Appendix G.

NCPN Protocol Development Summaries

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Air Quality

Parks Where Protocol will be Implemented:

BLCA, BRCA, CANY, CARE, ZION

Justification/Issues being addressed:

Both the Clean Air Act and the NPS Organic Act protect air resources in national parks. Additionally, the NCPN has identified several aspects of air quality as high priority vital signs for monitoring (Miller et al. 2003). Over the past three decades, the NPS has developed several internal and cooperative programs for monitoring various measures of air quality (NPS 2002) from which data the NCPN will summarize in its program.

The NCPN does not perform air quality monitoring in network parks. That work is being done by park staff, the NPS-ARD, the EPA, and affiliated contractors. However, the NCPN documents the methods used for data collection, archives, analyzes, and reports on the data. This protocol documents the methods currently used for collecting air quality data in NCPN parks and provides for regular review of changes in those methods. It describes how these data are retrieved, managed, and analyzed for regular reporting to NCPN parks.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine the weekly, seasonal, and annual status and trends in concentrations of visibility-reducing pollutants at BRCA, CANY, CARE, and ZION.

2. Determine the weekly, seasonal and annual status and trends in concentrations of N- and S- containing, and other selected ions from wet deposition at BRCA and CANY.

3. Determine the weekly, seasonal, and annual status and trends in ozone concentration at BLCA, CANY and ZION.

4. Determine the weekly, seasonal, and annual status and trends in dry deposition chemistry at CANY.

Basic Approach:

Most of the field collection of air quality samples and data is automated, the principal exceptions being the changing of sample collectors (filters, buckets). Field operations consist of weekly visits for inspection, routine maintenance, and sample collection by park staff, and semi-annual to annual maintenance by program specialists. Data from the various air quality monitoring programs are acquired from web-based program archives. Procedures for downloading these data are described in Standard Operating Procedures (SOPs). An annual report is prepared each year. It includes monthly and annually summarized data, calculated standard indices, identification of extreme conditions, and comparisons to historical conditions. Air quality monitoring involves four ongoing programs, the Clean Air Status and Trends Network (CASTNET), the National Atmospheric Deposition Program (NADP), the National Park Service, Air Resources

Division continuous ozone monitoring, and the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. The NCPN protocol is based on the assumption that these programs will continue to be externally funded. Facilities and equipment are described in the protocol narrative and in the SOPs. NCPN does not plan to fund additional air quality monitoring in the network park units. The workload for NCPN staff consists of data retrieval, archiving and analysis, and report preparation.

Principal Investigators and NPS Lead:

NPS lead: NCPN Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

A draft protocol that documents current methods and describes NCPN handling of external data is in review and available at http://www.nature.nps.gov/im/units/ncpn. Reporting will begin in Winter 2006.

Aquatic Macroinvertebrates

Parks Where Protocol will be Implemented:

ARCH, BLCA, CANY, CARE, CURE, DINO, NABR, ZION

Justification/Issues being addressed:

Aquatic macroinvertebrates are indicators of water quality and the condition of aquatic ecosystems. In much of the U.S., they are included in state standards for water quality. As major components of aquatic and riparian biodiversity they provide information on the biotic integrity of the systems. The status of aquatic macroinvertebrate communities is a high-priority vital sign for the NCPN (Miller et al. 2003).

Monitoring Objectives to be Addressed by the Protocol:

1. Determine annual status and trends in aquatic macroinvertebrate species abundance in selected reaches of perennial streams and rivers.

Basic Approach:

Periodic sampling of benthic invert communities will employ standard quantitative methods based on established USGS North American Water Quality Assessment (NAQWA) and EPA Environmental Monitoring and Assessment Program (EMAP) protocols. Field collection of samples is followed by initial sorting in field, and identification of species in a laboratory. Sampling may employ unequal probability selection if a reach classification scheme allows good replication. Sampling will be co-located with riparian and water quality monitoring where practicable.

Analyses will include ordination of community data, and summaries of community metrics (S, H`, EPT [an abundance ratio of several types of invertebrate taxa]).

Principal Investigators and NPS Lead:

The principal investigator for this protocol is Anne Brasher, USGS Water Resource Division, Salt Lake City. NPS leads: NCPN Program Ecologist, Southern Colorado Plateau Network (SCPN) Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

A draft protocol for pilot testing will be available in spring 2006. Implementation is anticipated to begin in 2006. This protocol development is funded jointly by the NCPN, SCPN and USGS-WRD. The NCPN contribution was $32,500 from FY 2004 funding and $10,000 from 2005 funding. Funding for 2006 is yet to be determined. Products are listed in Table 1, and include draft and revised components of a monitoring protocol for aquatic invertebrates in Colorado Plateau riparian systems, and reports assessing sampling approaches and temporal variability using proposed methods.

Table 1. Schedule of Deliverables for Aquatic Marcoinvertebrate Monitoring Protocol Development.

Product Description	Due Date
Review draft protocol report (methods sections)	December 2005
Draft protocol report (methods sections)	February 2006
Invertebrate field trial report (qualitative vs. quantitative sampling)	30 June 2006
Annual progress reports to meet NPS reporting requirements (I&M and IAR)	March, 2006; September, 2006
Review draft report, all USGS components of protocol documentation	December 2006
Final report, all USGS components of protocol documentation	February 2007 (with exception of within-year sampling frequency, which will be due 30 June 2007)
Invertebrate field trial report (within-year temporal variability)	June 2007

Climate

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, COLM, CURE, DINO, FOBU, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

Understanding the role of climate as a forcing agent for other vital signs is critical to NCPN monitoring. Observed changes in vital signs may be in response to multiple factors, such as anthropogenic stressors or variation in climatic conditions. Discerning reasons for observed changes that are responsive to mitigation measures (e.g., soil erosion vs. climate-driven change) will ensure effective management recommendations. Furthermore, untangling the effects of intrinsic climatic variation and climatic change will provide useful insights into regional trends in environmental change.

The NCPN climate monitoring effort will capitalize on extant climate monitoring programs. These programs provide consistent monitoring of climatic conditions, and in some cases, provide a long-term period of record. Information from climate stations in NCPN parks units will be archived on the NCPN server. Procedures for acquiring and archiving observations are developed in the Climate protocol. The databases established and maintained by this protocol will provide key information to understanding coarse-scale changes in climatic patterns in the NCPN, and aid in the interpretation and analyses of trends in the other monitored vital signs.

Monitoring Objectives to be Addressed by the Protocol:

1. Provide monthly and annual summaries of climatic parameters in NCPN park units. Common climatic parameters include air temperature and precipitation; additional parameters include wind speed and direction, solar radiation, fuel temperature and moisture.

2. Identify extremes of climatic conditions for common parameters (precipitation and air temperature), and other parameters where sufficient data are available (e.g., wind speed and direction, solar radiation, fuel temperature and moisture).

Basic Approach:

The goals and objectives of external climate monitoring programs have dictated the numbers and locations of weather stations in the NCPN. Maintenance and calibration of climate stations tend to be the responsibility of external agencies. Depending on the program, park staff are responsible for minor maintenance of most stations, such as replacement of malfunctioning equipment. Otherwise, regional program representatives service climate stations.

Data from all but two of the climate stations on NCPN park lands will be archived on the NCPN server. Data from the two CLIM-MET stations are not archived due to the temporary nature of these stations. Data acquisition and archive procedures focus on

climate stations in NCPN park units. Evaluations of climatic trends and trend analyses of other vital signs may be enhanced with data from climate stations adjacent to park lands.

An annual report on the climatic conditions of the most recent year is to be distributed by February of the following year. There are four components to the climate report: 1) a monthly summary of reported climatic parameters; 2) an annual summary; 3) assessments of annual, monthly, and daily measures in the context of historical trends (i.e., climatic extreme assessments); and 4) a comparison of climatic conditions among the NCPN park units.

The NCPN will not be directly involved in reading, recording, or reporting the observations from a climate station. Park staff will be involved in recording daily observations of NWS-Coop stations. Inspection and calibration of RAWS stations by park staff is required prior to the fire season. The Timpanogos Cave NM Avalanche station is serviced twice a year by park staff.

Climate monitoring involves seven ongoing monitoring programs. The NCPN protocol assumes that these programs will continue to be externally funded. Facilities and equipment are described in the protocol narrative and in the SOPs. NCPN does not plan to fund additional climate-monitoring in the NCPN park units.

Principal Investigators and NPS Lead:

NPS lead: NCPN Program Ecologist

Development Schedule, Budget, and Expected Interim Products:

This draft protocol is in review and available at http://www.nature.nps.gov/im/units/ncpn. Reporting will begin in Winter 2006. Procedures have been developed to access or derive daily measures for 28 of the NCPN climate stations; these can be viewed at the same web page.

Fine-scale Disturbance

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

Visitor-induced disturbances in the form of social trails, off-road vehicle trails, trail heads and campgrounds, occur at a relatively fine scale. However, these disturbances can have long-term and large-scale impacts due to the susceptibility of the dryland soils in the NCPN. Trampling by humans can eliminate biological soil crust (BSC) from a site for decades. Without soil-stabilizing BSC, soils are prone to water and wind erosion. Water erosion further impacts down-slope sites through the physical action of water runoff, and with the deposition of eroded soils.

Trampling and off-road vehicular traffic in riparian and riverine communities also are critical disturbances in the NCPN. Riparian areas are essential components in an otherwise xeric landscape. These areas provide habitat for wildlife by providing much needed water, shade, food resources, and nesting structures (Howe et al. 1999). The destruction of bank-stabilizing vegetation results in altered channel and flood-plain forming processes. These in turn lead to the ecological simplification of riparian communities and the loss of attendant biodiversity.

Fine-scale disturbances often are difficult to detect by conventional sampling designs, and census methods are cost prohibitive. A cost-effective and spatially-explicit assessment of visitor-use ‘footprints’ will better alert park managers to problem areas in a park.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine changes in the composition (types and amounts) and configuration (spatial pattern) of park visitor-use “footprints” in selected high-use areas (trails, trailheads, campgrounds, roads, and riparian areas).

Basic Approach:

Fine-scale disturbances associated with visitor-use will be monitored using aerial photography and photo interpretation. Visitor-use “footprints” targeted with this monitoring will include trail-head areas, trails, campgrounds, and backcountry roads (one and two track). Riparian vegetation by life-form or possibly species, and attributes of stream channels may be monitored with approach.

Data acquisition and costs will require the use of a spatial sampling design and a temporal revisit design. The selection of flight paths may employ the overall sampling frame developed for each park unit (see Chapter 4 – Sampling Design), or require some other frame. Sampling will be designed to detect fine-scale disturbances in spatially confined areas such as riparian corridors as well as in upland areas.

Comparison of interpreted sequential image will detect changes in composition and configuration of fine-scale disturbances. Key descriptors will consist of patch-size or

length-size distributions for general disturbance types. Trend assessments of individual descriptors will illustrate the tendency for disturbances to change in number, size, or in relation to certain land-cover types. Maps of detected disturbances will illustrate the spatial dispersion of disturbances relative to sampled areas. Managers can use these assessments and maps to guide changes in visitor-use policies as well as to determine areas in need of restoration.

Principal Investigator and NPS Lead:

The principle investigator for this effort is Robert Waltermire, USGS, Ft. Collins. NPS lead: NCPN Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

A preliminary test of this approach is being conducted in Summer 2005. The goals are to determine minimum resolution requirements for detecting disturbances of interest, and to develop cost estimates. In 2005, $2300 was invested in acquiring new 1:10,000 aerial photography for an area in ARCH. Assuming positive results from the preliminary test, a protocol will be completed in 2006, funding to be determined.

Human Demographics and Developments

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

A substantive threat to park resources is land-use activities outside of park lands. Encroaching urbanization imposes obvious boundary effects through increased cross-boundary contrast. This in turn increases the risk of introducing and extending edge effects onto park lands. More subtle effects include the loss of seasonally critical habitat and migration corridors, water pollution, and the disruption of hydrologic flow regimes. Agricultural development of adjacent lands also increases the risk of erosion and altered flow regimes, and additionally contributes to the threat of agro-chemical pollution on park lands. Distant land-use activities can impact park lands as much or even more than adjacent activities. Dam operations and industrial air-pollution can impact parks located hundreds of miles away.

Other protocols of the NCPN program monitor local agents of change by focusing efforts within or proximate to park lands. Monitoring the status and trends of extra-local activities provides information on larger-scale factors that may aid in understanding reasons for localized changes in park lands. Additionally, monitoring land-use indicators with known linkages to ecological function can provide predictions of how park resources may be impacted over time (Hansen and Gryskiewicz 2003). Managers can use land-use information to anticipate mitigation actions for park lands, to motivate conservation agreements with private or other public agencies, or to force change in extra-local land-use policies.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine changes in local human demographics, building permits, water diversion/allocations, well-drilling permits, and other land uses documented in public records.

Basic Approach:

Public records will be interrogated for information on housing development and population density (U.S. Census Bureau), water discharge and pollution (UT, CO, AZ, State Departments of Environmental Quality, and EPA), hydrological flow (USGS gauging stations), well-drilling permits, dam construction and operation (EPA National Watershed Characterization, The Colorado Water Quality Control Division, the Utah Division of Water Resources, BoR/CSU), large-scale changes in land cover (USGS, National Land Cover Dataset, Southwest Re-Gap mapping program, WY Gap Program), agricultural land-use trends & agro-chemical use (state Dept. of Agriculture in UT, WY, CO, and AZ; USDA Agricultural Statistics Service [http://www.nass.usda.gov/co/]), and grazing allotments (USDA Forest Service, USDI BLM, USDI NPS). Information will be

gathered at the finest-possible resolution (e.g., county) but be inclusive of the geographic range of the NCPN. Trends in land-use activities will be assessed by recording information every 3-5 years.

Conceptual linkages between land-use activities and ecological function within park units will be developed following methods in Hansen and Gryskiewicz (2003). Linkages will provide insight into the implications of land-use trends, and serve as the basis for making prognoses of park conditions based on observed trends. Changes in extra-local land use and the conceptual linkages also will aid in interpreting monitored, local trends in park resources.

Principal Investigators and NPS Lead:

NPS lead: NCPN Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

A draft protocol will be completed in Fall 2005. Reporting will begin in Winter 2006.

Invasive Plants

Parks Where Protocol Will Be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

Invasions of exotic plant species represent one of the most serious threats to natural ecosystem integrity (National Research Council 2002). Biological invasions are occurring at accelerated rates in nearly every major ecosystem (Mooney and Hobbs 2000). Invasive exotic plant species are of concern given their ability to quickly expand into new areas, to compete with and exclude native species, and to alter ecosystem processes across multiple scales. Invasive exotic plants are a significant stressor to park ecosystems, and a high-priority vital sign for the NCPN (Miller et al. 2003). Furthermore, NPS Management Policies (NPS 2001) state that "high priority will be given to managing exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controllable."

Prevention of plant invasions is the most effective, economical, and ecologically sound approach to managing invasive species (Center for Invasive Plant Management 2004). When preventative measures are not successful, early detection of new invasions is the next critical step. Hobbs and Humphries (1995) identified a significant time lag between the initial establishment of an invasive exotic plant and its rapid expansion toward local carrying capacity. Control efforts initiated during this lag phase are likely to cost less and achieve higher success rates compared to efforts begun later in the invasion cycle (Hobbs and Humphries 1995).

Through park base funding, natural resource projects, and network inventory efforts, some parks have completed inventories to describe the distribution and abundance of exotic plant species (Dewey et al. 2003, 2004a, 2004b). While useful, these inventories become outdated after a few years. Regular, comprehensive monitoring of the distribution and abundance of all exotic plant species within NCPN units is beyond the fiscal capabilities of the network and parks. The network is seeking a cost-effective approach to detection and status and trends monitoring of invasive exotic plants.

Monitoring Questions and Objectives to be Addressed by the Protocol:

1. Detect incipient populations and new introductions of invasive plant species before they become established in areas of management significance.
2. Determine status and trends of selected populations of invasive plants of management significance.

Basic Approach:

Monitoring of invasive plants will include detection and status and trends. Detection monitoring will emphasize key vectors and pathways for invasions, and areas of management significance or vulnerability to invasion. Status and trends monitoring will

focus on exotic plant populations of management significance. A revisit design will be employed with less than annual data acquisition per park.

For both detection and status and trends monitoring, index sites will be selected in consultation with park management. Standard methods (e.g. Gerlitzlehner 2003) will be employed to monitor selected populations or locations.

Principal Investigators and NPS Lead:

NPS lead: NCPN Program Manager.

Development Schedule, Budget and Expected Interim Products:

A national effort is underway in NPS to standardize monitoring invasive species. Protocols and a database are scheduled for completion in spring 2006. The NCPN will employ the national protocols (with modifications if necessary).

Land Bird Communities

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, COLM, CURE, DINO, FOBU, NABR, ZION

Justification/Issues being addressed:

The NCPN chose landbird communities as a vital sign because of the value of birds as indicators of ecosystem integrity, potential population declines, and because of the high public appeal of birds (Miller et al. 2003). Another key reason for selecting landbirds is the potential for NCPN to contribute to existing, regional monitoring programs (e.g., Leukering et al. 2000, Norvell et al. 2003). The NCPN will collaborate with one of these programs, the Rocky Mountain Bird Observatory's (RMBO) *Monitoring Colorado's Birds* (MCB), to monitor landbirds. Central to this partnership is the use of similar survey methods among NCPN and other ownerships throughout the intermountain west. The MCB program in NCPN park units will provide comparable information with the existing 900+ transects distributed in four other states, and contribute to enhancing the spatial extent of the program. Comparable methods will provide opportunities for comparisons within and among habitat types. Given land-use histories of national parks and other ownerships in the west, data from NCPN park lands will provide status and trend information for relatively 'natural' habitats. These data may serve as reference conditions for comparisons with more impacted areas. Comparable methods also provide the ability to evaluate the context of observed trends in NCPN units. Both global and local factors may lead to population declines on park lands. Global factors, such as the loss of migratory and wintering habitat or wide-spread pollution, will influence a species similarly and result in concomitant trends in breeding population density among land ownerships and locations. Conversely, local factors, such as breeding-habitat degradation, will promote site-specific trends that differ among management agencies. Discerning between global and local factors affecting population density of breeding-bird species is critical to recommending effective mitigation actions.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine status and trends in breeding-bird species' density in sagebrush, pinyon-juniper, and riparian habitats.
2. Determine if trends in breeding bird density (or abundance) and composition in NCPN park units differ from regional trends.

The sampling objective of the MCB protocol is an 80% probability of detecting a 3% decline in species' density over a 30-yr period, with a Type I error rate of 10%. This objective applies to the MCB program in NCPN park units.

Basic Approach:

The RMBO-MCB protocol uses a combination of two distance sampling methods to survey breeding birds – transect and point-count sampling. Thirty randomly-located

transects are used to sample a focal habitat, with transects randomly distributed among habitat patches. A total of 15 point-count stations spaced 250-m apart are located on each transect.

Sagebrush, pinyon-juniper, and riparian habitats will be monitored in NCPN park units using 15 transects per habitat type. A systematic sampling approach will be used to select habitat patches for monitoring. This protocol emphasizes monitoring and inference on a habitat level, not a park level. Thus, for each selected habitat type, patches will be combined across the park units selected for monitoring in deriving a systematic sample. Standard methods will be used to derive a probability-based systematic sample (Lohr 1999).

Analysis of data collected in NCPN Park units, as well as reporting of final results, is the responsibility of RMBO. Population trends will be analyzed using density estimates as an index that is not confounded by detectability issues. Analyses will be performed at the ecoregion, management unit (NCPN park units vs. others), and habitat level, for comparisons. The RMBO will provide annual summaries of observations, as well as periodic trend analyses, to the NCPN Inventory and Monitoring Project Manager. These reports and/or publications will also be available on the World Wide Web.

The Rocky Mountain Bird Observatory is responsible for hiring, training, and supervising field technicians conducting this Land Bird Monitoring Protocol in NCPN park units. Observers must attend a 5-day training program conducted by RMBO in early May of each year.

Principal Investigators and NPS Lead:

The NCPN Program Ecologist will be responsible for coordinating the implementation of this monitoring protocol with the RMBO. The data management (completing metadata and archiving of data collected by RMBO) aspect of the monitoring effort is the shared responsibility of the Project Manager and the NCPN Data Manager. The Ecologist is responsible for obtaining copies of all data collected in NCPN Park units by RMBO. The Data Manager is responsible for data archiving, data security, dissemination and metadata procedures

Development Schedule, Budget, and Expected Interim Products:

A cooperative agreement between NCPN and RMBO includes a funding level of $30,000 per year for landbird monitoring. RMBO is responsible for: 1) establishing and monitoring 45 transects, with two visits per transect, in selected habitats in NCPN park units; 2) hiring and training observers; 3) dispersing payment of salary and per diem to observers; 4) providing all necessary equipment with the exception of NCPN-provided GPS units; 5) performing data entry, management, and analysis and; 6) generating the annual status and trend reports.

The RMBO monitoring protocol has been revised to NPS standards and is available at http://www.nature.nps.gov/im/units/ncpn.

Land Condition

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

Land condition refers to the functional status of ecosystem processes within land-cover types. Information on land condition (i.e., plant vigor and productivity) is essential to understand how ecosystem resistance and resilience are impacted by anthropogenic and natural factors. In the NCPN, historical factors affecting land condition have been livestock grazing and fire suppression. Current disturbances such as livestock grazing and trailing, and visitor use (trails and back-country camp sites) have the potential to alter land condition across all parks units. Degradation in land condition on adjacent lands additionally can impact park lands indirectly by increasing cross-boundary contrasts, and directly by increasing wind and water erosion of soil along park boundaries. Moreover, global climatic change may play a large role in altering future land condition. Monitoring land condition and reasons for changes are important to management. Monitoring on park lands will allow managers to discern between natural and anthropogenic causes of land-condition change, and to develop effective mitigation actions. Monitoring land condition on adjacent lands will inform park managers of potential site-specific impacts on park lands, and promote effective mitigation strategies with adjacent ownerships.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine annual status and trends in the seasonally integrated Normalized Difference Vegetation Index (NDVI) for NCPN parks and adjacent lands. Where anomalous departures from previous trends are evident, investigate changes in vegetation and land cover likely to be causing the departures.

Basic Approach:

The MODIS (MODerate Resolution Imaging Spectroradiometer) satellite platform will be used to monitor land condition at a 250-m grain size. MODIS provides a Normalized Difference Vegetation Index (NDVI) that is a measure of vegetative productivity. MODIS-NDVI is available every 16-d, and will be acquired for the full extent of a park unit and at least a 5-km swath along a park boundary every year.

Seasonally integrated NDVI will be derived each year, and compared to trends of previous years. The integrated measure likely will be based on pixel aggregates instead of individual pixels to reduce data-processing load. Substantive departures in trends between the current and previous years will be interpreted as a change in productivity. Reasons for departures will vary. Changes may be due to subtle (e.g., trampling) or severe disturbances (e.g., wildfire, grazing), in response to climatic change, or reflect vegetative developmental patterns. Reasons for departures will be evaluated using ancillary information sources. The occurrence of disturbance agents will be gleaned from already collected plot-based data where possible (e.g., see Integrated Upland and

Integrated Riparian Protocol Development Summaries) and other remotely-sensed information sources (e.g., see Land Cover Protocol Development Summary), or involve focused field reconnaissance. Climate and air-quality attributes will be available from corresponding monitoring protocols. Where disturbance is a factor in land-condition change, correlations of intensity and severity with land condition will be examined. Similar assessments will be performed with abiotic factors to determine strengths of influence. To aid in evaluating relationships, information from similar land-cover types that lack anomalous departures will be included in assessments.

This protocol will produce overall trends in land condition in addition to site-level trends, and assessments for both park and adjacent lands. Information collected and analyzed in this protocol will be displayed as maps to visually illustrate current and past productivity, and areas experiencing substantive changes in land condition.

Principal Investigators and NPS Lead:

Principal investigators for this protocol are Mike White (Utah State University) and Bradley Reed (USGS EROS, Sioux Falls). NPS leads: NCPN Program Ecologist, Southern Colorado Plateau Network (SCPN) Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

Mike White was funded at $40,000 in 2004 to perform a proof of concept field trial to determine the utility of this approach. The report on his effort is due December 2005. Due to delays in the 2005 field season additional field work may be performed in 2006, delaying a final report until late spring. Given favorable results from the field trial, a protocol will be drafted in 2006 and implementation will commence in 2007.

Land Cover

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

Landscape structure supports the natural diversity of ecosystems and species. The composition (types and amounts of land-cover types), configuration (spatial arrangement of land-cover types), and connectivity (s.l. largest patch size) determine habitat availability, the movements of organisms, and energy and material flows on a landscape (Dunning et al. 1992; Taylor et al. 1993).

Substantive changes in landscape structure occur in response to natural and anthropogenic processes. Natural disturbance regimes largely are driven by climatic factors (e.g., Swetnam and Betancourt 1998). Expected changes in climatic conditions may elevate the frequency and severity of natural disturbances such as wildfire and insect and disease outbreaks. Monitoring current and future influence of natural disturbance on landscape change is key to understanding natural variation. Also, discerning between natural and anthropogenic forcing of change is critical to effective mitigation action. Management actions seldom can influence natural processes, but can be effective in mitigating human-induced changes.

Anthropogenic disturbance along park boundaries is of special concern. Increases in cross-border contrasts can lead to undesirable changes in energy and material exchange. NCPN park lands are highly vulnerable to increased flooding and gully formation due to degradation by grazing and trampling. Given the relatively high perimeter:area ratios of NCPN parks (Evenden et al. 2002), monitoring the effects of changes in landscape structure along park boundaries is a high priority for managers.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine the annual status and trends in the composition and configuration of land-cover types on park and adjacent lands.
2. Determine the annual status and trends in the connectivity of land-cover types within parks, and for park and adjacent lands combined.
3. Determine the annual status and trends in cross-boundary (park vs. adjacent lands) contrasts in land-cover types.
4. Determine long-term changes in fire frequency and extent.
5. Determine long-term changes in the frequency and extent of insect and disease outbreaks.

Basic Approach:

Land-cover information will be derived from Landsat or similar satellite imagery. Imagery may be acquired annually for the full extent of all parks, and for at least a 5-km swath around the boundary of a park. Alternatively, a temporal revisit design may be

employed depending on funding and data analysis constraints. Supervised classification will be used to generate land-cover classes that will include vegetation at the community level (e.g., blackbrush, pinyon-juniper), stream networks for large streams, rock, bareground, and anthropogenic features (e.g., buildings, roads, trials, campgrounds). Although the grain of Landsat is 30-m, the reflectance by the extensive amounts of soil and rock conditions inhibits accurate classification of features much less than 90 meters in the NCPN. Supervised classification will rely on plot data collected in the Integrated Upland and Integrated Riparian protocols.

Change-detection will be evaluated in several ways. Differences in spectral properties between sequential time periods will be used to produce a change-detection map. This approach relies on the raw digital number of spectral bands, not classification, and provides the most accurate measure of change. Where differences are detected, ground-based assessments or supporting information will verify that change occurred, and reasons for changes. Extent and spatial properties of change will serve as basic indicators of change, and be used in status and trend assessments. Additionally, substantive changes will appear as differences in classified land-cover maps. Status and trend assessments will be performed using a parsimonious set of landscape metrics that characterize composition (extent of land-cover types), configuration (e.g., patch size distributions, dispersion, juxtaposition), and connectivity (largest patch size and related measures) of land-cover types. Composition and configuration measures will be generated for all land-cover types. Connectivity (s.l. physical connectivity) measures will be derived for specific or combined cover types. Metrics will be generated using Fragstats (McGarigal and Marks 1995), and where necessary, customized programs. Patch-network and network-network patterns can influence the dispersal of propagules, and flows of energy and matter (Parendes 1997). Customized algorithms will be developed by the NCPN Program Ecologist to provide measures of adjacency and intersection between network (e.g., trails and roads) and patches (i.e., land-cover classes), and among network features (e.g., trails and roads). All land-cover related metrics will be generated separately for park and for adjacent lands; connectivity and network-related measures will apply to park lands, and to park and adjacent lands combined. Cross-boundary measures will consist of edge-contrast measures weighted by the degree of contrast between pairs of land-cover types. Weights will be assessed by NCPN and park staff, and be based on known or perceived functional differences between cover types.

Disturbances will be monitored indirectly. Large-scale changes in land-cover types between years likely will indicate disturbance. When such changes are detected, ground-based assessments will determine the occurrence and type of disturbance. Over a long time frame, the time series of observed disturbance frequency and severity will be used to determine changes in disturbance regimes. Monitored climate information will aid in detecting and understanding reasons for changes in disturbance regimes.

Principal Investigators and NPS Lead:

Protocol development is a joint effort with the Southern Colorado Plateau Network (SCPN) and Oregon State University, Department of Forest Science P.I.'s: Zhiqiang Yang, Warren Cohen, and Robert Kennedy. NPS leads: NCPN Program Ecologist, SCPN Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

A detailed study plan will be available in winter 2005. This protocol development is funded jointly by the NCPN and SCPN. Funding in 2005 was $123,000, split between the two networks. Funding for 2006 is likely to be similar amount. Products are listed in Table 2, and include a draft monitoring protocol for Land Cover in Colorado Plateau ecosystems.

Table 2. Schedule of Deliverables for Land Cover Monitoring Protocol Development

Item	Notes	Due Date
Literature & dataset review	Compile and summarize existing knowledge and identify on-going data collection efforts that are relevant to monitoring vegetation using remote sensing.	November 1, 2005
Draft Study Plan	Based on the literature and dataset review a draft detailed study plan will be completed.	December 1, 2005
Final Study Plan		February 1, 2006
Order and prepare data for pilot studies.	For tasks identified in the study plan, data will be assembled and collected. This will include ordering and preprocessing necessary remote sensing data, obtaining auxiliary information for data analysis, etc.	August 31, 2006
Protocols – Version 1.	Version 1 protocols for baseline mapping and change detection based on OSU's remote sensing knowledge and experience with remote sensing-based ecological monitoring at the North Coast and Cascades Network.	November 1, 2006

Peregrine Falcon

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, CURE, DINO, ZION

Justification/Issues being addressed:

Extensive population declines caused by the eggshell thinning effects of DDT metabolites led to the listing of the American Peregrine Falcon (hereafter, Peregrine Falcon) under the Endangered Species Act of 1973. Recovery efforts, including the banning of DDT as well as captive breeding and release, resulted in the formal delisting of this species in August of 1999 (Mesta 1999). Section 4(g)(1) of the Endangered Species Act requires a post-delisting monitoring period of at least 5 years for species removed from the list. In 2003, the U.S. Fish and Wildlife Service (USFWS) released its peer reviewed Plan for fulfilling this requirement, titled, Monitoring Plan for the American Peregrine Falcon (U.S. Fish and Wildlife Service 2003).

The Peregrine Falcon breeds throughout the Colorado Plateau, and occurs in 10 of the 16 NCPN park units - Arches N.P., Black Canyon of the Gunnison N.P., Bryce Canyon N.P., Canyonlands N.P., Capitol Reef N.P., Colorado N.M, Curecanti N.R.A., Dinosaur N.M., Natural Bridges N.M., and Zion N.P. Monitoring of Peregrine Falcon populations is a high priority for the overall NCPN, and is included in the NCPN conceptual model as an at-risk Focal Taxon. In an ecosystem context, the Peregrine Falcon is a top trophic-level predator. Preserving ecosystem integrity, in part, requires maintaining a functional trophic structure. Additionally, public interest in the species together with federal law motivate concerted effort to ensure that populations are recovering, and to document park-level populations in need of special conservation efforts.

The NCPN protocol will provide data required by the USFWS monitoring plan, but will be expanded in scope to provide more detailed information on Peregrine Falcons in NCPN park units. The USFWS plan encourages continued monitoring of Peregrine Falcon territories outside of those selected by the program, and will actively seek these data for incorporation into its national trend analysis. The NCPN protocol uses survey methods previously used in Alaska and NCPN park units.

The NCPN Inventory and Monitoring program is not directly involved in monitoring Threatened & Endangered (T&E) vertebrate species. The role of the NCPN monitoring program is to develop and update protocols for T&E vertebrates, and to distribute protocols to parks upon request. Individual park units are responsible for obtaining funding for, and conducting T&E vertebrate monitoring. Overall guidance and data management support will be provided by the NCPN, if requested.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine annual status and trends in territory occupancy of Peregrine Falcons.
2. Determine annual status and trends in nest success of Peregrine Falcons.
3. Determine annual status and trends in productivity of Peregrine Falcons.

Basic Approach:

The NCPN sampling design focuses on index study areas, fixed stretches of rivers or cliffs, which will be identified in park units with nesting Peregrine Falcons. All known and potential territories should be surveyed annually within these areas. The NCPN protocol recommends annual surveys, with a minimum of three visits per study area. Analysis of Peregrine Falcon population trends should be conducted after 3-5 years of monitoring, and potentially every year thereafter. There are two options for analyses. Trends analyses may be conducted at the individual park unit if numbers of territories and observations are sufficient for a statistically meaningful assessment. It is most likely that limited sample sizes will require data to be combined from all park units for trend assessments. Trends in the three key parameters (territory occupancy, nest success, productivity) will be evaluated using standard regression methods (e.g., Nur et al. 1999). Trend assessments at the park level should be included with the annual reports. Reports should include a description of the analyses performed, and an interpretation and discussion of the results. Additionally, the USFWS will produce triennial reports using regional data.

Trend assessments with data combined among park units will be conducted, upon request, by the NCPN Program Ecologist. A network-wide report will be produced that will include a summary of the data from participating park units, and interpreted results of trend assessments. Trend-assessment reports will be distributed to participating park units and the NCPN data manager for archiving.

Principal Investigators and NPS Lead:

The NCPN park unit requesting this protocol will designate a Principal Investigator (PI) as the lead on this protocol. The PI will be responsible for implementing the monitoring protocol, and will interface with NCPN Program Ecologist to insure that protocols are followed and survey data are managed appropriately. Observers will conduct the field work, and perform data entry, data management, analysis, and report writing. For trend assessments at the park level, either an observer or the PI should be responsible for data analysis and reporting. Network-wide trend assessments likely will be conducted by the NCPN Program Ecologist, who will be responsible for all aspects of analysis and reporting. The role of the USFWS National and Regional Coordinators of the Peregrine Falcon Monitoring plan is outlined in the Implementation Section of the USFWS Plan.

Development Schedule, Budget, and Expected Interim Products:

A draft monitoring protocol employing survey methods previously used in Alaska and NCPN park units is in review and available at http://www.nature.nps.gov/im/units/ncpn.

Integrated Riparian

Parks Where Protocol will be Implemented:

ARCH, BLCA, CANY, CARE, CURE, DINO, NABR, ZION

Justification/Issues being addressed:

Although of limited spatial extent, riparian ecosystems of the Colorado Plateau are critical landscape elements with unique, high levels of biological diversity. These systems are structured and maintained by physical and biological processes across a range of scales. Regional precipitation patterns and upland watershed conditions produce the primary drivers of these ecosystems: stream flow regime and flow-related geomorphic processes.

The most significant anthropogenic stressors to steams of this region include activities that disrupt natural flows of water and sediment, including damming or diversion of stream flow or construction of channel stabilization structures. Most of the larger perennial streams of the Colorado Plateau are subject to these stressors, which alter channel and flood plain forming processes, and typically result in the loss or ecological simplification of native riparian communities. Such changes also contribute to the establishment and spread of non-native species like Tamarisk, which alter ecosystem properties, increasing, for example, the frequency and intensity of fires, to the detriment of native species. The non-native riparian species, Tamarisk and Russian-olive, now represent the third and fourth most abundant riparian species in the western U.S. (Friedman et al., 2005). Park units affected to some degree by these abiotic and biotic changes include DINO, CANY, BLCA, and CARE.

Natural disturbance processes such as fire, and human land-use activities including livestock grazing, timber harvesting, agricultural clearing and groundwater pumping alter watershed conditions and thus indirectly influence downstream riparian ecosystems. Localized impacts like the creation of trails within riparian corridors further degrade site-specific riparian conditions and contribute to the possibility of arroyo cutting or channel incision. Although arroyo cut-fill cycles occur naturally throughout the southwestern U.S., the human activities described above, have clearly contributed to the frequency and intensity of these events, which have influenced riparian ecosystems at CARE.

Monitoring Objectives to be Addressed by the Protocol:

Specific objectives of this protocol include:

1. Determine annual status and trends in areal extent, cover, species composition and spatial structure of riparian vegetation (trees, shrubs, forbs, grasses) in selected reaches of perennial rivers and streams.
2. Determine annual status and trends in cover of exotic plants in selected riparian areas.
3. Determine annual status and trends in continuous stream flow/discharge of selected reaches of perennial rivers and streams.

4. Determine annual status and trends in bank stability, stream channel morphology (of surveyed cross sections) of selected reaches of perennial rivers and streams.

Basic Approach:

Monitoring physical variables--In each monitored stream reach, we will: 1) survey and construct a plan-view map of the reach, 2) permanently locate and resurvey channel cross-sections by placing surveyed head-pins, across the stream, on either side of the bottomland; 3) determine channel bed material composition; and 4) determine particle size composition of alluvial surfaces. We will also measure stream stage, and in conjunction with existing nearby USGS stream gages, will establish site-specific stage discharge relations. Where possible, we will use existing alluvial well information, or establish new alluvial wells, to develop functional relationships between surface water and alluvial groundwater dynamics. From this, hydrologic gradients, based on depth to groundwater or duration of surface water inundation can be developed for geomorphic surfaces or specific groups of plants (e.g., Auble et al. 1994, Auble et al. 2005) and used to develop a process oriented understanding of vegetation response to streamflow dynamics and channel change.

This sampling design will be replicated within similar geomorphic settings, for example, fan-eddy complexes in bedrock canyons or flood plain meanders in unconfined alluvial reaches. These geomorphic features will thus serve as a sampling template for measurements of related biotic response variables.

Monitoring riparian vegetation variables--At each sample location we will measure vegetation in plots and belt transects co-located with the channel cross-sections described above. A tag line will be stretched between the head-pins on each cross-section, and 1 by 2 m plots will be used to sample herbs (cover and richness by species) by randomly locating and surveying in plots on all identifiable alluvial surfaces from waters edge to the upland boundary (following G. Auble and M. Scott, unpublished data). Similarly, tag lines will be used to quantify the percent cover of all woody riparian species by recording linear distance over which individual crowns intersect the line. Patches of woody vegetation intersected by the line will also be measured for vertical structural diversity using a pole-intercept method (following Lite and Stromberg, in press). In this way, vegetation structure and composition can be precisely re-sampled over time and vegetation metrics can be directly and quantitatively linked to key physical variables.

Principle Investigator and NPS Lead:

Principal investigator for this protocol is Mike Scott, USGS-BRD. NPS leads: NCPN Program Ecologist, Southern Colorado Plateau Network (SCPN) Program Ecologist.

Development Schedule, Budget, and Expected Products:

This project is jointly funded by the NCPN, SCPN and US Geologic Survey, Biological Resources Discipline (USGS-BRD). In FY04 NCPN and SCPN each provided $11,500 toward literature review and conceptual model development, $30,000 per network is budgeted in FY05 for field work associated with protocol development. FY06 funding is yet to be determined. Interim products (Table 3) include review draft monitoring protocol, field trials reports and annual progress reports.

Table 3. Schedule of Deliverables for Integrated Riparian Monitoring Protocol Development.

Description	Due Date
Review draft protocol report (methods sections)	30 December 2005
Draft protocol report (methods sections)	28 February 2006
2005 field trial report (including results of methods comparisons, application of classification and site selection methods, between-observer error trials, and sample adequacy of 11 transects)	28 February 2006
2006 field trial report (including results of methods comparisons, application of classification and site selection methods, between-observer error trials, and sample adequacy of 11 transects)	30 December 2006
Review draft report, all USGS components of protocol documentation	30 December 2006
Final report, all USGS components of protocol documentation	28 February 2007 (with exception of within-year sampling frequency, which will be due 30 June 2007)
Annual progress reports to meet NPS reporting requirements (I&M and IAR)	15 September, 2006; March, 2006

Springs, Seeps, and Hanging Garden Communities

Parks Where Protocol will be Implemented:

ARCH, BLCA, CANY, CARE, CURE, DINO, HOVE, NABR, ZION

Justification/Issues being addressed:

Springs, seeps, and hanging gardens were identified as focal ecosystems by the NCPN (Miller et al. 2003). Colorado Plateau spring, seep, and hanging garden ecosystems support high levels of biodiversity, including endemic or obligate taxa, and they are sensitive to several anthropogenic stressors affecting NCPN parks (Welsh and Toft 1981, Spence and Henderson 1993).

Human activities have reduced the ecological integrity of many wetland, riparian, and spring ecosystems through groundwater diversion, recreation, and livestock grazing. The array of specific anthropogenic stressors was documented at more than 220 springs in northern Arizona on the southern Colorado Plateau (Grand Canyon Wildlands Council 2002, 2004, Stevens and Springer, unpublished data). These data demonstrate that more than 93% of springs on non-National Park Service federal lands have been ecologically impaired or are functioning at risk. This circumstance lends urgency to management of the relatively unimpaired spring and seep ecosystems protected within NPS units.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine long-term trends in discharge for selected springs and seeps.
2. Determine long-term trends in core and site-specific water chemistry parameters for selected springs and seeps.
3. Determine long-term trends in habitat area for selected springs and seeps.
4. Determine long-term trends in vegetation composition and structure for selected springs and seeps.
5. Determine long-term trends in diversity and abundance of aquatic and riparian invertebrates at selected springs and seeps.

Basic Approach:

NCPN and the Southern Colorado Plateau Network (SCPN) are working collaboratively through a Colorado Plateau CESU agreement with Northern Arizona University to develop inventory protocols and conduct a baseline inventory of springs across both networks. Inventory data will provide the basis for selecting core monitoring parameters. Monitoring design will take into consideration the fragile nature of these areas, and minimize observer impact and the potential for increasing park-visitor use. Methods and measures used for monitoring springs and seeps will be coordinated as much as possible with the NCPN Integrated Riparian Protocol.

Principal Investigators and NPS Lead:

Principal investigators for the inventory portion of the NCPN/SCPN spring, seep and hanging garden project are Abraham Springer and Lawrence E. Stevens, Northern

Arizona University. Investigators for the monitoring portion of this study remain to be determined. NPS leads: NCPN Vegetation Program Manager; and SCPN Program Manager. The Glenn Canyon National Recreation Area Botanist serves as a project advisor.

Development Schedule, Budget, and Expected Interim Products:

Schedule and budgets for spring, seep, and hanging garden monitoring will be developed following the field inventory component of this project (2005). Monitoring protocols will be developed and tested in 2007, and implemented in 2008. It is anticipated that SCPN will contribute to this effort.

Threatened Endangered and Sensitive Plants

Parks where protocol will be Implemented:

CARE, ZION

Justification/Issues being addressed:

Plant species can become threatened with extinction for many of reasons including over-harvest, habitat degradation, loss of pollinators, mortality from grazing or trampling, competition from invasive species, and elimination of ecological processes necessary for establishment and reproduction (Given 1994). In the arid western United States, many federally listed or candidate Threatened and Endangered plants are vulnerable to these impacts because of small populations and local endemism. Ensuring the continued survival of these species is legally mandated under the Endangered Species Act and the National Park Service management guidelines (NPS 2001: 4.2.1, 4.4.2.3). Changes in the status of listed or vulnerable plant species may reflect broader resource conditions of national parks.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine the annual status and trend of selected populations of listed Threatened, Endangered, or other plant species of concern.
2. Describe habitat conditions (vegetation composition and cover, disturbances) for selected populations of target species.
3. Determine demographic properties of management interest (e.g., longevity, recruitment) and key life cycle stages where species are most vulnerable to threats for target species.

Basic Approach:

A protocol has been drafted with specific methods for individual target species or guilds of target species with similar taxonomic or ecological attributes (Table 4). Monitoring intensity varies according to the degree of threat to each species and the level of information need. High risk taxa receive more intensive and quantitative study than species with low threats and stable populations (Menges and Gordon 1996). Populations of each target species are monitored through periodic site visits. Populations may be censused or sampled. Habitat condition and threats will be documented through permanent photo plots. Other measures include population size, density, frequency, or percent cover and species cover of associated vegetation. For species requiring more detailed information on population dynamics (e.g., demography, longevity, recruitment), randomly selected individuals will be permanently marked and tracked over many seasons. Specific demographic data may be collected to inform population viability analyses (Menges and Gordon 1996). Monitoring protocol development employed existing inventory and monitoring data, and builds on existing monitoring efforts. For each species or guild, the protocol identifies the target populations and includes criteria for selection of specific monitoring sites within populations. Emphasis will be placed on sampling populations from a variety of habitat types and across the species range in each park or in adjacent areas as necessary (in collaboration with other agency partners).

Principal Investigators and NPS Lead:

Protocols are being developed by Walter Fertig, a subcontractor of the consulting firm environmental engineering Management. NPS lead: NCPN Vegetation Program Manager. Some protocol development work is a cooperative project between NPS-NCPN, BLM Richfield District, and Fishlake and Dixie National Forests in southwestern Utah.

Development Schedule, Budget, and Expected Interim Products:

A protocol with species and guild specific methods is undergoing internal review and field testing. A draft protocol will be externally reviewed and implemented in 2006. Project budget: $35,000 NPS FY 2004; $6,000 BLM/USFS FY 2004.

Table 4. Preliminary target species, threats, monitoring questions and priorities for the TES Plant monitoring protocol.

Species/Status	Parks	Threats	Monitoring Objectives	Priority
Astragalus ampullarioides Shivwits milkvetch Status: Endangered	ZION	Probably low in ZION but very high rangewide from urbanization, OHV recreation, weed competition	Determine population status and trends Determine longevity and recruitment rates Document habitat conditions	High
Cycladenia humilis var. *jonesii* Jones' cycladenia Status: Threatened	CARE	Low seed production, loss of pollinators, drought, herbivory	Determine population status and trends Determine longevity and recruitment rates	Medium
Erigeron maguirei Maguire's daisy Status: Threatened	CARE	Trampling, flooding	Confirm persistence of selected populations Document habitat	Low
Gilia [*Aliciella*] *caespitosa* Rabbit Valley gilia Status: Candidate	CARE	Over-collection for commercial trade, trampling	Determine population status and trends Determine longevity and recruitment Document habitat	Medium

Species/Status	Parks	Threats	Monitoring Objectives	Priority
Pediocactus despainii San Rafael cactus Status: Endangered	CARE	Over-collection for commercial trade, mineral development, OHV recreation, trampling	Determine population status and trends Determine longevity and recruitment Document habitat	High
Pediocactus winkleri Winkler's cactus Status: Threatened	CARE	Over-collection for commercial trade, mineral development, OHV recreation, trampling	Determine population status and trends Determine longevity and recruitment Document habitat	High
Schoenocrambe barnebyi Barneby's reed-mustard Status: Endangered	CARE	Mineral development, road construction, trampling	Determine population status and trends Determine longevity and recruitment Document habitat	Medium
Sclerocactus wrightiae Wright's fishhook cactus Status: Endangered	CARE	Over-collection for commercial trade, recreation, mineral exploration, *Opuntia* borer beetle	Determine population status and trends Determine longevity and recruitment Quantify habitat conditions	High
Spiranthes diluvialis Ute ladies'-tresses Status: Threatened	CARE DINO*	Changes in hydrology, recreation, loss of pollinators, urbanization	Determine current status and trends in CARE & DINO Quantify habitat conditions	Low*

Species/Status	Parks	Threats	Monitoring Objectives	Priority
Townsendia aprica Last Chance townsendia Status: Threatened	CARE	Mineral development, trampling, drought?	Determine population status and trends Determine longevity and recruitment Quantify habitat conditions	High

* Existing monitoring in place in DINO. May be extirpated in CARE.

Integrated Upland

Parks Where Protocol will be Implemented:

ARCH, CANY, CARE, CURE, DINO, ZION

Justification/Issues being addressed:

The NCPN identified soil/site stability, hydrologic function, nutrient cycling, biological soil crust, sagebrush shrub lands, and native grasslands as high priority vital signs. Feedbacks between soil, water, and vegetation condition are central to the conceptual models developed for the region. It is widely held that the ability of a site to retain soil, water, and nutrients is critical to ecosystem resilience in the semiarid west (Whitford 2002). The loss of these functions leads to key ecosystem changes, such as reduced vigor and productivity of vegetation, increased soil erosion, and increased susceptibility to invasion by exotic plants. Positive feedbacks among these processes lead to desertification. Upland ecosystems will be monitored by an integrated suite of measures based on current interagency protocols for semi-arid upland ecosystems. Integrated monitoring of upland ecosystems will improve understanding of the intrinsic variability of these systems. Assessment of upland conditions in relation to other vital signs will facilitate identification of drivers and distinguishing "natural" from anthropogenic change. Additionally, plot data from this effort will be used in the classification and interpretation of remotely sensed data (e.g., see Land Cover Protocol Development Summary).

Monitoring Objectives to be Addressed by the Protocol:

For selected ecological sites in selected NCPN parks:

1. Determine annual status and trends in cover of biological soil crusts by species or morphological group.
2. Determine annual status and trends in cover of exotic plants in upland areas.
3. Determine annual status and trends in ground cover (live and standing dead vegetation, litter, rock, biological soil crust, and bare ground); soil aggregate stability and compaction as indicators of soil/site stability, hydrologic function, and nutrient cycling.

Basic Approach:

Methods will be based on monitoring protocols developed for semi-arid ecosystems (Herrick et al. 2004), with adaptations to meet specific network needs not otherwise addressed (e.g., monitoring forest trees). These methods employ transect based measurements of cover, composition, and spatial structure of plants, and biological soil crust and ground cover; and soil susceptibility to erosion. In addition, some measurements will be recorded only under certain circumstances. For example, soil compaction and aggregate stability may be measured only when related indicators (e.g., biological soil crust or ground cover) are below some threshold. Initial site visits will likely include an assessment of site condition relative to its reference condition, based on

NRCS (National Resources Conservation Service) ecological site descriptions. It is anticipated that the design of plot- or transect-based sampling will accommodate information needs of remotely-sensed, spatially extensive monitoring.

Site selection will be derived using the grid-base sampling frame (see Chapter 4 of the NCPN Monitoring Plan) and GRTS sampling. Unequal probability sampling with probabilities based on access and ecological site will be used. Efforts are underway to improve the resolution of ecological site polygons using ancillary data (aerial photography) and image analysis. A split panel revisit design will be used to monitor only a subset of sites each year. A limited number of ecological sites and parks will be selected for monitoring based on park management needs, per plot costs, and replication needs for desired statistical power.

Principal Investigators and NPS Lead:

The principal investigator for this protocol is Mark Miller, USGS-BRD ecologist. NPS leads: NCPN Program Manager, Southern Colorado Plateau Network (SCPN) Program Manager, NCPN Program Ecologist, and SCPN Program Ecologist.

Development Schedule, Budget, and Expected Interim Products:

The protocol development is being jointly funded by USGS-BRD, NCPN and SCPN with a budget of $122,000 in 2005 (split between NCPN and SCPN). In FY05, NCPN and SCPN program ecologists will develop methods to use ecological-site classifications in site selection. Field trials for methods comparisons and variability assessment will occur in FY 2005; a protocol will be drafted by spring 2006. Interim products include a report summarizing the results of field methods assessment (December 2005), preliminary data analyses (December 2005) and a draft protocol (by March 2006). Implementation will begin in 2006.

Visitor Use Patterns

Parks Where Protocol will be Implemented:

ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION

Justification/Issues being addressed:

Monitoring of visitor-use was a high priority vital sign for all NCPN park units (Miller et al. 2003). Of specific concern were potential impacts associated with visitor use, such as trampling effects on soils, vegetation, and aquatic resources, and behavioral disturbances to wildlife. Visitor-use information gathered at entrance stations provides only indirect measures of potential impacts to park resources, and limited information on location of potential impacts. Some park units conduct visitor-use monitoring of specific sites. Information about changes in the numbers and distribution of visitors among areas of a park will support analysis of fine-scale disturbance data and better aid in management decisions.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine status and trends in numbers, and spatial and temporal distribution of visitors in selected NCPN parks.

Basic Approach:

Information on current visitation monitoring will be acquired from each NCPN park. A scoping meeting will be held with parks to identify park-specific monitoring objectives to incorporate in to protocols. The cooperator (Univ. of Montana) will develop and describe a limited range of design-and-methods options that vary in terms of spatial extent (e.g., numbers and configuration of locations sampled), temporal resolution (e.g., frequency of sampling), information richness of sampling approach, and relative costs and benefits. A subset of these methods will be described in a monitoring protocol following NCPN review.

Principal Investigator and NPS Lead:

The principal investigator for this protocol is Neil Moisey, University of Montana. NPS lead: NCPN Program Manager.

Development Schedule, Budget, and Expected Interim Products:

This project was funded with $39,000 in FY 2004. Specific deliverables and due dates are presented in Table 5.

Table 5. Schedule of Deliverables for Visitor Use Patterns Monitoring Protocol Development.

Item	Due Date
Conduct inventory of visitor monitoring programs	Sept 2004-March 2005
Report of existing programs	May 2005
Conduct scoping workshop	August 2005
Develop recommendations and protocols for visitor monitoring programs	Aug – Dec. 2005
Final Report on recommendations and draft protocols	Jan. 30, 2006

Water Quality

Parks Where Protocol will be Implemented:

ARCH, BLCA, CANY, CARE, CURE, DINO, ZION

Justification/Issues being addressed:

Water quality is a high priority vital sign for the NCPN (Miller et al. 2003). National Park Service Management Policies for water quality commit the park service to protect, maintain or restore the quality of surface waters and ground waters within the park's consistent with the Clean Water Act and all other applicable federal, state and local laws and regulations (NPS 2001: 4.6.3). Monitoring data will inform the need for restoration and demonstrate whether or not park water quality is being protected or maintained.

Monitoring Objectives to be Addressed by the Protocol:

1. Determine status and trends in core parameters and selected constituents of selected water bodies.

Basic Approach:

Water quality monitoring in NCPN parks will be consistent with the standard procedures prescribed by the USGS (USGS, 1998) and the State of Utah, with the later preeminent in Utah parks and the former in other states. Where deviations are made, such as giving more emphasis to flow measurement than is typically done by Utah Dept. of Water Quality (DWQ), these will be documented and justified in the NCPN protocol.

The NCPN supports water quality monitoring staff at three locations in the network, BLCA/CURE, Southeast Utah Group and BRCA. Two of these (BLCA/CURE and Southeast Utah Group) are existing operations that will be augmented with NCPN funding.

In addition to the protocol objectives presented above, specific 'data objectives' are listed below.

- All data shall be of a known and documented quality that is acceptable to state agencies for the purposes of determining compliance with the Clean Water Act.
- All data shall be comparable through the network and with other water quality monitoring programs through the region.
- All data shall be representative of the parameters being measured with respect to time, location, and the conditions from which the data are obtained. The use of the standard methodologies contained in the QAPP insures that the data generated is representative.

<u>Site Selection</u>: Specific sample sites will be selected that are: 1) well mixed and representative of the larger water source; 2) not influenced by nearby inputs from tributaries, major springs or pollutant discharges, or if these are present the sampling location will be far enough downstream to permit thorough mixing; 3) near an established

stream gage or where a flow measurement is practical; 4) reasonably accessible; 5) where past sampling provides a historic record; and 6) that are complementary of other vital signs monitoring.

Field Measurements: The core parameters (temperature, pH, specific conductance, and dissolved oxygen) will be measured in the field using a multimeter (In-Situ Inc. Troll 9000E and Hydrolab Minisonde 4a). Turbidity will also be measured in the field.

Discharge will be measured using several generally accepted techniques, with the specific technique depending on site characteristics. For sites that can be locate in the near vicinity of a stream gauge, the gauge measurement at the time of the sampling will be obtained. For larger un-gauged streams water velocity measurements will be made at several points across the channel using a Price AA or "mini" meter. For smaller discharges, measurement may be made by installing a portable flume, capture of flow in a measured container, or using the Floating Stick method. In sites where none of the above are applicable, mostly diffuse flow from springs or through wetlands, the discharge will be estimated.

Sample Collection: Grab samples will be collected (i.e. samples collected at one point in time) in labeled bottles. Composite samples may be assembled from sub-samples collected across the channel for streams larger than 10cfs, or through a depth profile for reservoir sampling. Surveys for specific conductance across the channel will be used as an indicator of the need for composite sampling.

Standard procedures for preparing sampling bottles and processing equipment for inorganic samples will be used. This involves a detergent wash when needed, a deionized water rinse and an acid rinse for non metallic equipment. Sample bottles will be rinsed in ambient water (for unfiltered samples), or filtered ambient water (for filtered samples) prior to the final filling with sample water. In Utah, prepared sample bottles are supplied by the state laboratory.

For bacteria samples, 100ml to 200ml of water will be collected depending on the expected bacterial concentrations. Sample bottles will be treated with sodium thiosulfate if a discharge of chlorinated wastewater or potable water occurs upstream.

Temporal Sampling: Sampling will employ a split panel revisit design. Utah DWQ requests monthly sampling for major ions and nutrients, quarterly sampling for trace elements, and the NCPN will adhere to this schedule, access permitting. Sites in other states may be visited less than monthly.

Sample Processing: Processing will take place at the field vehicle or office laboratory space. Samples to be analyzed for dissolved constituents will be filtered using a peristaltic pump and 0.45um micron filter cassette. After filtering, samples for major ions and trace elements will be fixed with HNO_3. Nutrient samples will be unfiltered (for total concentration) or filtered (for dissolved concentration) and preserved with H2SO4. Once processed, samples will be chilled to less than 4°C and shipped to the laboratory in coolers.

Samples for bacteria will be placed on ice as soon as possible after collection, and maintained on ice until analyzed.

Lab Processing: In Utah, the state laboratory will be used for analysis. Laboratory facilities must have a current EPA certification for the analyses to be performed, and have the capability to analyze to limits of detection that are significantly lower than the water quality standards applied to park waters and low enough to meet data objectives.

Local laboratories will be used for bacteria analysis to accommodate the 6-hour limit between collection and incubation.

Laboratory Results and Data Management: In Utah, the laboratory will enter laboratory results into STORET. For samplers not using the Utah Laboratory, the responsibility for entering data into STORET will rest with NPS-Water Resources Division following receipt of an NCPN data deliverable. In either case, results will be examined as soon as possible after they are available: 1) to ensure the results are within the range of expected values; 2) to identify problems with the sampling program, laboratory or data entry; and 3) to identify important occurrences or trends that might warrant a modification in the monitoring program or a management response.

Training Requirements: Annual training is conducted by Utah DWQ and required for its cooperating field staff. Current staff at BLCA/CURE have received USGS training, though annual biennial refreshers and training for any new staff will be required.

Principal Investigators and NPS Lead:

The NPS leads for protocol development are NCPN Hydrologist and ZION Hydrologist, with technical support provided by USGS and NPS-WRD. Field sampling is assisted by personnel from CANY and CURE, and USGS WRD.

Development Schedule, Budget, and Expected Interim Products:

A draft protocol will be prepared and implementation will begin by fall 2005. Some aspects of the protocol will require field testing, specifically: sample site locations; flow measurement methodology; sample processing in the field; and logistics of sample transport.

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