques, and 1 project manager or supervisor who will train the technicians, oversee their work, and verify, summarize, analyze, and interpret data each year (see Appendix E.1. and E.2. for additional detail on roles and responsibilities and specific tasks). The work could also be done with 2 or more crews of 2 technicians.

Qualifications and Training

The 2 technicians must become adept at all aspects of the sampling procedures, must be able and willing to travel and work independently at the 5 UCBN parks for which the sagebrush steppe protocol will be implemented, and must know or be able to learn quickly the plant species that will be encountered. They also must be careful and organized, giving attention to accurate site location, sampling documentation, accurate plant identification, appropriate collection of voucher specimens and unknown specimens, as required, and oversight of data recording for accuracy, thoroughness, and clarity.

The supervisor must have 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 plant identification. Many aids are available to assist in plant identification, including species lists for the 5 Parks (Appendix B) and standard taxonomic references (see SOP #2: Training Observers). Both plant species lists and annotated photo-identification references are being compiled for the 5 Parks, with draft versions complete for CIRO and CRMO and one underway for JODA. These will be updated substantially after protocol testing in 2007 and should then be updated annually as the database of plant species present in the 5 focal parks grows and as knowledge is accumulated of the characteristics that best distinguish easily-confused species in the field.

Operational Requirements

Annual Workload and Field Schedule

Vegetation surveys will begin no earlier than April (for the lowest elevation parks) and be complete by no later than mid-July, to reduce as much as possible differences in detectability, 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.

Pilot work suggests that JODA should be sampled first, then HAFO, CIRO, and CRMO in 2007. The order in which HAFO and LARO will be sampled will be determined according to visits to determine phenology, information from Park Resource staff, latitude and altitude of Parks, and any other available information on plant phenology of the areas to be sampled. {Tom, I searched around online for climate inventory work to support this (WRCC), but did not find the correct material – can you supply the info or the source please?}

Field sampling will require a 2-person crew and some time on the part of a coordinator/supervisor. Method testing in summer 2006 suggests that 6 sites (sample grid cells) can be sampled in day, though areas of Craters of the Moon will have higher travel time, resulting in a somewhat lower number of samples in a day.

The initial required workload for the field-crew is (10 weeks):

- 4 days pre-season training
- 4 days in-season re-training, review
- 10 days data entry/data quality work
- JODA (32 samples; 4 travel days, 6 sampling days)
- HAFO (20 samples; 2 travel days, 4 sampling days)
- CIRO (24 samples; 2 travel days, 6 sampling days)
- LARO (20 samples; 3 travel days, 4 sampling days)
- CRMO (64 samples; 5 travel days, 16 sampling days)

Facility and Equipment Needs

Field Facilities and Housing

This protocol requires only standard field equipment that is commonly used in plant sampling, plus access to references for identification of plants. A list of necessary and recommended field sampling equipment is given in Table x in SOP #5. It is useful to have access to a dissecting scope that can be taken to the field, and it is useful to have access to sheltered areas in which a dissecting scope can be used, reference materials can be kept dry and accessed, plant samples can be dried and examined, and data sheets can be checked daily for accuracy, clarity, and thoroughness. Thus, it is desirable to have some use of indoor housing, especially when working at the more distant parks or for longer sampling trips.

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

- 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 crew must arrange permission to camp within CIRO. Either is satisfactory for work there.
- Housing must be arranged through NPS personnel at CRMO, which has limited facilities at Headquarters in the northern portion of the park, or else the sampling crew 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.
- HAFO – (to be developed)
- JODA – Housing should be sought at the Oregon Museum of Science and Industry's Hancock Station, in the Clarno Unit of JODA. Because of the large travel times that could be involved in getting around JODA if the crew is unable to stay within the park, and preferable within the somewhat centrally located Clarno unit, it is very important to arrange housing at JODA well in advance of the field season. Alternatively, there are a number of campgrounds in the vicinity of the park.
- LARO – Camping, and perhaps housing, is available in LARO and nearby areas.

Equipment and Supplies Needs

Budget

Personnel expenses for field work are based on a crew of 3 people: 2 botanists-ecologists-technicians to do the field sampling, and 1 botanist-ecologist-supervisor-manager to train personnel, supervise the field-work and data entry-verification, and supervise or do the data analysis. Field time will be further refined through protocol testing. <<Tom, Costs will depend on your UCBN pay scales. Please fill in.>>

Field work (salary)	8 weeks for 2 technicians 2 weeks for 1 supervisor
Field work (travel)	Vehicle rental and mileage, 8-10 weeks lodging as needed
Data management/reporting	(2 weeks for 2 techs, plus 3 weeks for 1 supervisor to analyze and report)
Start-up equipment costs	\$2000-3000 (including field dissecting microscope and GPS)
Annual equipment/supplies	\$1200 (including maintenance and updating of field equipment and purchase of consumable supplies)
Total	

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