

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 1

Preparations and Equipment Setup Prior to the Field Season

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/2007	SGarman	Updated equipment list	Provide more logical organization of equipment needs	1.1

This SOP provides information on how to prepare for the summer field season, including a list of field equipment needed. This SOP was adopted with modifications from the Vegetation Community Monitoring Protocol For the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program Standard Operating Procedure (SOP) # 1 - Preparations and Equipment Setup Prior to the Field Season Version 1.0 (December 2004).

I. General Preparations

Prior to the field season each year, all field-crew members should review the entire protocol, including SOPs. The following list includes key points to consider in preparing for the upcoming field season.

1. Acquire a list of plots to be monitored in the upcoming field season from the Integrated Upland Principle Investigator (PI). Some plots may be first-time visits and require establishment. Others may already exist and just require re-measurement. The UTM coordinates, general description of the plot (in terms of ecological site), and travel directions (if a re-visit) should be acquired from the PI. All geographic data should be included on a GPS unit.
2. Species lists from previous years should be reviewed if available to identify any unique plants that may be encountered. Prior knowledge of species most likely to be encountered in a park will aid botanists in preparing for the sampling season. Therefore, species lists from previous community monitoring efforts in a park should be compiled and compared to reference manuals to identify species not recorded which have a probability of being recorded. Primary sources are certified species lists from NPSpecies, available from the NCPN data management staff and/or the PI. Copies of these combined species list should be carried into the field as quick references.

3. Monitoring will be conducted during the period coinciding with the growing season across the Colorado Plateau. Sampling dates should be scheduled and logistics organized prior to the start of each field season. Logistics include scheduling park housing, where possible, and the acquisition of back-country camping permits, where necessary. A preliminary schedule should be approved by the PI. Upon approval, resource staff of park units being visited should be notified (via an email message) of the dates the upland field crew will be in their parks. Just prior to the time the field crew enters a park unit, the resource staff of the park is to be provided with the actual dates field-crew members will be working in the park, a list of their names, and approximate locations of monitoring activity.
4. All equipment should be organized and made ready for the field season a month in advance of the field season. This allows time to make needed repairs and order equipment. The following is a list of field equipment needs for one two-person crew (Table 1). Equipment specified for Plot Establishment should be prepared and taken into the field even if all plots are to be re-measured, to replace any monuments removed since the last visit. However, at most, 1-2 pieces of rebar and 5 spikes should be carried to existing plots. This should be sufficient to cover replacement needs without undue burden to field crews.

Table 1. Equipment needs associated with vegetation community sampling

Activity	Equipment
Plot establishment or re-visit	Acid bottle, filled with 1-M HCL (2) Camera (35 mm) with color film Chain pins (6) Compass (2) Engineers rule (2-m) (2) GPS unit Maps Metal detector – for finding transect ends Plastic flagging – for marking rebar and witness trees, and keeping field equipment visible Sampling Frame (1 m ²) constructed of PVC Sampling Frame (10 m ²) consisting of two L-shaped 2 x 5-m metal pieces Slake Kit (soil-aggregate stability) Soil sieve (2-mm) Spray bottle with De-ionized water Stopwatch Tapes – 50-meter (2) Trowel
Plot Establishment (equipment needs in addition to list above)	Al tags (6 per plot) Clinometers (2) Ecosite descriptions Ecosite dichotomous key Pliers/wire cutters for cutting wire and for attaching Al tag to rebar Rebar (6 pieces, 0.5-m long)/plot, 30 spikes/plot, and hammer Wire for attaching tags to rebar (enough for 6 tags per plot) Wire flags – for temporary marking of transect ends

Data collection	Clip boards Data Sheet for all field-based procedures Handlens Pencils Plant Press Species Identification Manuals and Taxonomical Books Species lists (previous observations, potential observations) Species Master Names and Codes list Unknown Specimen Forms
Required Miscellaneous Items	Backpacks (2) Duct Tape First-Aid Kit Nourishment Radios Sun Screen Towels (2) Water

II. Field Data Forms

Sufficient copies of all data forms should be generated for the full field season. Data forms used in field measures are referenced below. Actual forms are located in the various SOPs.

1. **Site Characterization** - this is filled out prior to initial establishment of a plot. It is not necessary to complete this data sheet on subsequent return visits. See SOP# 5.
2. **Site Establishment Data Sheet for Upland Monitoring** – this is filled out during the initial establishment of a sample unit. It is not necessary to complete this data sheet on subsequent return visits. See SOP#6.
3. **Repeat Photographs** – this is filled out during every visit to a plot. See SOP#7.
4. **Measuring Occurrence and Cover of Vegetation and Soil Surface Features, and Shrub Density** – this is filled out during every visit to a plot. See SOP#21.
5. **Measuring Basal and Canopy Gaps Using Line-Intercept Sampling** - this is filled out during every visit to a plot. See SOP#9.
6. **Soil Aggregate Stability** – this is filled out during every visit to a plot. See SOP#11.
7. **Site Impact Assessment** - this is filled out during every visit to a plot. See SOP#12.

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 2

Training Observers

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Addition of reference to SOP #4	To emphasize procedures that minimize crust busting	1.1

This SOP provides information to train field personnel at the start of the field season.

Procedures

Monitoring must be conducted in a reliable and repeatable manner. To this end every effort must be made to hire and retain well-qualified staff to conduct this work. Necessary skills to be acquired or honed before beginning each season's field data collect are reviewed below.

I.

I. Knowledge of the use of a GPS is essential. GPS is used to navigate to plots, and in the future, may be employed to record key site information. SOP#3 (Use of a GPS) should be thoroughly reviewed. Questions on the use of a GPS should be directed to the NCPN GIS/Cartographer. Training sessions described below will require field crew members to exercise the use of a GPS.

II. Plant identification skills are critical. Only field crew members with demonstrated plant ID skills should be hired. Even so, fine-tuning ID skills for NCPN plant species is still important. The NCPN Vegetation Ecologist or designee will provide training for all crew members. Training will consist of field-based identification of plants anticipated to be observed during the field season, with emphasis on difficult-to-ID species. Additionally, field crews will be instructed in the use of taxonomic keys and reference materials which will be available to all crew members.

III. Identifying Ecological Site types is critical during plot-establishment. Establishing new plots requires determining if the pre-selected plot corresponds to the targeted ecological site. Ecological site is an underlying strata in NCPN upland monitoring, and it is important that the

computer-selected plots actually represent the intended ecological-site stratum. Ecological Site narratives and an Ecological Site dichotomous key will be provided to each crew member. The PI or their designee will provide verbal instructions on the use of narratives and key, and will demonstrate their use in the field by visiting examples of each target ecological site.

IV. Plot Establishment and Measurement procedures will be exercised prior to operational monitoring efforts. This exercise will be conducted on non-NPS lands, such as BLM lands in the vicinity of Moab, UT. The PI or designee will provide several days of instruction covering the operational procedures of all field-based procedures. Procedures will commence with using a GPS to locate a pre-determined plot center. Each crew members will be tasked with finding plot centers using a GPS. At one or more plot centers, Site Characterization procedures will be explained and demonstrated, which includes evaluation of Ecological Site conditions. Plot Establishment, on-site measurement methods, and site-impact procedures will be explained and demonstrated. For each of these categories of activities, field crew members will be paired, and required to exercise all procedures under the critical eye of the PI or designee. All procedures will be exercised to the full extent, including actual recording of observations on data sheets.

An overall critical component of this exercise is the enforcement of the Crust-Friendly procedures, detailed in SOP#4. Concern for “crust-busting” of Biological Soil Crust requires that crew members observe and practice minimal-impact procedures while walking to and from plots, during plot set-up, and while recording measures.

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 3

Using Global Positioning System (GPS) Units

Version 1.00 (August 2006)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) explains the procedures and considerations that all observers should follow when collecting geospatial data or navigating to locations. This SOP is written for recreational-grade GPS units such as those manufactured by Garmin or Magellan. These units are far less expensive than mapping-grade units (e.g., Trimble GeoExplorer), yet they are effective for obtaining point information at a level of spatial accuracy that is required for this project. Recreational-grade GPS units do not have the capability of a data dictionary for storing attribute information with point locations.

This SOP assumes that each observer is familiar with the operation and function of the GPS unit to be used for this project. This SOP is intended to complement, not replace, the operations manual accompanying the GPS unit. Each observer should be familiar with the use of their particular GPS unit before entering the field to collect data or navigate to points.

This SOP does not require the use of a specific type or brand of GPS unit; however, the unit is required to meet the minimum standards listed below. The Northern Colorado Plateau Network (NCPN) primarily has used Garmin units, specifically, the eTrex, III Plus, and 76 models. The procedures below provide project-specific guidelines that are applicable to any recreation-grade unit. Attachment A contains detailed instructions relating to the operation of the Garmin 76 model. GPS functions other than those associated with this protocol are not explained in this document.

Procedures:**1. The minimum GPS receiver standards for navigating and mapping are:**

- Capable of storing date, time, and coordinates of features collected.
- Capable of exporting features collected to a format that can be used by GIS
- Capable of maintaining an EHE (Estimate of Horizontal Error) of less than or equal to 12 meters. Maintaining an EHE (or EPE – Estimate of Positional Error) of 12 meters or less meets the National Map Accuracy Standard.
- Capable of tracking a minimum of 4 satellites
- Capable of collecting real-time differentially-corrected positions (DGPS)

2. Required equipment

- GPS unit
- One set of extra batteries
- Operation manual
- Compass
- Rangefinder
- USGS 1:24,000-scale topographic map
- Personal computer for downloading data from the GPS unit. DNR Garmin (freeware, available at <http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions.html>) should be installed on the computer to facilitate the data download.

3. GPS Unit Setup before leaving the office (see Attachment A).

- Set GPS unit standards

Minimum GPS Receiver Settings Standards

Name	Standard
Projection (displayed coordinates)	UTM
Datum	NAD 83
WAAS	Enabled (on)

- Upload background data (MapSource)
- Upload existing waypoints to the GPS unit (if necessary)

4. Navigation to an existing location

If an existing upland monitoring plot is to be revisited, the observer can relocate that point using the GPS unit. Navigation to the point is best accomplished by using background maps that have been loaded onto the GPS unit, in addition to using hard-copy USGS 1:24,000-scale topographic maps.

- Select the waypoint you wish to navigate towards and follow the pointer displayed on the unit.
- In order to navigate, the GPS unit must be moving

5. Collecting new location data

The observation point providing the best direct line of sight to a nest must be recorded. This waypoint is documented by recording UTM and Lat/Long coordinates. Also, the bearing and distance to the nest site from this point is recorded.

- Take (or mark) a waypoint, and identify it with a unique ID that matches the location identifier recorded on the field sheet.
- Record waypoint UTM coordinates that are displayed on the GPS unit on field sheet.
- Use compass to determine bearing to nest site and record on field sheet.
- Record approximate distance from observation point to nest site. Use rangefinder, or, if out of range, determine distance using topographic map.

6. Downloading Data from GPS unit (see Attachment A)

The data from the GPS unit are downloaded to a personal computer daily, or after each field stint. Frequent, regular downloads will safeguard against any loss of data.

NCPN recommends the use of the DNR Garmin extension. This tool facilitates the communication between ArcView and Garmin Brand GPS units by allowing users to download and upload waypoints (and tracks) as text files, shapefiles and/or graphics. DNR Garmin is freeware, and is available at

<http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions.html>)

- Connect the GPS unit to the personal computer using a USB or serial cable.
- Download GPS data (.txt files) into appropriate folders (Figure 3-1). Fields required from a unit download are: ident (waypoint), lat, long, y_proj, x_proj, comment, altitude, and model.
- Review the downloaded data for accuracy and completeness.

Text files are required as part of the download. GIS shapefiles can be created at the same time. See Attachment A for additional information on shapefile creation. NCPN recommends that during the field season, downloads be limited to text files with a single set of GIS shapefiles created at the conclusion of the field season.

Downloaded GPS text files will be appended to the Integrated Upland database at the time of data entry (see SOP #18).

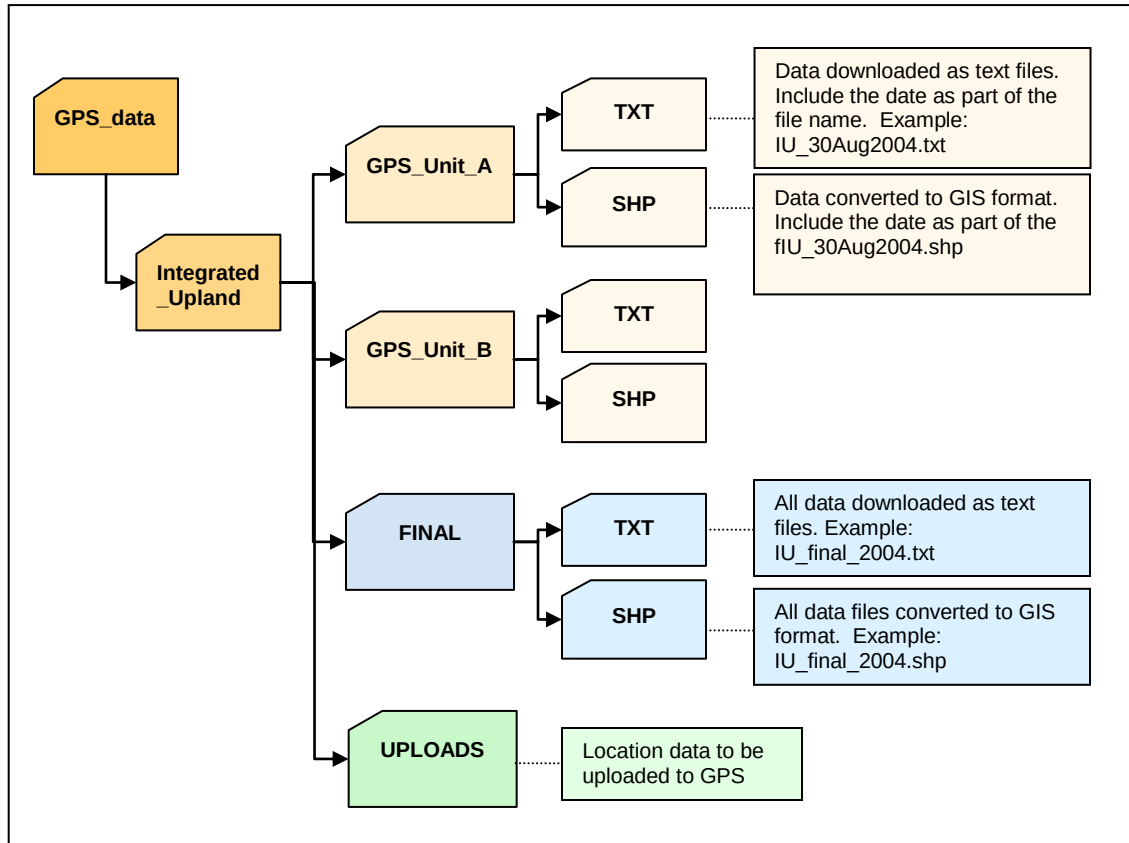
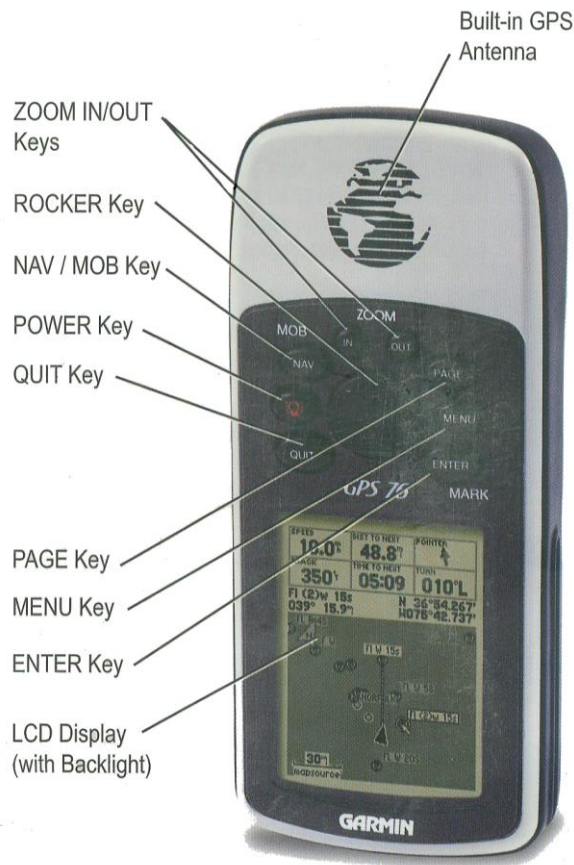


Figure 3-1. Recommended directory structure for data downloaded from GPS unit.

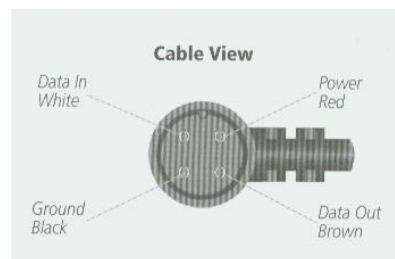
Attachment A



This graphic demonstrates the keys of a Garmin 76 GPS unit, and their functions. These keys are referred to in the following instructions.

1. To Connect GPS to Computer

- Either a serial or USB port cable will accompany the GPS unit. This is the cable that connects the GPS receiver to your workstation computer, allowing the uploading and downloading of waypoints.
- The serial or USB end of the cable attaches to your workstation computer. The other cable end (below) inserts into the Garmin GPS unit (lift bottom of black flap on the back of the GPS unit)



2. To change the displayed map projection:

- Turn on the unit by depressing the POWER key
- Set Projection
 1. Access the Main Menu (press the MENU key twice)
 2. Using the rocker key, scroll down to Setup and press the ENTER key
 3. There are several tabs listed (General, Time, Units, Location, Alarms & Interface) – using the rocker key, scroll over to the Location tab. Scroll down with the rocker key to Location Format and press the ENTER key.
 4. Scroll down the list of formats to UTM UPS, make sure this choice is highlighted, and press the ENTER key.
 5. Scroll down to Map Datum, press the ENTER key. Scroll down through the Map Datum choices, press the ENTER key when NAD 83 is highlighted.
 6. Press the PAGE key to get back to the “GPS Information” screen. (If the GPS Information screen is not showing, press the PAGE key; it will cycle through the screens). The bottom of the screen should now be displaying coordinates as UTM.

3. Set GPS to log differentially correct data

- If not already on, power up the GPS
- Enable WAAS
 1. Access the Main Menu (press the MENU key twice)
 2. Using the key, scroll down to Setup and press the ENTER key
 3. There are several tabs listed (General, Time, Units, Location, Alarms & Interface) – using the rocker key, scroll over to the Location tab. Scroll down with the rocker key to General and press the ENTER key.
 4. Scroll down to WAAS, press ENTER, highlight Enabled, and press ENTER
 5. Press the PAGE key to exit Setup

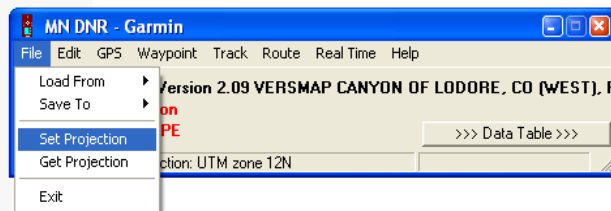
4. In the Field

- Collect (or mark) a waypoint
 1. When at the observation location, check the GPS Information page for number of satellites (4 or more needed) and accuracy (12 meters or less)
 2. Press and hold the ENTER/MARK key until the Mark Waypoint Page is displayed.
 3. Using the Rocker key, change the waypoint ID to Nest Territory number plus site letter (GPS number optional).
 4. Using the Rocker key, highlight “OK” and press ENTER
- Navigation
 1. Press the NAV key
 2. Select ‘Go To Point’ then press the ENTER key
 3. Select ‘Waypoints’ then press the ENTER key

4. Select 'your point' then press the ENTER key
5. Highlight the 'GoTo' button, press ENTER
6. As you start walking, the Pointer will point to your destination

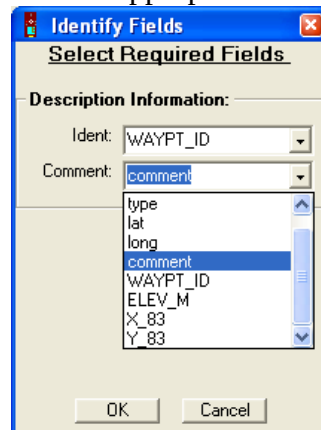
5. Upload Background Data

- Upload background maps from MapSource (proprietary software) if needed
- Upload waypoints using DNR Garmin
 1. Connect GPS to the computer
 2. Turn GPS on, then open DNR Garmin, it will connect to the computer
 3. When the MN DNR – Garmin window opens, make sure that the projection is set to UTM, NAD 83, zone 12N (unless at CURE or BLCA, which are zone 13N). Go to File, then Set Projection to



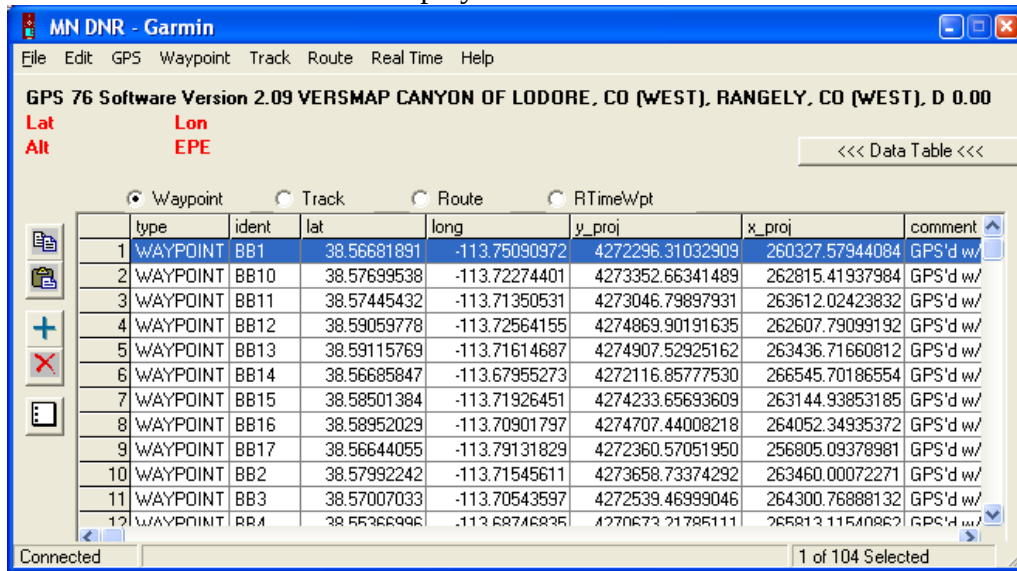
change projection.

4. Click on File, then Load From. You can upload a .txt file, .dbf file or a shapefile. Navigate to the file you wish to upload and click Open.
5. A window will open prompting you select description information. Choose appropriate fields for Ident (ID) and Comment and click OK.



6. A window will open stating "File was loaded successfully from...", click OK

7. Points will be displayed in the MN DNR – Garmin window.

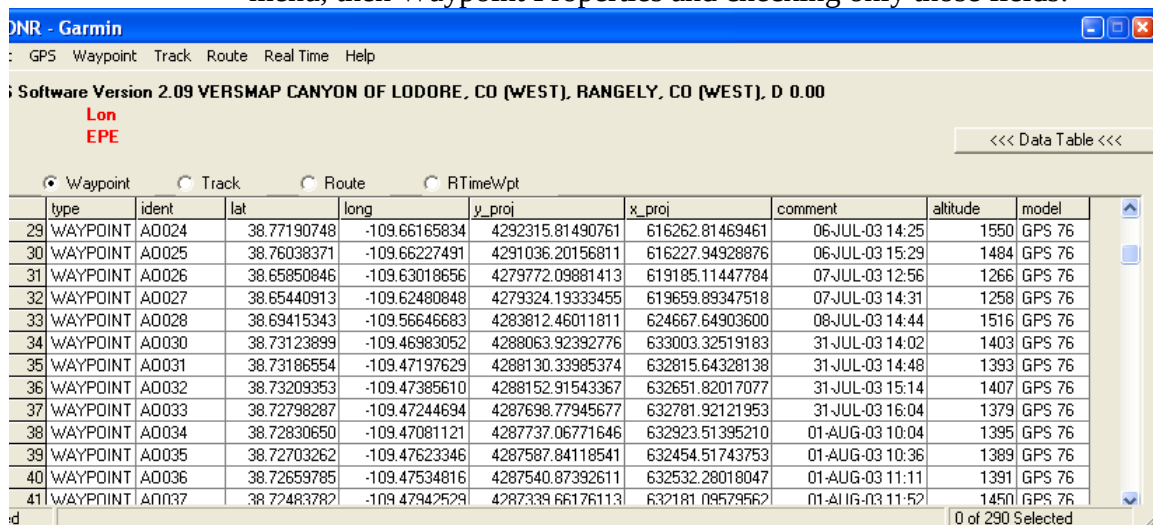


8. If the points are correct, click on WAYPOINT, then Upload

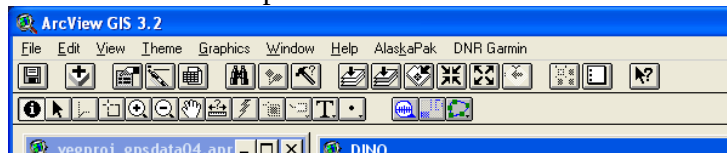
9. A window will pop up stating “Transfer Complete. # points uploaded”

6. Downloading Waypoints

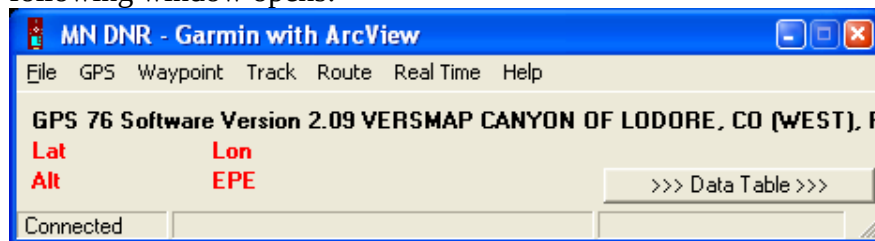
- Download waypoints using MN DNR Garmin freeware
 1. Connect the GPS to the computer and turn on the GPS unit, then open the program DNR Garmin on the computer
 2. From the DNR Garmin main menu, click on Waypoint, then Download. Your data will appear in the MN DNR Garmin window (see below). Elements to be included in the downloading process are: type, ident, lat, long, y_proj, x_proj, comment, altitude & model. These fields can be chosen by choosing Waypoint from the main menu, then Waypoint Properties and checking only those fields.



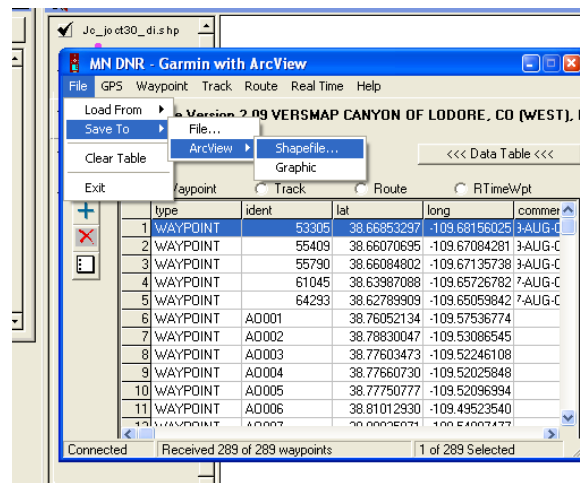
3. Click on File, and then Save To. Navigate to the proper folder on the computer (see possible directory structure, Figure 3-1)
 4. There are several file types which you can save the file as. The NCPN recommends saving the data as a Text File (Comma delimited)(* .txt) file. This is the default choice.
 5. Name the file with the date of download in the file name (example: Peregrine_June10_05.txt) and click the Save button. A window will display “File successfully written to ...”
- Download waypoints using MN DNR Garmin and ArcView 3.x
 1. Connect GPS unit to workstation
 2. Open and activate the DNR Garmin-ArcView extension in ArcView. A DNR Garmin dropdown menu will be added to ArcView.



3. From the DNR Garmin menu, choose “Set Projection”. Choose UTM NAD83, and the appropriate zone (12 for all NCPN parks except CURE and BLCA which are 13)
4. From the DNR Garmin menu, choose “Open Garmin GPS”. The following window opens:



5. From this window, click on Waypoint, then Properties. Choose (check) the following fields: type, ident, lat, long, y_proj, x_proj, comment, altitude & model. Click OK to dismiss the Properties window
6. Click on Waypoint, and then Download. All points collected will be downloaded.
7. Click on File, and then Save To, then ArcView, then Shapefile.



8. Navigate to the appropriate folder, and click Save. The newly created shapefile will appear in the active ArcView view window. Notice that X & Y coordinates have been added to the shapefile.

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 4

Crust-Friendly Field Procedures

Version 1.0 (March 2007)

Revision History Log:

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

This SOP describes general procedures for minimizing soil disturbance while walking to monitoring plots, and while recording measurements on a plot.

Procedures

Biological Soil Crust (BSC) is an important system component of the Colorado Plateau. BSC plays a critical role in nitrogen fixation, and in soil stability. BSC is easily destroyed through trampling, and the relatively long regeneration time of well-developed crust (may be as long as a century) is problematic. NCPN monitoring efforts must exercise considerable effort to minimize ‘crust busting’ for several reasons. First, park values in general must not be compromised by monitoring efforts. Second, on-plot destruction of crust can impact the validity of the monitoring data – that is, monitoring information is undermined by the effects of monitoring. The latter introduces bias and provides a false representation of ‘natural’ system dynamics. The latter, of course, is what monitoring is intended to observe. The following procedures were adapted from those used by USGS researchers working in the Colorado Plateau. All crew members must become familiar and follow these procedures.

I. Walking into a monitoring plot. Footprints last a long time in the desert systems of the Colorado Plateau. Walking the same route from a road or trail to a monitoring plot can quickly create the appearance of an ‘established’ trail. Park visitors tend to gravitate to such trails and over time, the plot-access route can become heavily trampled. Additionally, such trails increase the chance of monitoring-plot disturbance by visitors, which is always to be avoided. A) To avoid trail development always use a separate route to and from a monitoring plot where your footprints will create a noticeable trail. B) When traversing to and from a monitoring plot, select a route that crosses slick rock or other large rocks than can be used as stepping stones, and in washes. Tracks in the latter will be erased during the next rain storm. At all times, avoid stepping on crust, no matter the developmental stage. C) When walking on soil, only leave one

set of footprints. That is, walk in single file and step in the footprints of preceding crew member(s).

II. Walking on a monitoring plot. Site evaluation, site establishment, and measurement procedures require crew members to restrict their impact to specific areas on a plot. A) When walking around the plot select a pathway that optimizes stepping on rock, dead vegetation, and washes. If these features are not available, walk at least 20-m away from the edges of the plot. B) Avoid huddling with other crew members to look at the GPS unit, to look at an unknown plant species, when taking a break from the afternoon sun, etc. C) During plot set-up and measurements, carry your water bottle and other necessities with you so a trip across the plot to reach your backpack is not necessary. D) Always leave one set of footprints by walking in existing footprints. E) Measurement procedures described in other SOPs are designed to minimize leaving the area along the transect. For example, closer inspection of species occurring at the outer-edge of a quadrat can be accomplished by leaning over the quadrat, or using stepping-stones afforded by rock or dead plant material.

III. When re-measurement of a monitoring plot, if soil disturbance due to previous visits is extreme, note this on the site-impact form (SOP#12), photograph the disturbance (if possible without walking onto the plot), do not re-measure the plot, and immediately report the disturbance to the Principle Investigator. Extreme disturbance is where soil erosion originating from previous footprints is noticeable, or where deep furrows with loose soil were obviously created from previous trampling. The plot will be either rested before consideration for re-measurement, or abandoned to avoid further degradation. Detailed description and pictures will be useful to determine the proper course of action.

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 5

Site Characterization

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Added additional instructions for site rejection	To expedite site assessments	1.1

This SOP provides instructions for characterizing potential field sites using the following three components: (1) field characterization, (2) soil collection, and (3) recommended soil analyses. This SOP is used only during the initial visit to a plot.

Locating Plot Center, and Initial Assessments

A list of plot locations will be provided by the project manager. This list will contain the accession number of the plot, the master plot ID, the NRCS soil-map unit number of the plot, the target Ecological Site and soil component of the plot. Visit the locations in the proper accession order to maintain the integrity of the sampling design.

Use a GPS unit (SOP #3 “Using the Global Positioning System”) to navigate to the pre-determined macroplot centroid, and mark this point with a pin flag. To avoid trampling the area sampled by the middle transect (see Fig. 7), estimate the location of this transect and traverse the macroplot ca. 1-2 meters down slope of the transect.

Site assessment procedures are described below. However, there are a variety of reasons for immediate rejection of a site, and they can be ascertained before in-depth assessments and before walking any more on the plot. 1) If it is obvious that the 50-m transects forming the macroplot will extend beyond the park boundary, the plot will not be used (see SOP# 6 for macroplot layout design). 2) If it is obvious that one or more transects will span a paved road, reject the plot. 3) If transects will cross a well-used jeep road, reject the plot. Transects can cross trails, and infrequently used roads. 4) If transects are within 50-m of park buildings, the plot is rejected. 5) If inclusions are present in more than 30% of the area

sampled by the quadrat, transect configuration of the macroplot, the plot is rejected. Inclusions include slickrock or pockets of non-target ecological site discernable as very different vegetation from the target ecological site. 6) If any of the 3 transects spans areas presenting safety hazards (cliff, deep ravine), reject the plot. If a plot is immediately rejected for reasons noted above, record the information listed below under General Plot Info., record reasons for site rejection (see “(6) Site Selection” below), leave the site, and visit the next plot on the accession list.

During the initial and subsequent assessments never re-locate plot center to ensure the macroplot design will fit the spatial and ecological-site requirements. There will be some error in the designation of plot center due to GPS technology. This is acceptable. Purposely moving plot center, however, begins to introduce bias into the site-selection process. Sites are chosen using a probabilistic approach, and moving sites will degrade the statistical inference of sample estimates. Reject sites, don’t move sites, if not appropriate – sites were selected in a manner that accommodates rejection with out bias to parameter inference.

Field Characterization

1) General Plot Info.

Fill out the information at the top of the “Site Characterization Data Sheet” including:

- **Park Name** – Use the 4-letter code for a park (e.g., ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, FOBU, GOSP, HOVE, NABR, PISP, TICA, ZION).
- **Plot ID** – Plot IDs are unique numbers pre-assigned to upland plots within a park unit. This number is provided along with the UTM coordinates prior to field time.
- **Date** – mm/dd/yyyy.
- **Recorder** – Record the last name of the person recording data. Where necessary, include the first-name initial.
- **Soil survey area** – Determine the soil survey corresponding to the park unit and plot (multiple, non-overlapping soil surveys were conducted in some park units). This information should be condensed in a table for each park containing soil and vegetation characteristics for ecological sites of interest. Hereafter, these tables will be referred to as “ecological site tables”. See Table A1 in Appendix A for an example.
- **Soil map unit** – Using the appropriate soil map, determine the soil map unit in which the centroid lies.
- **GPS file** – Record the name of the GPS file for the centroid coordinates (UTM), and the Datum and UTM Zone. Datum should be NAD83.
- **UTM coordinates** – Record the easting and northing (e.g. 596717 E; 4215867 N).

2) Soil and Vegetation Characterization

Use the “Site Characterization Data Sheet” (Appendix A) to collect information that will help you decide whether the macroplot centroid is located on the target ecological site. The target soil component and ecological site for each pre-selected site location will be provided to you by the project manager. Fill out the data sheet using the guidelines below for each letter. The NRCS figures in this SOP have been condensed into two sheets that can be taken in the field for quick reference (Appendix C).

- A. Geologic setting – Characterize the geologic setting and predominant geomorphic processes evident on site. See NRCS data sheet in Field Book; pages 2-75.

- B. Landform – Use the information from the ecological site table (e.g., Table A1) to determine if you are on the correct landform. Geomorphologists have probably identified a few thousand different types of landforms, and it is NOT necessary to familiarize yourself with all of these landforms. It is important to determine whether or not you are on the expected landform for the ecological site of interest. Landforms commonly encountered on the Colorado Plateau include alluvial fans, cuestras, hillslopes, mesas, plateaus, sand sheets, and structural benches. Definitions of common landforms on the Colorado Plateau (B1) and a list of landscapes and landforms by geomorphic environment (B2) are listed in Appendix B. Additional landforms are listed in the NRCS “Field Book for Describing and Sampling Soils” (Schoeneberger et al. 2002), and definitions are provided on the NRCS website <http://soils.usda.gov/technical/handbook/contents/part629glossary1.html>. Write in the appropriate landform on the data sheet.

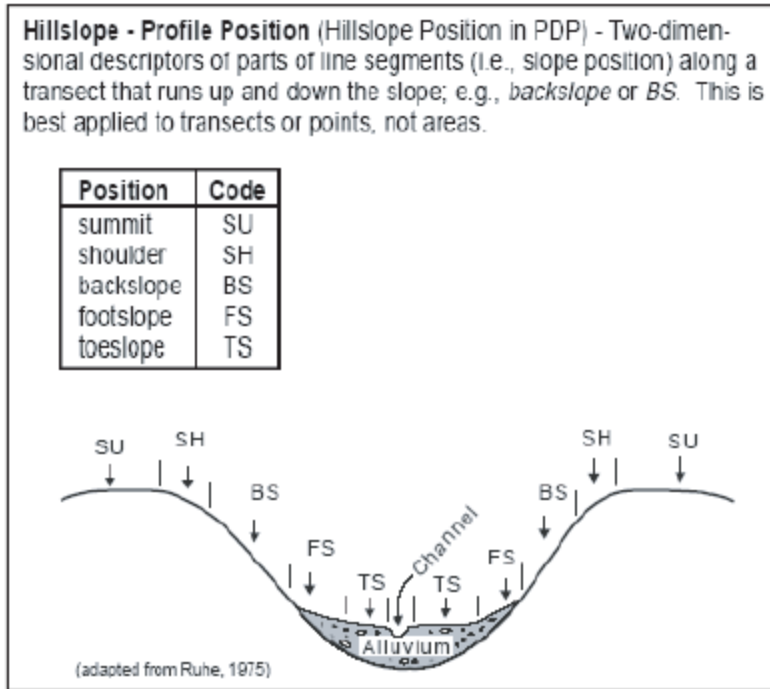


Figure 1. NRCS figure for determining hillslope position (Schoeneberger et al. 2002)

- C. Hillslope position – Use Figure 1 to select the hillslope position that describes your location. Possible hillslope positions include summit, shoulder, backslope, footslope, and toeslope. Circle the appropriate hillslope position on the data sheet. Hillslope position may not be relevant in some cases, such as for mesa tops or mountain tops. In such cases circle summit on the data sheet.
- D. Slope complexity – This refers to the relative uniformity of the ground surface leading down slope and across the macroplot. Figure 2 illustrates examples of simple vs. complex slopes. Decide which best describes your location and circle the appropriate category on the data sheet.

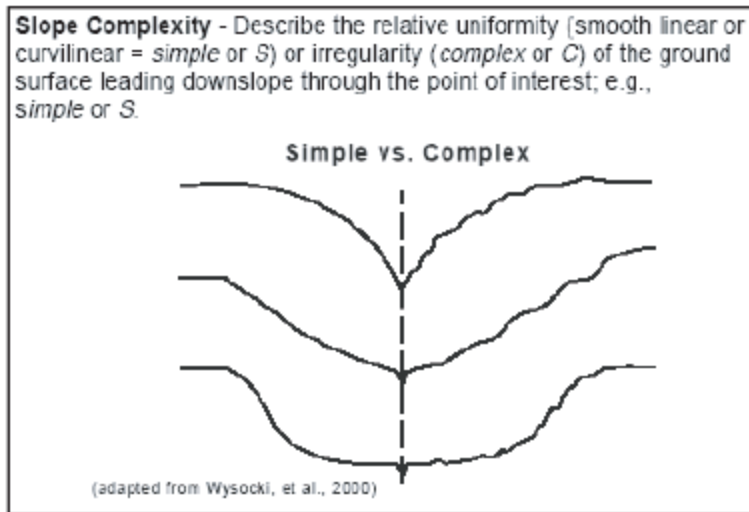


Figure 2. NRCS figure for determining hillslope complexity (Schoeneberger et al. 2002)

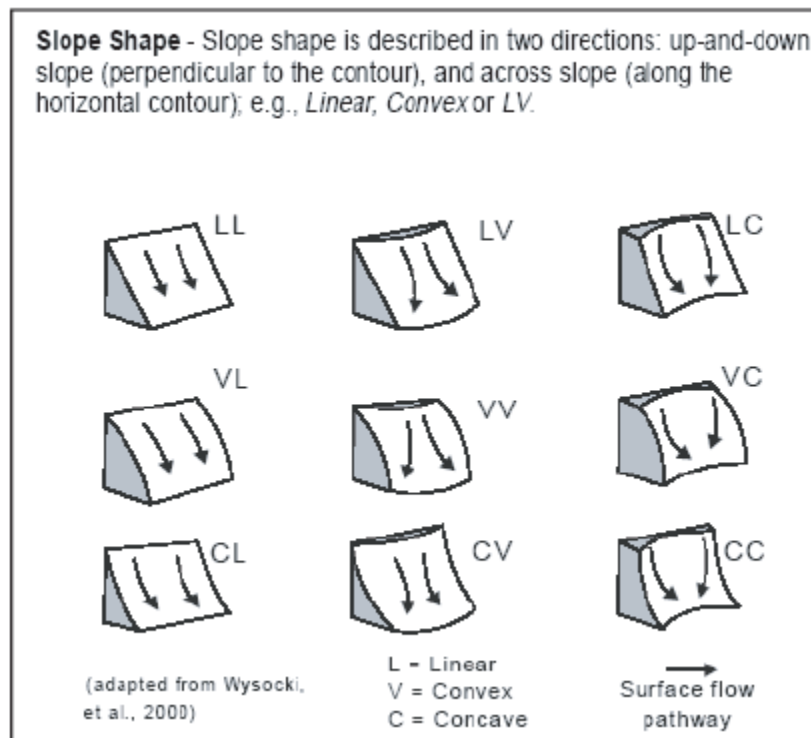
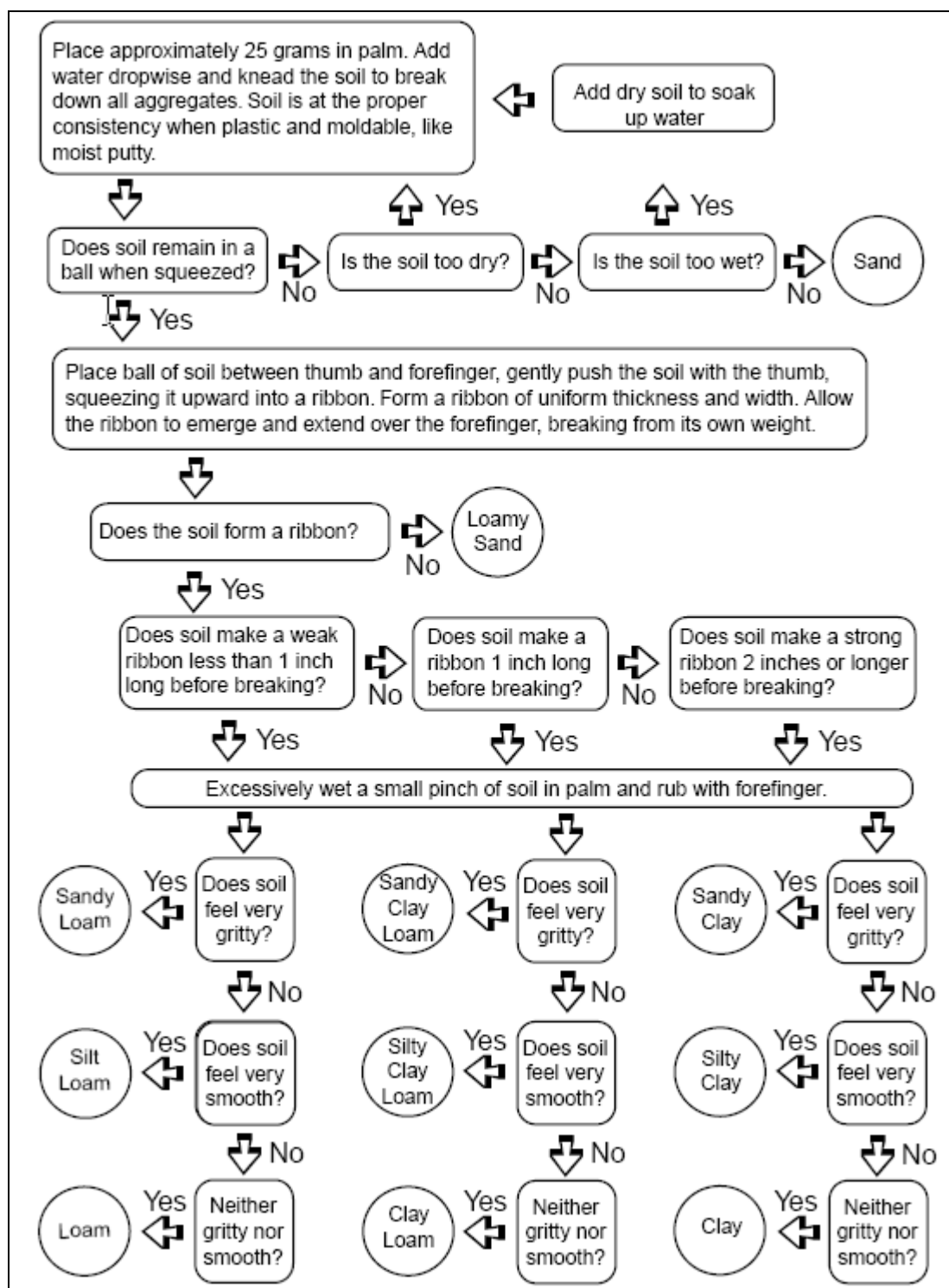


Figure 3. NRCS figure for determining slope shape (Schoeneberger et al. 2002)

Table 1. Conversion of slope angle from degrees (Deg) to percent (Pct)

Slope angle	
Deg	Pct
1	1.7
2	3.5
3	5.2
4	7.0
5	8.7
6	10.5
7	12.3
8	14.1
9	15.8
10	17.6
11	19.4
12	21.3
13	23.1
14	24.9
15	26.8
16	28.7
17	30.6
18	32.5
19	34.4
20	36.4
21	38.4
22	40.4
23	42.4
24	44.5
25	46.6
26	48.8
27	51.0
28	53.2
29	55.4
30	57.7
31	60.1
32	62.5
33	64.9
34	67.5
35	70.0
36	72.7
37	75.4
38	78.1
39	81.0
40	83.9
41	86.9
42	90.0
43	93.3
44	96.6
45	100.0

- E. Slope shape – Determine the slope curvature (linear, concave, or convex) for across slope and downslope. Figure 3 illustrates possible combinations of slope curvature. Circle the appropriate categories on the data sheet.
- F. Percent slope – Determine the percent slope using a clinometer. This is an approximate measurement used to decide if the slope at your location fits into the range of slopes for the ecological site of interest. Take a reading downslope from the centroid, sighting to the same height above the ground as your eye level. Record the reading in percent (not degrees). If your clinometer only has degrees, use Table 1 to convert to percent slope.
- G. Surface soil texture – Soil texture refers to the particle size distribution of the fine earth fraction (sand, silt, and clay particles <2 mm in diameter). Use a trowel to scoop a small amount of surface soil into the 2-mm sieve in order to separate rock fragments from the fine fraction. Collect a small amount of sieved soil in your hand and add water slowly using a spray bottle or dropper. Mix the water and soil in your hand and use the key in Figure 4 to determine the soil texture. If you have never textured soil, practice this technique with the guidance of an experienced co-worker before the beginning of the field season. The texture triangle (Fig. 5) is also helpful for understanding the relationship between different soil particle sizes in determining soil texture. Write the soil texture in the blank provided on the data sheet.



(Herrick et.al. 2005)

Figure 4. Soil texture key. Begin in the top left corner and answer the yes/no questions to determine soil texture.

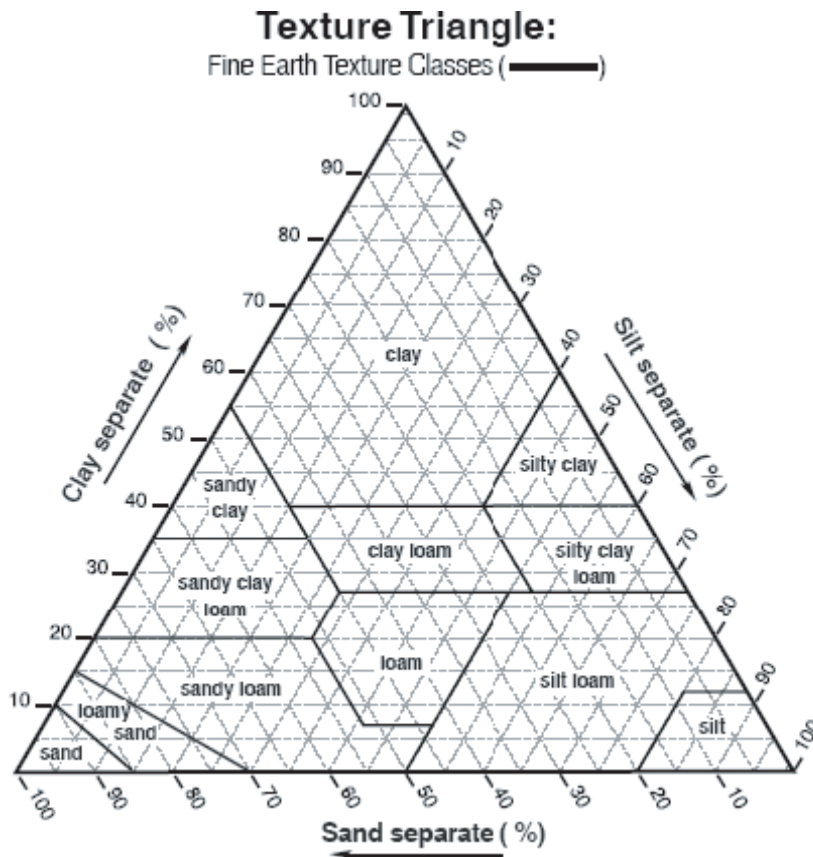


Figure 5. Soil texture triangle (Schoeneberger et al. 2002)

- H. Sand modifier – If sand is a major part of the soil texture (e.g. loamy sand or sandy loam), determine the predominant size class of sand. Use the sand particle sizes detailed in Figure 6 to choose one of two size classes: very fine/fine/medium or coarse/very coarse. The border between the two classes is 0.5 mm. Circle your choice on the data sheet. If the words “sand or “sandy” are not included in soil texture then circle “n/a”.

FINE EARTH										ROCK FRAGMENTS					
										150		380		600 mm	
										channers		flagst.	stones	boulders	
Clay ²		Silt		Sand						Gravel			Cob- bles	Stones	Boulders
fine	co.	fine	co.	v.fi.	fi.	med.	co.	v.co.	fine	medium	coarse				
0.0002	.002 mm		.02	.05	.1	.25	.5	1	2 mm	5	20	76	250		600 mm

Figure 6. Sizes of soil particles and rock fragments (Schoeneberger et al. 2002). Definitions of channers and flagstones are listed in Appendix B. (v.fi.= very fine, fi.=fine, med.= medium, co.=coarse, v.co.= very coarse, flagst.=flagstones)

- I. Rock fragment texture modifiers – Some soil types are further described by rock fragment quantity and size (e.g., very gravelly sandy loam). First, use rock fragments remaining in the soil sieve and exposed on the soil surface to determine the percent of rock fragments by volume. If there is less than 15% rock fragment by volume then no rock fragment texture modifier is necessary. Circle “n/a” for “quantity adjective” and “none” for “size”. If there is more than 15% rock fragment by volume, use the following categories to determine the appropriate rock fragment texture modifiers.

QUANTITY ADJECTIVE: Determine the approximate rock fragment content percent by volume, and refer to Table 2 for the appropriate rock fragment quantity adjective. Rock fragments 15 to <35% by volume require only fragment size (e.g. gravelly loam), therefore, circle “none” for “quantity adjective” on the data sheet. Use “very” and “extremely” to describe soils with 35 to < 60% and 60 to < 90% rock fragments respectively (e.g. very gravelly loam and extremely gravelly loam). If there is 90% or more of rock fragment then soil is described by only the rock fragment size and not by the fine earth component (e.g. gravel).

SIZE: Use the rock fragment size chart in Figure 6 to determine the largest dominant fragment. The largest dominant fragment is the largest rock fragment class present unless a smaller size-class is present in substantial quantity. A smaller fragment size-class must exceed two times the volume of a larger fragment before it is called the dominant fragment. Circle the appropriate size class on the data sheet.

Table 3 provides examples of rock fragment texture modifiers for rock fragments of different quantity and size.

Table 2. NRCS texture modifiers to describe the amount of rock fragments in soil (Schoeneberger et al. 2002).

TEXTURE MODIFIERS - Conventions for using "Rock Fragment Texture Modifiers" and for using textural adjectives that convey the "% volume" ranges for Rock Fragments - Size and Quantity .	
Fragment Content % By Volume	Rock Fragment Modifier Usage
< 15	No texture adjective is used (noun only; e.g., <i>loam</i>).
15 to < 35	Use adjective for appropriate size; e.g., <i>gravelly</i> .
35 to < 60	Use "very" with the appropriate size adjective; e.g., <i>very gravelly</i> .
60 to < 90	Use "extremely" with the appropriate size adjective; e.g., <i>extremely gravelly</i> .
≥ 90	No adjective or modifier. If ≤ 10% fine earth, use the appropriate noun for the dominant size class; e.g., <i>gravel</i> . Use Terms in Lieu of Texture .

Table 3. NRCS texture modifiers by rock quantity and size (Schoeneberger et al. 2002).

TEXTURE MODIFIERS - (<i>adjectives</i>)			
ROCK FRAGMENTS: Size & Quantity ¹	Code		Criteria: Percent (By Volume) of Total Rock Fragments and Dominated By (<i>name size</i>): ¹
	Conv.	PDP/ NASIS	
ROCK FRAGMENTS (> 2 mm; ≥ Strongly Cemented)			
Gravelly	GR	GR	≥ 15% but < 35% gravel
Fine Gravelly	FGR	GRF	≥ 15% but < 35% fine gravel
Medium Gravelly	MGR	GRM	≥ 15% but < 35% med. gravel
Coarse Gravelly	CGR	GRC	≥ 15% but < 35% coarse gravel
Very Gravelly	VGR	GRV	≥ 35% but < 60% gravel
Extremely Gravelly	XGR	GRX	≥ 60% but < 90% gravel
Cobbly	CB	CB	≥ 15% but < 35% cobbles
Very Cobbly	VCB	CBV	≥ 35% but < 60% cobbles
Extremely Cobbly	XCB	CBX	≥ 60% but < 90% cobbles
Stony	ST	ST	≥ 15% but < 35% stones
Very Stony	VST	STV	≥ 35% but < 60% stones
Extremely Stony	XST	STX	≥ 60% but < 90% stones
Bouldery	BY	BY	≥ 15% but < 35% boulders
Very Bouldery	VBY	BYV	≥ 35% but < 60% boulders
Extremely Bouldery	XBY	BYX	≥ 60% but < 90% boulders
Channery	CN	CN	≥ 15% but < 35% channers
Very Channery	VCN	CNV	≥ 35% but < 60% channers
Extremely Channery	XCN	CNX	≥ 60% but < 90% channers
Flaggy	FL	FL	≥ 15% but < 35% flagstones
Very Flaggy	VFL	FLV	≥ 35% but < 60% flagstones
Extremely Flaggy	XFL	FLX	≥ 60% but < 90% flagstones
PARAROCK FRAGMENTS (> 2 mm; < Strongly Cemented) ^{2, 3}			
Parabouldery	PBY	PBY	(same criteria as bouldery)
Very Parabouldery	VPBY	PBYV	(same criteria as very bouldery)
Extr. Parabouldery	XPBY	PBYX	(same criteria as ext. bouldery)
etc.	etc.	etc.	(same criteria as non-para)

¹ The "Quantity" modifier (e.g., *very*) is based on the total rock fragment content. The "Size" modifier (e.g., *cobbly*) is independently based on the largest, dominant fragment size. For a mixture of sizes (e.g., *gravel and stones*), a smaller size-class is named only if its quantity (%) sufficiently exceeds that of a larger size-class. For field texture determination, a smaller size-class must exceed 2 times the quantity (vol. %) of a larger size class before it is named (e.g., 30% gravel and 14% stones = *very gravelly*, but 20% gravel and 14% stones = *stony*). For more explicit naming criteria see NSSH-Part 618, Exhibit 618.11(Soil Survey Staff, 2001b).

- J. *Effervescence* – The degree of effervescence relates to the quantity and surface area of carbonate compounds in the soil. Apply a few drops of 1-M HCl to the fine soil fraction, and use Table 4 to determine the effervescence class. More bubbles indicate higher amounts of carbonate compounds in the soil. Circle your choice on the data sheet.

Table 4. NRCS effervescence classes determined by dropping 1-M HCl on the fine soil fraction (Schoeneberger et al. 2002)

Effervescence Class	Code		Criteria
	PDP	NASIS	
Noneffervescent	4	NE	No bubbles form.
Very Slightly Effervescent	0	VS	Few bubbles form.
Slightly Effervescent	1	SL	Numerous bubbles form.
Strongly Effervescent	2	ST	Bubbles form a low foam.
Violently Effervescent	3	VE	Bubbles form a thick foam.

- K. *Soil Profile Characterization* - NPS compliance requires that an archeologist is present when digging any holes on NPS lands. If an archeologist is not present, you will not be able to complete this step.

Use an 10-cm diameter soil auger dig a single hole to characterize the soil profile that best represents the predominant soil-geomorphic setting associated with the macroplot. Dig the hole within the macroplot to ensure that it represents the macroplot, but make sure it is not within a quadrat or in a location which may otherwise result in impacts to on-site dynamics. Dig to a depth of 1 m or until you reach bedrock or root restricting layers (e.g. argillic (clay) horizons or calcic hardpans), whichever comes first. It will be difficult to nearly impossible to dig through restrictive layers. Use a tarp to lay out 10-cm soil increments, and to allow soil to easily be gathered and returned to hole after completing characterization and sampling. Characterize each 10-cm increment of the soil profile for texture, abundance of rock fragments by size class and predominant lithology, and degree of effervescence using information from sections G through J above. Record this information on the data sheet.

- L. *Depth class* –Measure the depth to bedrock or a root restricting layer. Use Table 5 to determine the depth class, and circle your choice on the data sheet. If an archeologist is not present, you will have to do your best to assign a soil depth class based on your observations of bedrock exposures or naturally occurring profile exposures in the area.

Table 5. Depth to root restricting layer in centimeter (cm) and inches (in) for depth classes (Soil Survey Staff 1993).

Root restricting depth		
Depth class	Cm	In
Very shallow	< 25	< 10
Shallow	25 - 50	10 - 20
Moderately deep	50 - 100	20 - 40
Deep	100 - 150	40 - 60
Very deep	>= 150	> = 60

M. *Potential vegetation and dynamics* – Identify dominant plants species at the site and record this information on the data sheet. Use vegetation identification keys if necessary, but avoid spending too much time on this. Examine “Potential vegetation” and “Dynamics” columns on the ecological site tables. Look specifically for evidence of vegetation listed as “Potential vegetation” for the ecological site. Familiarize yourself with the range of variation in the plant community due to natural and/or anthropogenic disturbances. Think about how well the vegetation you see fits the expected vegetation for the ecological site.

3) Soil Assessment

Compare the information you collected on the data sheet with the characteristics of the target ecological site on the ecological site table to determine if observed soil and landscape characteristics *reasonably* match those associated with the target soil component and ecological site? Large departures in ecologically significant characteristics such as depth and texture are grounds for answering NO to this question. Large departures in profile characteristics (e.g. presence and depth of argillic or calcic horizons) also are grounds for answering NO, but these soil properties usually cannot be determined without digging a hole. Use the following examples to help you decide.

Large departures:

- If the target soil is deep, and the observed soil is very shallow or shallow.
- If the target soil is a sandy loam, and the observed soil is a channery clay loam.

Relatively minor departures:

- If the target soil is shallow and the observed soil is very shallow.
- If the target soil is a gravelly sandy loam and the observed soil is a very gravelly loamy sand.

Use the information you collected on the data sheet and the ecological site table to determine the probable soil component at the centroid. Write this on the data sheet (or write “unknown” if the soil component cannot be determined) and decide whether this matches the target soil component(s). If you suspect several soil components to be present on the macroplot but the most dominant component matches the target component, indicate a positive match by circling yes, but note the probable occurrence of other components in “Additional comments”. If the soil component does not match the target ecological site or if

non-target components are dominant, circle “no” and add narrative explaining your choice in “Additional comments”.

4) Vegetation Assessment

Does the observed vegetation reasonably match expected vegetation associated with the target ecological site? Soil, landscape, and climate characteristics are primary determinants of ecological sites. Existing vegetation *should only be used with great caution* as a clue in determining whether you are on the target ecological site. Observed vegetation may differ from expected vegetation due to effects of land use, natural disturbances such as fire, or climate. In answering this question, it is important to consider the full range of potential vegetation dynamics on a site – including natural post-disturbance successional processes, typical fluctuations in relation to climate, and possible degradational changes associated with invasive species, overgrazing, and/or major soil loss or redistribution. If observed vegetation is within this range of potential dynamics (natural and anthropogenic) for this ecological site, then the answer should be YES. However, if observed vegetation appears to be beyond the realm of potential dynamics, then the answer should be NO. Use the following examples to help you decide.

Departures within the range of potential dynamics:

- In reference condition, potential vegetation for the target ecological site is co-dominated by sagebrush and native perennial grasses, but the observed vegetation is dominated by invasive annuals (e.g. cheatgrass) or juniper with evidence of past sagebrush presence.
- Potential vegetation for the target ecological site is a mixed conifer forest but the observed vegetation is an aspen forest. The aspen forest may be a post-fire successional stage.

Departures beyond the range of potential dynamics:

- Potential vegetation for the target ecological site is a desert grassland dominated by black grama and observed vegetation is a montane shrubland dominated by gambel oak and serviceberry.

If a mixture of vegetative communities is present on the macroplot but the dominant community matches the target ecological site, then circle ‘yes’, but indicate in “Additional comments” the presence of other types. If the dominant community differs from the target ecological site, circle “no” and add narrative explaining your choice in “Additional comments”.

5) Ecological Site Assessment

The responses to the Soil and Vegetation Assessments above (nos. 4-5) determine if the site matches the target ecological site. Fill in the name of the ecological site that you characterized and provide an estimate of the macroplot area (%) comprised of this site type. For macroplots with more than one ecological site type, indicate the second-most common and the percent area. Write “unknown” if you are unable to determine the ecological site

from the information you have. Estimate the total length of transect (in meters) that falls outside the primary or target ecological site and write this on the data sheet. Remember that each macroplot has three 50-m transects separated by 25 m (Fig. 7) for a total of 150 meters of transect.

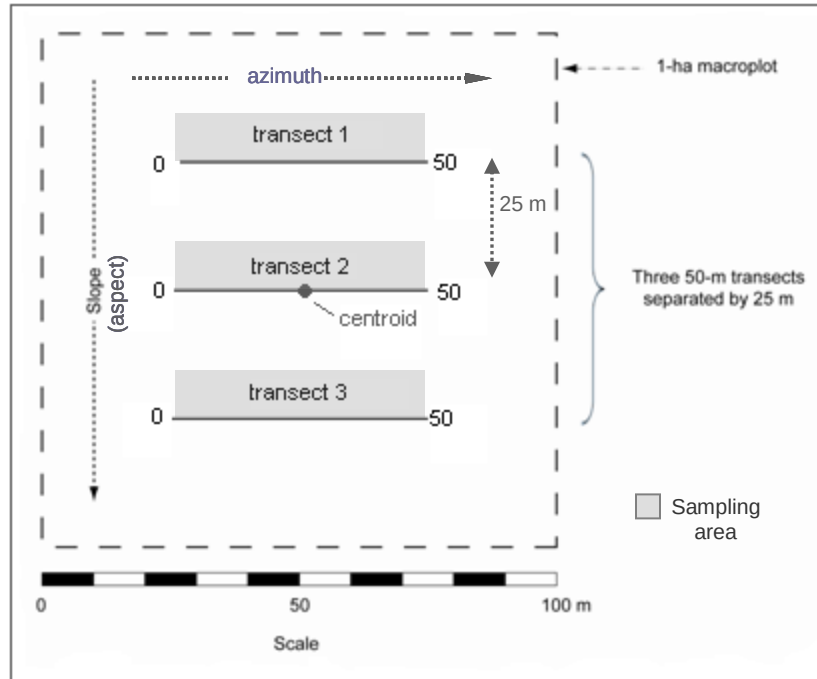


Figure 7. Standard macroplot and transect layout for upland monitoring.

6) Site Selection

Plots will be rejected if they do not match the target ecological site (wrong slope, slope position, landform, soil, soil depth, or vegetation), or if >30% of the total transect length crosses into another ecological site or an impermeable obstruction or cliff.

If both soils and vegetation are characteristic of the target ecological site, and $\leq 30\%$ of all 3 transects appear to have suitable soil and vegetation characteristics, then circle accepted on the data sheet and set up the monitoring plot (SOP #6). Using instructions from SOP #6, make sure to record the aspect, azimuth, and slope of the macroplot on the bottom of the "Site Characterization Data Sheet".

If the vegetation or the soil do not match the expected characteristics for the ecological site, circle rejected on the data sheet and describe your rationale in the "Comments" section.

7) Soil Collection

If you accept a site, collect the following soil samples. However, if an archeologist is not present, you will not be able to complete this step.

a) Using the hole dug for soil profile characterization, collect a soil sample from each 10-cm increment. Place a handful of soil in a soil collection bag and label it with the PlotID, date, and 10-cm increment (e.g. 10-20 cm). Note the number of 10-cm samples collected on the data sheet.

b) Next, collect composite soil samples from within the plot. A composite sample is composed of 25 subsamples collected from representative areas throughout the plot. The Principle Investigator will provide randomly generated locations of the 25 subsamples. Composite soil samples are collected for 0-2 cm and 2-10 cm depth using a probe or trowel. For each depth class, samples are placed in a bucket and mixed well before storing in soil collection bags. Place a handful of soil in a bag and label with the PlotID, date, and depth (e.g. 0-2 cm). Samples should be air-dried prior to storage for analysis. On the data sheet, record the number of soil samples collected, by strata.

The following are recommended soil analyses:

For each 10-cm increment of soil profile:

- **particle size (fine fraction)**
- **percent rock fragments by size class**
- **carbonate content**
- gypsum content

For 0-2 cm and 2-10 cm composite samples:

- **particle size (fine fraction)**
- **percent rock fragments by size class**
- **carbonate content**
- **pH**
- total N, P (Na-bicarbonate extraction), and S
- exchangeable cations Ca, Mg, K, and Na
- micronutrients Zn, Mn, Fe, and Cu
- organic matter (or organic C)
- cation exchange capacity (CEC)
- electrical conductivity (saturated paste).

*Minimum set of variables in **bold**.

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- Soil Survey Staff. 1993. Soil survey manual. USDA, Soil Conservation Service, Agricultural Handbook No. 18, U.S. Gov. Print. Office, Washington, D.C. 503 pp.

Appendix A.

Site Characterization Data Sheet

Site Characterization Data Sheet (p.1)

1. GENERAL PLOT INFO.

Park: _____ Plot ID: _____ Date: _____ Recorder: _____
Soil survey area: _____
Soil map unit: _____ GPS file name: _____
Centroid Coordinates (UTM): _____ m E _____ m N
Datum _____ UTM Zone _____

2. SOIL AND VEGETATION CHARACTERIZATION

A. Geologic setting: _____

B. Landform: _____

C. Hillslope position: summit - shoulder - backslope - footslope - toeslope - low level

D. Slope complexity: complex - simple

E. Slope shape - down slope: linear - concave - convex

across slope: linear - concave - convex

F. Percent slope: _____

G. Soil texture: _____

H. Sand modifier: very fine – fine - medium – coarse - very course - n/a

I. Rock fragment modifiers --- quantity adjective:

n/a (<15%) - none (15 to <35%) - very (35 to <60%) - extremely (60 to <90%) - >90%

--- size:

none - gravelly - cobbly - stony - bouldery - channery - flaggy - gravel - cobble - stone - boulder

J. Effervescence: none - very slight - slight - strong - violent

K. Soil Profile:

	Texture	Rock fragments		Effervescence
		Quantity Adj.	Size	
0-10 cm				
10-20 cm				
20-30 cm				
30-40 cm				
40-50 cm				
50-60 cm				
60-70 cm				
70-80 cm				
80-90 cm				
90-100 cm				

Site Characterization Data Sheet (p.2)

L. Depth: very shallow - shallow - moderately deep - deep - very deep - unknown

M. Dominant vegetation: _____

3. SOIL ASSESSMENT **target match:** yes - no

Probable soil component: _____

Additional comments: _____

4. VEGETATION ASSESSMENT **target match:** yes - no

Additional comments: _____

5. ECOLOGICAL SITE ASSESSMENT

Primary Ecological site: _____ **% Area:** _____

Other Ecological site: _____ **% Area:** _____

Estimated transect length outside of target ecological site: _____ m

6. SITE SELECTION: accepted - rejected

Comments: _____

7. SOIL COLLECTION (NO. OF SAMPLES)

____ Soil profile (= 10 cm groups) ____ 0-2 cm composite ____ 2-10 cm composite

Table A1. Example of the table used to organize descriptions of NRCS map units and ecological sites. This table is generated for each target ecological site, for each NCPN park unit.

Park	Survey area	Soil map unit no.	Soil map unit name	Landscape setting -- map unit	Component	Pct of map unit	Surface texture	Depth class	Parent material	Carbonates	Taxonomy	Slope percent	Landscape setting or landform -- component	Position on landform	Ecological site	Potential vegetation	Dynamics
CANY	Soil Survey of Canyonlands Area, Utah, Parts of Grand and San Juan Counties (UT633)	71	Rizno, dry - Rock outcrop complex, 3-15 percent slopes	Structural benches, cuestas, and mesas	Rizno	45	Gravelly fine sandy loam	Shallow	Eolian deposits over residuum derived dominantly from sandstone and shale	Moderately calcareous	Torriorthent	3-15	Structural benches, cuestas, hogbacks, and mesas		Semidesert Shallow Sandy Loam (PJ)	Blackbrush, Mormon tea, Utah juniper, Colorado pinyon	May degrade to rockland due to massive soil loss.
					Rock outcrop	25											
					Arches	10	Fine sand	Shallow	Eolian deposits derived dominantly from sandstone	Moderately calcareous	Torripsamment	2-8	Structural benches		Desert Shallow Sand (Blackbrush)	Blackbrush	May degrade to coppice dunes or rockland due to massive soil loss or redistribution.
					Mido	5	Loamy fine sand	Very deep	Eolian deposits derived dominantly from sandstone		Torripsamment	2-35	Sand drifts		Semidesert Sand (Fourwing Saltbush)	Grasses, Fourwing saltbush	May degraded to unstable sands and sparse vegetation, possibly with coppiced shrubs and Salsola.
					Sazi	5	Very fine sandy loam	Moderately deep	Eolian deposits derived dominantly from sandstone	Slightly calcareous	Calciorthid	1-15	Mesas		Semidesert Sandy Loam (Fourwing Saltbush)	Grasses	May degrade to dominance by annuals and bare ground, often including cheatgrass and other invasive exotics.
					Begay	5	Fine sandy loam	Very deep	Eolian deposits derived dominantly from sandstone	Non-calcareous	Camborthid	2-15	Structural benches		Semidesert Sandy Loam (Fourwing Saltbush)	Grasses, Fourwing saltbush	May degrade to dominance by annuals and bare ground, often including cheatgrass and other invasive exotics.

Park	Survey area	Soil map unit no.	Soil map unit name	Landscape setting -- map unit	Component	Pct of map unit	Surface texture	Depth class	Parent material	Carbonates	Taxonomy	Slope percent	Landscape setting or landform -- component	Position on landform	Ecological site	Potential vegetation	Dynamics
		80	Sheppard fine sand, 2-8 percent slopes	Sand sheets and sand shadows on structural benches and cuestas	Ignacio	5	Fine sandy loam	Moderately deep	Eolian deposits derived dominantly from sandstone	Non-calcareous	Camborthid	2-6	Mesas		Semidesert Sandy Loam (Fourwing Saltbush)	Grasses, Fourwing saltbush	May degrade to dominance by annuals and bare ground, often including cheatgrass and other invasive exotics.
					Sheppard	70	Fine sand	Very deep	Eolian deposits derived dominantly from sandstone	Moderately calcareous	Torrip-samment	2-8	Broad valleys and structural benches		Desert Sand (Sand Sagebrush)	Indian ricegrass, sand dropseed, sand sagebrush, sandhill Muhly	May degrade to coppice dunes dominated by sand sagebrush, invasive annuals, and bare, blowing soil
					Arches	10	Fine sand	Shallow	Eolian deposits derived dominantly from sandstone	Moderately calcareous	Torripsamment	2-8	Cuesta floors		Desert Shallow Sand (Blackbrush)	Blackbrush	May degrade to coppice dunes or rockland due to massive soil loss or redistribution.
					Trail	10	Fine sand	Very deep	Alluvim derived dominantly from sandstone	Moderately calcareous	Torrifluvent	0-5	Fluves		Sandy Bottom	Indian ricegrass, galleta grass, sand dropseed, fourwing saltbush	May degrade to dominance by annuals and bare ground.
					Nakai	10	Fine sand	Very deep	Alluvial and eolian material derived dominantly from sandstone		Calciorthid	0-8	Stable eolian sheets and in depressional areas		Desert Sandy Loam	Indian ricegrass, galleta grass, sand dropseed, fourwing saltbush	May degrade to dominance by annuals and bare ground.

Appendix B.

B1. NRCS landform and rock fragment definitions

alluvial fan - A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes, shaped like an open fan or a segment of a cone, deposited by a stream (best expressed in semiarid regions) at the place where it issues from a narrow mountain or upland valley; or where a tributary stream is near or at its junction with the main stream. It is steepest near its apex which points upstream and slopes gently and convexly outward (downstream) with a gradual decrease in gradient. GG

alluvial flat (a) (colloquial: western U.S.A.) A nearly level, graded, alluvial surface in bolsons and semi-bolsons which commonly does not manifest traceable channels, terraces or floodplain levels. Compare - flood-plain step, terrace, valley flat. FFP, GG, & SW. (b) (**not preferred**) A general term for a small flood plain bordering a river, on which alluvium is deposited during floods. GG

alluvial terrace - (not preferred) refer to stream terrace.

chanter - A thin, flat fragment of sandstone, shale, slate, limestone, or schist as long as 15 cm along the longest axis.

cuesta - An asymmetric, homoclinal ridge capped by resistant rock layers of slight to moderate dip (commonly less than 15 percent); produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope), that roughly parallels the inclined beds, and on the other side has a relatively short and steep or cliff-like slope (scarp) that cuts through the tilted rocks. Compare - hogback, mesa, dipslope, scarp slope, cuesta valley. SW & HP

flagstone - A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist as long as 15 to 38 centimeters long.

hill - A generic term for an elevated area of the land surface, rising at least 30 m (100 ft.) to as much as 300 meters (approx. 1000 ft.) above surrounding lowlands, usually with a nominal summit area relative to bounding slopes, a well-defined, rounded outline and slopes that generally exceed 15 percent. A hill can occur as a single, isolated mass or in a group. A hill can be further specified based on the magnitude of local relief: *low hill* (30 - 90 m) or *high hill* (90 - 300 m). Informal distinctions between a hill and a mountain are often arbitrary and dependent on local convention. Compare - hillock, plateau, mountain, foothills, hills. SW & HP

hillslope - A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of the hill. Compare - mountain slope. HP

landforms - discrete, natural, individual earth-surface features mappable at common survey scales.

landscapes - broad assemblages or unique groups of natural, spatially associated features.

mesa - A broad, nearly flat-topped, and usually isolated landmass bounded by steep slopes or precipitous cliff and capped by layers of resistant, nearly horizontal, rocky summit width greater than the height of bounding escarpments. (Colloquial: western USA; not preferred) Also used to designate broad structural benches and alluvial terraces that occupy intermediate levels in stepped sequences of platforms bordering canyons and valleys. Compare - butte, plateau, cuesta. HP & GG

plateau - [geomorphology] A comparatively flat area of great extent and elevation; specifically an extensive land region considerably elevated (more than 100 meters) above adjacent lower-lying terrain, and is commonly limited on at least one side by an abrupt descent, has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level. Compare - hill, foothill, mountain, mesa, plain. GG

sand dune - A low mound, ridge, bank or hill of loose, windblown, subaerially deposited granular material (generally sand), either barren and capable of movement from place to place, or covered and stabilized with vegetation, but retaining its characteristic shape. (See barchan dune, parabolic dune, parna dune, shrub-coppice dune, seif dune, transverse dune). SW & GG

sand sheet - A large, irregularly shaped, commonly thin, surficial mantle of eolian sand, lacking the discernible slip faces that are common on dunes. GG

structural bench - A platform-like, nearly level to gently inclined erosional surface developed on resistant strata in areas where valleys are cut in alternating strong and weak layers with an essentially horizontal attitude. Structural benches are bedrock controlled, and in contrast to stream terraces, have no geomorphic implication of former, partial erosion cycles and base-level controls, nor do they represent a stage of flood-plain development following an episode of valley trenching. Compare - pediment, ledge; see scarp. HP

valley - An elongate, relatively large, externally drained depression of the Earth's surface that is primarily developed by stream erosion or glacial activity. Compare - basin. HP

valley floor - A general term for the nearly level to gently sloping, lowest surface of a valley. Landforms include axial stream channels, the flood plain, flood-plain steps, and, in some areas, low terrace surfaces. Compare - flood-plain landforms, meander, braided channel, valley side.

B2. NRCS Landscapes and Landforms by Geomorphic Environment

(NASIS code follows each term; LF=landform, LS=landscape)

1. FLUVIAL - related to concentrated water flow (channel flow), including both erosional and depositional features.

Landscapes:

alluvial plain —
alluvial plain remnant —
badlands BA
bajada BJ
breaks BK
canyonlands —
delta plain —
fan piedmont FP
meander belt MP
river valley —
scabland SC

Landforms:

alluvial cone —
alluvial fan AF
alluvial flat AP
arroyo AY
axial stream (w) —
backswamp BS
bajada BJ
bar BR
basin-floor remnant BD
block stream BX
box canyon —
braided stream BZ
canyon CA
channel CC
coulee CE
cutoff CV
delta DE
delta plain (also LS) DC
drainageway DQ
draw DW

ephemeral stream —
fan apron —
fan collar —
fanhead trench FF
fan remnant —
fan skirt FI
flood plain FP
flood-plain playa FY
flood-plain splay FM
flood-plain step FO
giant ripple GC
gorge GO
gulch GT
gut (valley) GV
inset fan IF
intermittent stream —
levee [stream] LV
meander scar MS
meander scroll MG
natural levee NL
overflow stream channel —
oxbow OX
oxbow lake (ephemeral) OL
paleoterrace —
point bar PR
ravine RV
river valley (also LS) —
slot canyon —
strath terrace SU
stream terrace SX
valley border surfaces —
valley flat VF
wash WA
wind gap WG

2. EOLIAN - wind-related erosion or deposition.

Landscapes:

dune field —
sand hills SH
sand plain —

Landforms:

barchan dune BQ
blowout BY
climbing dune —
deflation basin DB
dune DU
dune lake (w) —
dune slack —
falling dune —
foredune FD

interdune ID
loess bluff LO
loess hill LQ
longitudinal dune —
paha PA
parabolic dune PB
parna dune PD
playa dune —
sand ramp —
sand sheet RX
seif dune SD
star dune —
transverse dune TD
yardang —
yardang trough —

3. VOLCANIC and HYDROTHERMAL

Landscapes:

foothills FH
hills HI
lava field (also LF) —
lava plain (also LF) —
lava plateau (also LF) —
mountains MO
volcanic field (also LF) —

Landforms:

a'a lava flow —
ash flow AS
block lava flow —
caldera CD
cinder cone CI
crater [volcanic] CR
fissure vent —
geyser —
geyser basin —
geyser cone —
hot spring —
kipuka —
lahar LA
lava field (also LS) —

lava flow unit —
lava flow LC
lava plain (also LS) LN
lava plateau (also LS) LL
lava trench —
lava tube —
louderback LV
maar —
mawae —
mud pot —
neck [volc.] —
pahoehoe lava flow —
pillow lava flow —
plug [volc.] —
plug dome PP
pressure ridge [volc.] PU
pyroclastic flow —
pyroclastic surge —
shield volcano —
step toe —
stratovolcano SV
volcanic cone VC
volcanic dome VD
volcanic field (also LS) —

4. MASS MOVEMENT (= MASS WASTING) – related to movement by gravity.

Landscapes: These generic Landscapes are not Mass Movement features per say, but are commonly modified by, and include localized areas of Mass.

Movement.

foothills FH

hills foothills FH

hills HI

mountain range —

mountains MO

Landforms:

avalanche chute AL

block glide —

block stream BX

complex landslide —

debris avalanche DA

debris fall —

debris flow DF

debris slide —

debris spread —

debris topple —

earth flow EF

earth spread —

earth topple —

fall FB

flow —

lahar LA

landslide LK

lateral spread —

main scarp (also Micro) —

mudflow MW

rock fall (also Micro) —

rockfall avalanche —

rock glacier RO

rock spread —

rock topple —

rotational debris slide —

rotational earth slide —

rotational rock slide —

rotational slide RP

sag (also Micro) —

sag pond (w; also Micro) —

sand flow RW

scree slope —

slide SJ

slump SK

slump block SN

soil fall —

talus cone —

talus slope —

topple —

translational debris slide —

translational earth slide —

translational rock slide —

translational slide TS

5. TECTONIC and STRUCTURAL - related to regional or local bedrock structures or crustal movement; recognized only if expressed at or near the land surface.

Landscapes:

batholith —
bolson BO
foothills FH
hills HI
intermontane basin IB
mountain range —
mountains MO
mountain system —
plateau PT
rift valley —
semi-bolson SB
tableland TB
valley VA

Landforms:

anticline AN
canyon bench —
cuesta CU

cuesta valley —
diapir DD
dike DK
dipslope DL
dome DO
fault-line scarp FK
fault zone —
fold FQ
graben GR
hogback HO
horst HT
louderback LU
meteorite crater —
monocline MJ
scarp slope RS
sill RT
strike valley —
structural bench SB
syncline SZ

6. SLOPE - generic terms that emphasize form rather than any particular genesis or process.

Landscapes:

badlands BA
breaks BK
canyonlands —
foothills FH
hills HI
mountain range —
mountains MO
mountain system —
piedmont PI
piedmont slope —
plateau (also LF) PT
tableland TB
upland UP

Landforms:

beveled base —
block stream BX
bluff BN
broad interstream divide —
butte BU
canyon bench —
cliff CJ
cuesta CU
dome DO
escarpment ES
faceted spur FS
fault-line scarp FK
free face FW (also Geom. Component-
Hills, Mountains)
gap GA
headwall HW
high hill —

hill (plural = LS) HI
hillslope —
hogback HO
interfluvium (also Geom. IV Component -
Hills)
knob KN
knoll KL
ledge LE
low hill —
mesa ME
mountain (plural = LS) MM
mountain slope MN
mountain valley MV
notch NO
paha PA
peak PK
pediment PE
plain (plural = LS) PN
plateau (also LS) PT
ridge RI
rim RJ
rock pediment —
scarp RY
scarp slope RS
scree slope —
spur SQ
stack [geom.] —
structural bench SB
talus cone —
talus slope —
tor TQ
valley VA
wind gap WG

7. EROSIONAL - related to water erosion, excluding perennial channel flow.

Landscapes:

badlands BA
breaks BK
canyonlands —
foothills FH
hills HI
mountain range —
mountains MO
piedmont PI
piedmont slope —
plateau (also LF) PT
tableland TB

Landforms:

ballena BL
ballon BV
basin floor remnant BD
beveled base —
canyon bench —
col CL
cuesta CU
cuesta valley —
eroded fan remnant —
eroded fan-remnant —

sideslope
erosion remnant ER
free face (also Geom. FW
Component-Hills,
Mountains)
gap GA
hogback HO
inselberg IN
monadnock MD
notch NO
paha PA
partial ballena PF
peak PK
pediment PE
plateau (also LS) PT
rock pediment —
saddle SA
scarp slope RS
stack [geom.] SR
strike valley —
structural bench SB
tor TQ
valley border surfaces —
wind gap WG

8. DEPRESSIONAL - low area or declivity features, excluding permanent water bodies.

Landscapes:

basin BS
bolson BO
semi-bolson SB
valley VA

Landforms:

alluvial flat AP
basin floor BC
basin floor remnant BD
box canyon —
canyon CA
Carolina Bay CB
closed depression —
col CL
coulee CE
cove [geom.] CO
cuesta valley —
depression DP
drainageway DQ
gap GA
gorge GO
gulch GT

gut (valley) GV
intermontane basin IB
kettle KE
mountain valley MV
open depression —
playa PL
playa floor —
playa rim —
playa slope —
playa step —
pothole PH
ravine RV
saddle SA
sag —
slot canyon —
strike valley —
swale SC
trough TR
U-shaped valley UV
valley VA
valley floor VL
V-shaped valley VV

Appendix C.

Quick Reference Sheets

Soil Texture, Depth, and Effervescence

Root restricting depth		
Depth class	Cm	In
Very shallow	< 25	< 10
Shallow	25 - 50	10 - 20
Moderately deep	50 - 100	20 - 40
Deep	100 - 150	40 - 60
Very deep	>= 150	>= 60

Effervescence Class	Code		Criteria
	PDP	NASIS	
Noneffervescent	4	NE	No bubbles form.
Very Slightly Effervescent	0	VS	Few bubbles form.
Slightly Effervescent	1	SL	Numerous bubbles form.
Strongly Effervescent	2	ST	Bubbles form a low foam.
Violently Effervescent	3	VE	Bubbles form a thick foam.

TEXTURE MODIFIERS - Conventions for using "Rock Fragment Texture Modifiers" and for using textural adjectives that convey the "% volume" ranges for **Rock Fragments - Size and Quantity**.

Fragment Content % By Volume	Rock Fragment Modifier Usage
< 15	No texture adjective is used (noun only; e.g., <i>loam</i>).
15 to < 35	Use adjective for appropriate size; e.g., <i>gravelly</i> .
35 to < 60	Use "very" with the appropriate size adjective; e.g., <i>very gravelly</i> .
60 to < 90	Use "extremely" with the appropriate size adjective; e.g., <i>extremely gravelly</i> .
≥ 90	No adjective or modifier. If ≤ 10% fine earth, use the appropriate noun for the dominant size class; e.g., <i>gravel</i> . Use Terms in Lieu of Texture .

SIMPLIFIED KEY TO SOIL TEXTURE

Add water to hand-full of soil and knead to break down aggregates. Soil is at proper consistency when plastic and moldable like moist putty.

- Soil does not remain in a ball when squeezed.....**Sand (Sa)**
- Soil remains in a ball when squeezed.....2

Squeeze ball between thumb and forefinger, attempting to make a ribbon that you push up over finger.

- Soil does not form ribbon.....**Loamy Sand (LSa)**
- Soil does form ribbon; may be very short.....3

- Ribbon extends < 1 inch before breaking.....4
- Ribbon extends > 1 inch before breaking.....5

- Add excess water to small amount of soil; soil feels very gritty.....**Sandy Loam (SaL)**, or slightly gritty.....**Loam (L)**
- Soil feels very smooth.....**Silt Loam (SiL)**

- Soil makes ribbon that breaks when 1-2 inches long; cracks if bent into ring.....6
- Soil makes ribbon > 2 inches long; doesn't crack if bent into ring.....7

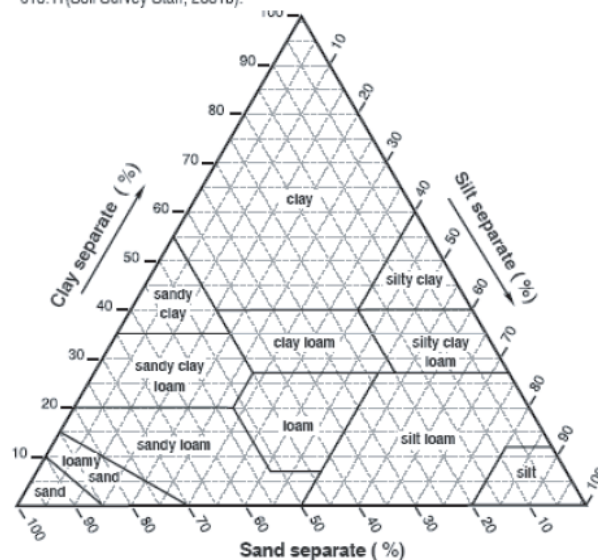
- Add excess water to small amount of soil; soil feels at least slightly gritty.....**Sandy Clay Loam (SaCL)** or **Clay Loam (CL)**
- Soil feels smooth.....**Silt (Si)** or **Silty Clay Loam (SiCL)**

- Add excess water to small amount of soil; soil feels at least slightly gritty.....**Sandy Clay (SaC)** or **Clay (C)**
- Soil feels smooth.....**Silty Clay (SiC)**

TEXTURE MODIFIERS - (adjectives)

ROCK FRAGMENTS: Size & Quantity ¹	Code		Criteria: Percent (By Volume) of Total Rock Fragments and Dominated By (name size): ¹
	Conv.	PDP/ NASIS	
ROCK FRAGMENTS (> 2 mm; ≥ Strongly Cemented)			
Gravelly	GR	GR	≥ 15% but < 35% gravel
Fine Gravelly	FGR	GRF	≥ 15% but < 35% fine gravel
Medium Gravelly	MGR	GRM	≥ 15% but < 35% med. gravel
Coarse Gravelly	CGR	GRC	≥ 15% but < 35% coarse gravel
Very Gravelly	VGR	GRV	≥ 35% but < 60% gravel
Extremely Gravelly	XGR	GRX	≥ 60% but < 90% gravel
Cobbly	CB	CB	≥ 15% but < 35% cobbles
Very Cobbly	VCB	CBV	≥ 35% but < 60% cobbles
Extremely Cobbly	XCB	CBX	≥ 60% but < 90% cobbles
Stony	ST	ST	≥ 15% but < 35% stones
Very Stony	VST	STV	≥ 35% but < 60% stones
Extremely Stony	XST	STX	≥ 60% but < 90% stones
Bouldery	BY	BY	≥ 15% but < 35% boulders
Very Bouldery	VBY	BYV	≥ 35% but < 60% boulders
Extremely Bouldery	XBY	BYX	≥ 60% but < 90% boulders
Channery	CN	CN	≥ 15% but < 35% channers
Very Channery	VCN	CNV	≥ 35% but < 60% channers
Extremely Channery	XCN	CNX	≥ 60% but < 90% channers
Flaggy	FL	FL	≥ 15% but < 35% flagstones
Very Flaggy	VFL	FLV	≥ 35% but < 60% flagstones
Extremely Flaggy	XFL	FLX	≥ 60% but < 90% flagstones
PARAROCK FRAGMENTS (> 2 mm; < Strongly Cemented) ^{2, 3}			
Parabouldery	PBY	PBY	(same criteria as bouldery)
Very Parabouldery	VPBY	PBYV	(same criteria as very bouldery)
Extr. Parabouldery	XPBY	PBYX	(same criteria as ext. bouldery)
etc.	etc.	etc.	(same criteria as non-para)

¹ The "Quantity" modifier (e.g., *very*) is based on the total rock fragment content. The "Size" modifier (e.g., *cobbly*) is independently based on the largest, dominant fragment size. For a mixture of sizes (e.g., *gravel and stones*), a smaller size-class is named only if its quantity (%) sufficiently exceeds that of a larger size-class. For field texture determination, a smaller size-class must exceed 2 times the quantity (vol. %) of a larger size class before it is named (e.g., 30% gravel and 14% stones = *very gravelly*, but 20% gravel and 14% stones = *stony*). For more explicit naming criteria see NSSH-Part 618, Exhibit 618.11 (Soil Survey Staff, 2001b).



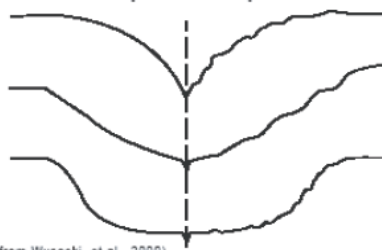
FINE EARTH										ROCK FRAGMENTS						150	380	600 mm
										channers			flagst.	stones	boulders			
Clay ²		Silt		Sand					Gravel			Cob- bles	Stones	Boulders				
fine	co.	fine	co.	v. fi.	fi.	med.	co.	v. co.	fine	medium	coarse							
0.0002	.002 mm		.02	.05	.1	.25	.5	1	2 mm	5	20	76	250	600 mm				

Hillslope Descriptors & Cover / Volume Estimation

Slope angle	
Deg	Pct
1	1.7
2	3.5
3	5.2
4	7.0
5	8.7
6	10.5
7	12.3
8	14.1
9	15.8
10	17.6
11	19.4
12	21.3
13	23.1
14	24.9
15	26.8
16	28.7
17	30.6
18	32.5
19	34.4
20	36.4
21	38.4
22	40.4
23	42.4
24	44.5
25	46.6
26	48.8
27	51.0
28	53.2
29	55.4
30	57.7
31	60.1
32	62.5
33	64.9
34	67.5
35	70.0
36	72.7
37	75.4
38	78.1
39	81.0
40	83.9
41	86.9
42	90.0
43	93.3
44	96.6
45	100.0

Slope Complexity - Describe the relative uniformity (smooth linear or curvilinear = *simple* or *S*) or irregularity (*complex* or *C*) of the ground surface leading downslope through the point of interest; e.g., *simple* or *S*.

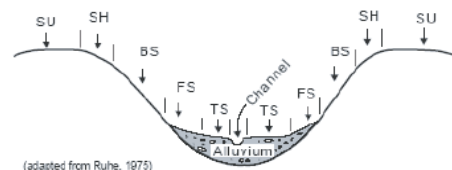
Simple vs. Complex



(adapted from Wysocki, et al., 2000)

Hillslope - Profile Position (Hillslope Position in PDP) - Two-dimensional descriptors or parts of line segments (i.e., slope position) along a transect that runs up and down the slope; e.g., *backslope* or *BS*. This is best applied to transects or points, not areas.

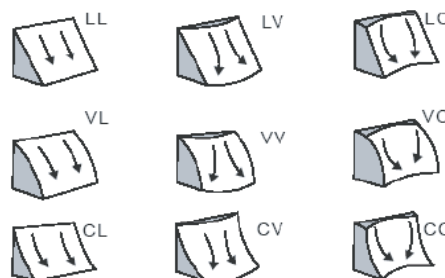
Position	Code
summit	SU
shoulder	SH
backslope	BS
footslope	FS
toeslope	TS



(adapted from Ruhe, 1975)

Slope Classes	Pct. Gradient
Level	< 1
Nearly level	1-3
Gently sloping	4-6
Strongly sloping	7-10
Moderately steep	11-20
Steep1	21-45
Steep2	46-75
Steep3	76-100
Very steep	> 100

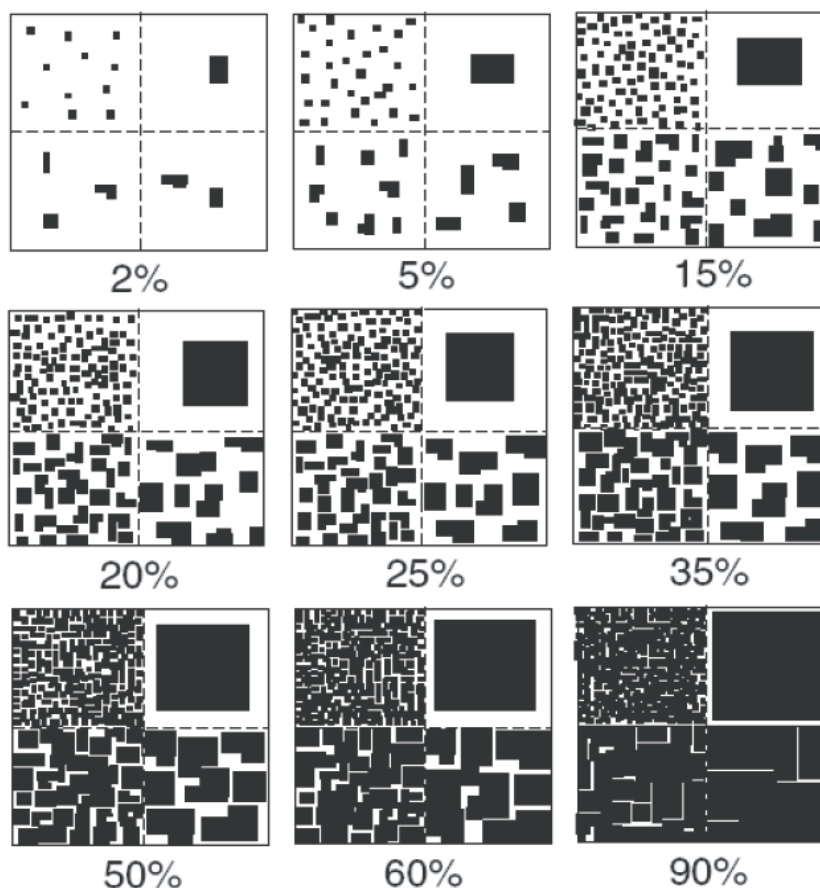
Slope Shape - Slope shape is described in two directions: up-and-down slope (perpendicular to the contour), and across slope (along the horizontal contour); e.g., *Linear*, *Convex* or *LV*.



(adapted from Wysocki, et al., 2000)

L = Linear
V = Convex
C = Concave

Surface flow pathway



Foliar cover classes	
Class	Cover %
1	< 1
2	1 - 5
3	5 - 10
4	10 - 25
5	25 - 50
6	50 - 75
7	75 - 100

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 6

Establishing and marking permanent monitoring sites, and revisiting permanent monitoring sites

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	1) Added specific reference to SOP #4 2) Add instructions for recording re-visit comments	1) To emphasize minimizing site impacts 2) Addition of revisit data sheet	1.1

This SOP provides instructions for establishing a permanent monitoring site, recording changes to permanent monuments, and recording general comments upon revisiting an existing monitoring site. For establishment purposes, the first three procedures of this SOP are used in the first visit to a plot after ensuring that the site meets all criteria for sampling (see SOP#5 Site Characterization). The last procedure is employed upon re-visiting a monitoring site. This SOP was adopted with modifications from Herrick (2004) and USDI National Park Service (2003). SOP#4 (Crust-Friendly Field Procedures) should be reviewed before plot establishment

I. Plot Establishment Procedures

1. General Plot Information

Note the park, plot ID, date, and observer at the top of the Plot Establishment data sheet (Appendix A). If plot establishment does not immediately follow the Site Characterization (SOP#5), then the centroid coordinates, datum, and zone fields should be filled in based on the actual plot center location used to establish a plot. Otherwise, centroid information does not need to be recorded.

2. Slope and Aspect Measurements

A general measure of slope is recorded during site characterization (SOP #5). More representative measures of both slope and aspect are required prior to actual site establishment. These measures are recorded from 5-10-m upslope from the 1st transect

using a clinometer sighted on a reference or sighting pole located 5-10m downslope from the 3rd transect. A PVC pole or an unfolded 2-m engineer ruler can be used for the sighting pole. Before taking measurements, select the member who will use the clinometer. Holding the sighting pole or unfolded 2-m engineer ruler next to this crew member, use a piece of flagging to mark eye-level on the sighting pole or ruler.

If plot establishment commences immediately after site characterization (SOP #5), envision the center transect running parallel to the slope contour. Step ca. 1-2 meters downslope from this envisioned transect, and walk 30-40 meters parallel to the slope contour in order to get outside of the sampling area. The crew member with the clinometer should walk upslope 30-40 meters to locate themselves 5-10 meters upslope from the 1st transect. The second crew member should walk 30-40 meters downslope to a location about 5-10 meters downslope from the 3rd transect. Care should be taken to ensure that areas to be sampled along the three transects are not trampled. For reference, Fig. 1 illustrates the transect scheme for a macroplot.

If plot establishment occurs asynchronous with site characterization, then using a GPS estimate plot center and the 5-10m distance above and below the outer most transects of the macroplot. If a centroid marker is present on the plot, use this marker to estimate the top and bottom transects of the macroplot.

Standing ca. 5-10m above where the 1st transect is likely to be located, record percent slope with a clinometer by sighting to the sighting pole directly down hill and located ca. 5-10-m below the 3rd transect. Slope is recorded at 0, 25, and 50-m along the 1st transect. These distances can be paced off; laying a tape is not required. Aspect (direction of downhill-slope) is measured along with each slope measurement. The average of the three slope measures and of the three aspect measures is recorded on the Plot Establishment Data Sheet (Appendix A). For complex slopes, average the two most similar measures for each attribute. Record the average percent slope and aspect on the data sheet. See SOP#5 for percent-slope conversion from degrees slope, if necessary.

3. Azimuth of the Center Transect

The transect azimuth is the direction of a transect from the origin to the “finish” end. Transects are oriented parallel to the slope contour. Facing upslope, transects run from left (origin) to right (end). The azimuth of the center transect (transect #2) is based on the average aspect of the macroplot. This azimuth number should be 90° less than the average aspect. Derive this azimuth from the average macroplot aspect measure taken above, and record it on the data sheet.

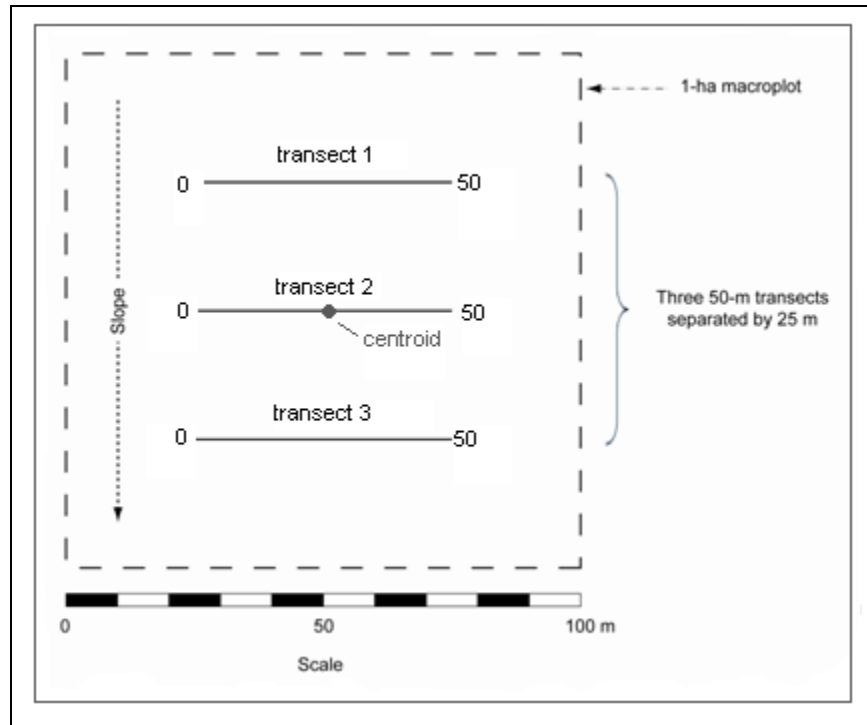


Figure 1. Standard macroplot and transect layout for upland monitoring.

4. Establish the center transect. Using the Transect Azimuth derived in #3, lay out the tape from the origin to end of the center transect (50 m). The origin is to the left when facing upslope. If on level ground arbitrarily determine the orientation of the origin.
5. Drive a 0.5" diameter rebar stake into the ground at the origin of the transect, leaving less than 30 cm exposed. If it is not possible to sink the rebar in at the origin or at the end (i.e. bedrock exposure), locate the closest possible point along the transect and drive the rebar stake in there. Always note the distance along the transect where the rebar is placed (i.e., at the origin, the distance is 0). This will clarify if the rebar stake was moved and to what distance it was moved. There are special requirements for rebar placement whenever a plot is highly visible to park visitors. If a piece of rebar is easily detectable from a road or trail, only leave ca. 10 cm of the bar above ground or sink it to ground level, and note this in the comments of the data form. If a transect end is on a trail or dirt road, locate the rebar where it will not be noticed by visitors and note the displacement as instructed above.
6. Attach a metal tag to the rebar stake using wire. If the rebar has a hole at the top, thread a piece of wire through the hole and the tag, and securely fasten the tag. If the rebar lacks a hole, thread the tag with a piece of wire and wrap the wire securely around the top of the rebar. On one side scribe the following: NCPN, *the date (e.g., Aug 06)*, RS29. This is required by the research permit, and identifies the study by the Research Study number. On the other side of the tag, scribe the following information. The PlotID number is always at the top of the tag. Beneath the PlotID is the transect ID. The transect ID identifies the transect and the end points of a transect. This is accomplished using the following convention: XY, where X = 1 for upper transect (i.e., uphill), 2 for the center transect, 3 for lower transect (downhill transect); Y = O for origin, C for center, E for end

of the transect. The origin of a transect is to the left when facing upslope. If the plot is on level ground, arbitrarily select 'uphill' and 'downhill' and the side for the origin. For the latter situation, be consistent among transects.

7. Using the GPS, record the UTM coordinates and elevation of the rebar marking the transect origin on the Plot Establishment Data Sheet.
8. Repeat steps 2-4 for the transect center point, except UTM coordinates are not required.
9. Repeat steps 2-4 for the transect end.
10. Repeat steps 4-9 for the upper and lower transects. Note: these transects should be parallel to the center transect, even if they are no longer exactly parallel to the slope.
11. NOTE that the quadrats located along the transect are further monumented during the quadrat sampling effort (SOP#21).

II. Plot Photos

1. Photographs of each of the three transects should be taken every plot visit. See SOP#7 for instructions.

III. Plot Directions

1. Complete the Plot Establishment Data Sheet by adding detailed directions to the plot. Detailed directions are those adequate for someone unfamiliar with the site to locate it. Begin with road travel, where to park, describe (and photograph) landmarks used in navigating the origin of the center transect. Note particular obstacles or hazards to be avoided at (and en route to) this particular site.

IV. Revisiting An Existing Monitoring Site

1. If the monuments of the transect ends have been altered due to disturbances and can not simply be replaced at the same locations, they should be relocated. For example, if a tree fell and covered the location of the previous rebar, or if the development or expansion of a gully or wash removed the previous rebar and will remove any future monument at that location. After determining a suitable location for a transect-end monument, use the GPS to record the new UTM coordinates, and record these coordinates and the rebar location (relative to the transect as specified above) on the Plot Revisit data sheet (Appendix B).
2. If the original centroid coordinates, or slope and aspect of the plot are deemed to be inaccurate, record new measures on the Plot Revisit data sheet, and indicate why these variables were re-recorded.
3. Comments related to the overall condition of the plot, or general observations not required in the Site Impact assessment (see SOP #12) are recorded under comments on the Plot Revisit data sheet. Comments are open-ended, but could include a visual interpretation of recent plant growth, the extent of exotic annuals, etc.

Appendix A

Plot Establishment Data Sheet

Plot Establishment Data Sheet

Park: _____ Plot ID: _____ Date : _____ Page ____ of ____

Observer : _____

Centroid Coordinates (UTM): _____ m E _____ m N

Datum _____ UTM Zone _____

Slope (%): _____ Aspect (°): _____ Centroid Transect Azimuth (°): _____

TRANSECT LOCATION:

Transect	Rebar at transect origin		Rebar location (m)	Rebar at transect end		Rebar location (m)	Elevation m
	UTM E	UTM N		UTM E	UTM N		
1) Upper (uphill)							
2) Center							
3) Lower (downhill)							

DIRECTIONS TO PLOT: _____

Appendix B

Plot Revisit Data Sheet

Plot Revisit Data Sheet

Park: _____ Plot ID: _____ Date : _____ Page ____ of ____

Observer : _____

Centroid Coordinates (UTM): _____ m E _____ m N

Datum _____ UTM Zone _____

Slope (%): _____ Aspect (°): _____ Centroid Transect Azimuth (°): _____

TRANSECT LOCATION:

Transect	Rebar at transect origin		Rebar location (m)	Rebar at transect end		Rebar location (m)	Elevation m
	UTM E	UTM N		UTM E	UTM N		
1) Upper (uphill)							
2) Center							
3) Lower (downhill)							

COMMENTS: _____

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 7

Repeat Photographs

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Added additional photo points	To provide a more comprehensive photo record of plot conditions	1.1

This SOP provides instructions for taking photographs at each upland monitoring site. In each site visit, one photo of each transect is required as well as one photo of the three 10-m² quadrats along the diagonal of the macroplot. A third photo, taken within the same 10m² quadrat, documents biological soil crusts.

For more information on photo point monitoring, see the USFS Photo Point Monitoring Handbook (www.fs.fed.us/pnw/pubs/gtr526/). This SOP was adopted with modifications from Herrick et al. 2005, Volume 1, pg. 6 – 9. [Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2004. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. Published as 2 volumes. Jornada Experimental Range, USDA 236 pp.]

I. Photo Points

Photos are to be taken using a 35-mm camera with color film. Do the following at the origin of each transect while the transect tape is stretched out along a transect:

1. Label photo point ID board (Appendix B) and lean it next to the rebar marking the origin of a transect.
2. Stand 5 meters back from the end of a transect, set the camera body on top of a 1.5-m pole (monopod), and point the camera down the transect. The tape serves as a reference. The 2-m engineers rule can serve as the monopod. The sign board should be at the bottom of the field of view. If the photo clearly shows the vegetation and site conditions along the transect, take a photo, record the film information on the Photo Data Sheet (Appendix A), and record the location of the photo point as -5 m. If the view is obstructed, move the photo point along the transect and note the location in the Photo Data Sheet.

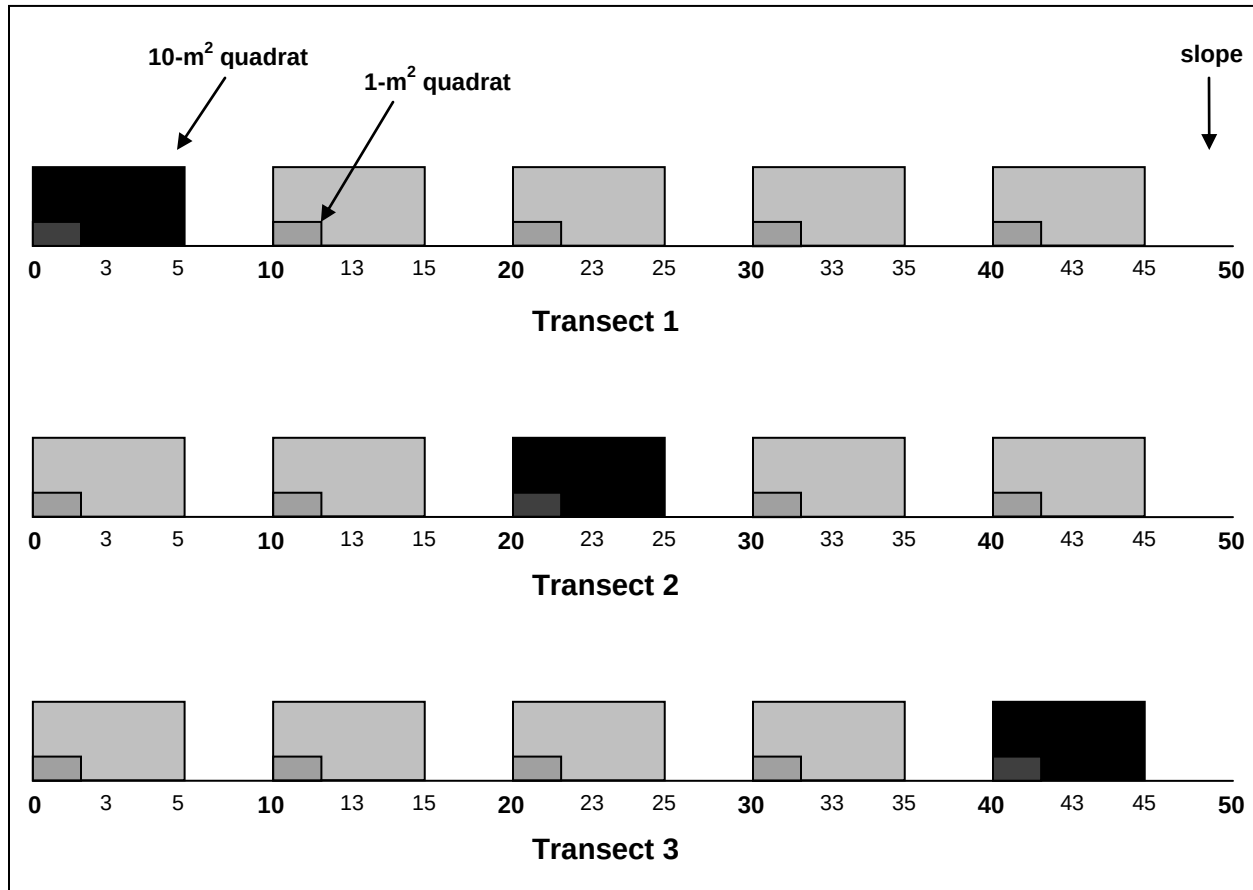


Figure 1. Quadrat placement along transects. Transects are not drawn to scale.

3. Photographs of the three diagonal 10-m² quadrats are required (black-filled quadrats in Fig. 1). Photos should be taken during the quadrat measurement procedure (see SOP #21) to minimize repeated trampling along a transect. With the folding rules outlining the quadrat, stand 2m further down the tape from the "far" edge of the quadrat (e.g., 7m, 27m, or 47m), place the camera on the 1.5-m monopod, adjust the camera's field of view (horizontal format) to include full extent of the quadrat, take a photo, and record the location and film information on the Photo Data Sheet (Appendix A). If the field of view is obstructed for any reason, choose another location for a photo and be sure to record the actual location on the data sheet.

4. For the biological crust photo, stand at the "0" corner of the diagonal 10m² plot (i.e., 0m, 20m or 40m), aim the camera straight down so that the tape barely appears along the bottom of the image and shoot a horizontal-format photo. Record the relevant information on the data sheet.

Appendix A. Photo Data Sheet.

Photo Data Sheet

Park: _____ Plot ID: _____ Date : _____

Transect #	Roll #	Frame #	Photographer	Direction	Location of photo point along transect (meters)
1 (upper)					
2 (center)					
3 (lower)					

Quadrat	Roll #	Frame #	Photographer	Direction	Location of photo point along transect (meters)
First quadrat, transect #1					
Third quadrat, transect #2					
Fifth quadrat, transect #3					

Biological Crust	Roll #	Frame #	Photographer	Direction	Location of photo point along transect (meters)
First quadrat, transect #1					
Third quadrat, transect #2					
Fifth quadrat, transect #3					

Appendix B. Photo point ID card

Site:

Date:

Transect #:

Direction:

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 9

Measuring Canopy and Basal Gaps Using Line-Intercept Sampling

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Enhanced instructions for integrating this SOP with SOP#21	To ensure that procedures are conducted in concert with other SOPs	1.1

This SOP gives step-by-step instructions for obtaining gap intercept estimates between plant canopies and between plant bases. This procedure is conducted in conjunction with quadrat sampling (SOP#21) on a transect, and thus is implemented in every plot visit. Material for this SOP was taken, with modifications, from the *Monitoring manual for grassland, shrubland and savanna ecosystems, Volumes I & 2* (Herrick et al. 2005a,b).

Sampling teams

Gap intercept sampling requires a two-person team: one “observer” to call out gap measurements and one “recorder” to write down gap measurements.

Procedures

This SOP is implemented concurrently with frequency, cover, and shrub-density measures within quadrats (see SOP#21). The canopy gap portion of this SOP is conducted in conjunction with quadrat measurements along a transect (see SOP#21). That is, after recording all required information on a 10m² quadrat, the observer subsequently records canopy gap measures along the transect up to the location of the next 10m² quadrat. The recorder remains at the 50-m end of the transect following the canopy gap/quadrat reading. The observer back tracks along the transect to record basal gaps. The observer either calls out basal gap measurements or uses walkie-talkies to convey the information to the recorder. This cross-walking among SOPs was designed for efficiency and to minimize soil-trampling impacts. This SOP and SOP#21 should be carefully reviewed before conducting canopy and basal area gap measurements.

1. Fill out relevant information at the top of the “Gap Intercept Data Sheet” including:

- **Park Unit** - Use the 4-letter codes to indicate the park (see SOP#5).
- **PlotID** – this is the unique, pre-assigned number for the plot.
- **Transect#** - 1-3 based on slope position (1 is the upslope transect, 2 is the middle transect, and 3 is the downslope transect).
- **Date** – mm/dd/yyyy.
- **Observer** – Record the initials of the person calling out gap measurements. If initials of two or more persons are the same, include a middle initial or some other distinguishing initial.
- **Recorder** – Record the initials of the person recording data.
- **Page #** – Record the page # and the total number of data pages for each transect.

2. Sample canopy gaps.

Stand on the downhill side of the transect at the 0-m end and work from left to right towards the 50-m end. Look straight down on the tape and use a meter stick or other stiff stick to project a line vertically to the ground on the uphill side of the tape. Record the class of canopy cover/gap and the start to the nearest centimeter. Segments along a transect fall in three distinct classes:

- **Canopy gap** – A space between canopy cover at least 20 cm in length.
- **Shrub** – Shrub canopy <2 m in height. Include all shrubs from the list provided, except dwarf-shrubs.
- **Other vegetation** – Any canopy cover not included in the shrub category. Record dwarf-shrubs in this category (i.e., cactus, yucca, snakeweed, etc.). Annual species are not included as other vegetation. Essentially, annual species are ignored when measuring canopy as well as basal gaps.

Use the abbreviations g for gap, s for shrub, v for other vegetation on the data sheet.

Follow these rules:

- A canopy gap occurs any time there is at least 20 cm of gap between plant canopies. Therefore, canopy gaps are always at least 20 cm long (Figs. 2 & 3, Tables 1 & 2).
- Canopy occurs any time 50% of any 3 cm segment of tape edge intercepts live or dead plant canopy based on a vertical projection from canopy to ground. The only exception to this rule occurs when you have a space between canopies <20 cm. When shrub canopy and other vegetation canopy occur less than 20 cm from each other along the transect, the boundary between the two canopy types is the mid-point of the intercepted space between them. When the space occurs between canopy cover in the same class, include the space within the appropriate canopy cover type (shrub or other vegetation).

- Imagine there is a brick wall at either end of the tape. If a space <20 cm between canopies occurs on either end of the transect, do not count this as a gap. At the beginning of the tape, start recording data at the first canopy cover intercept. At the end of the tape, record the endpoint to reflect the end of the last section of canopy cover intercepted. Usually the end will be 5000 cm, but it can be as low as 4981 cm if a space <20 cm occurs at the end of the transect.

3. Record the remaining information at the top of the data sheet.

Record the species which were identified as shrubs along the transect.

4. Sample basal gaps.

Immediately after you finish record all other measures on a transect (see SOP#21), begin sampling basal gaps from the 50-m end of the tape working back towards the 0-m end of the tape. Remain on the downhill side of the transect, and use the same technique as for canopy gaps to project vertically down to the ground. Record the start and end of each gap to the nearest centimeter (Figs. 2 & 3, Tables 1 & 2). **Annual species are not considered in this measurement.** In essence, the basal area of annual species is treated as not being present.

Follow these rules:

- A plant base is any plant stem emerging from the soil surface along the uphill edge of the tape that would force an ant walking along the line on the soil to step off the line to get around it (minimum diameter = 1 mm).
- A basal gap occurs any time there is at least 20 cm of intercept without a plant base. Therefore, there should always be at least 20 cm between basal gap starts and basal gap ends.
- A plant base can stop a gap whether live or dead.
- Plant bases must be anchored in the ground. Litter is not a plant base.
- If a space <20 cm occurs on either end of the transect, do not count this as a gap.

5. Continue sampling.

Follow steps 1 through 4 to complete gap intercept sampling on transects 2 and 3.

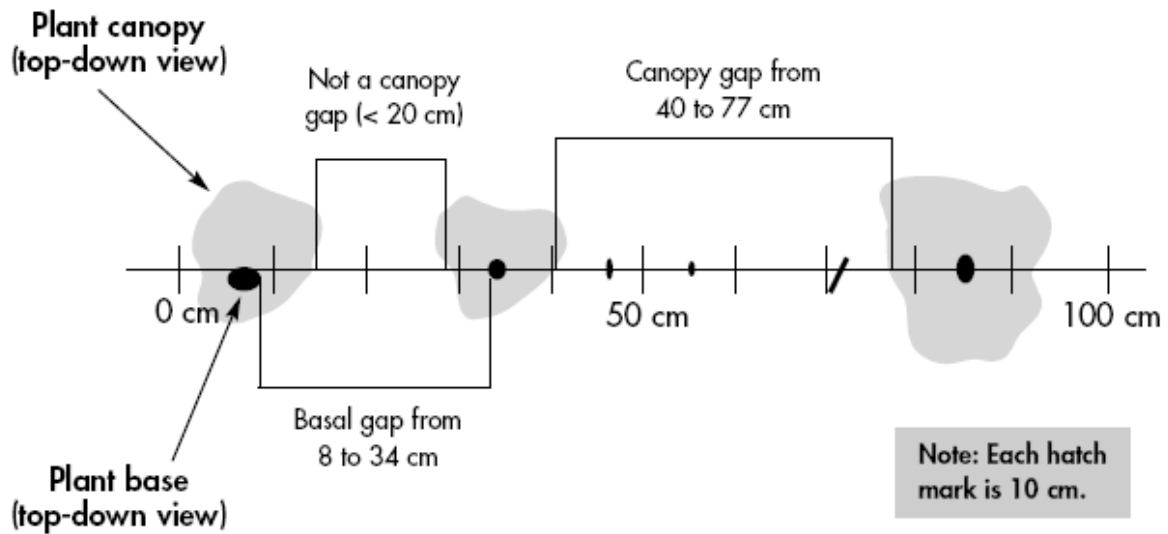


Figure 2. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 1 m (100 cm) of a 50-m transect. Canopy gaps: Since the first two plants along the transect are both shrubs and the space in between is less than 20 cm, the entire segment from 0-40 cm is considered shrub canopy. There is a gap from 40 to 77 cm because the plant canopies present do not cover more than 50% of any 3-cm segment. Basal gaps: There is a basal gap between 8 and 34 cm. The three small plant bases between 34 and 86 cm are all within 20 cm of an adjacent plant base, therefore, no basal gaps exist even though there is a canopy gap. (From Herrick et al. 2005a.)

Table 1. Gap intercept data sheet example associated with Figure 2.

Canopy Gaps		Basal Gaps	
Class (s, v, g)	Start (cm)	Start (cm)	End (cm)
s	0	8	34
g	40		
s	77		

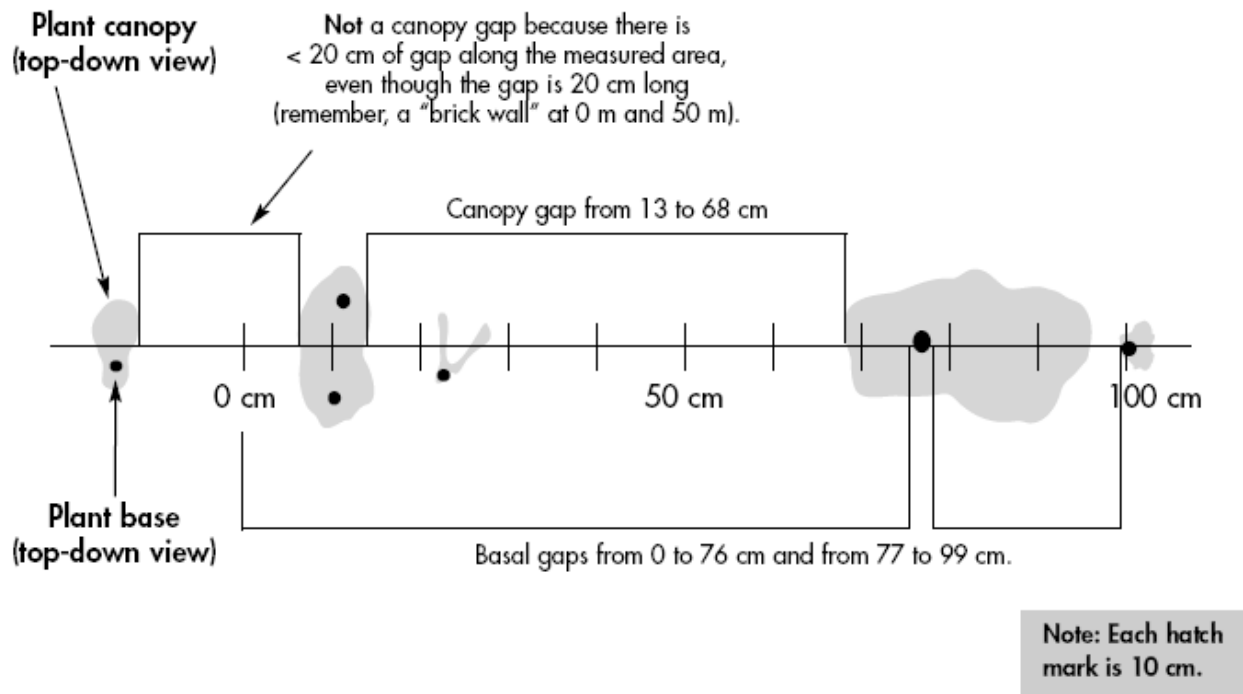


Figure 3. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 1 m (100 cm) of a 50-m transect. Canopy gaps: Shrub canopy starts at 6 cm since the space from 0 to 6 cm is not large enough to be considered a canopy gap. Look at the plant canopy intercept between the 20 and 30 cm marks on the transect. Because each canopy intercept covers less than 50 percent of a 3-cm segment of the line, it does not count as canopy. Notice also that the canopy cover at 100 cm shifts from shrub canopy to other vegetation canopy with <20 cm space in between. In this case, record the midpoint of the space intercepted by the canopies, beginning other vegetation canopy at 98 cm. From Herrick et al. 2005a.

Table 2. Gap intercept data sheet example associated with Figure 3.

Canopy Gaps				Basal Gaps			
Class (s, v, g)	Start (cm)	Class (s, v, g)	Start (cm)	Start (cm)	End (cm)	Start (cm)	End (cm)
s	6			0	76		
g	13			77	99		
s	68						
g	98						

References:

- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005a.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp. [available online at http://usda-ars.nmsu.edu/jer/monit_assess/monitoring.htm]
- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005b.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume II: Design, supplementary methods and interpretation. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 200 pp.

Appendix A.

Gap Intercept Data Sheet (p. 1)

Park: _____ Plot ID: _____ Transect#: _____ Date: _____ Page ____ of ____

Observer: _____ Recorder: _____

Shrub species on transect

Canopy Gaps

[illegible]

Canopy Gaps

[illegible]

Gap Intercept Data Sheet (p. 2)

Basal Gaps

[illegible]

Basal Gaps

[illegible]

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 11

Soil Aggregate Stability

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Enhanced instructions for integrating this SOP with SOP#21	To ensure that procedures are conducted in concert with other SOPs	1.1

This SOP provides instructions for using a field kit to estimate soil aggregate stability when exposed to rapid wetting, and for filling in the “Soil Stability Test Data Form” (Appendix A). This SOP is conducted in every plot visit. Material for this SOP was taken directly from the *Monitoring manual for grassland, shrubland and savanna ecosystems, Volumes I & 2* (Herrick et al. 2005a,b).

Procedures

Soil samples should be collected while conducting quadrat sampling (SOP#21). This minimizes the number of times a transect must be traversed, reducing trampling impacts. It takes about 10 minutes to process 18 samples.

1. Fill out the information at the top of the “Soil Stability Test Data Form” including:

- **Monitoring plot** – Since this is an form from Herrick et al. (2005a), combine the Park name and PlotId by first listing the 4-letter Park unit code, followed by the pre-assigned, unique PlotID.
- **Observer** – Record the initials of the person performing the soil stability test. If initials of two or more persons are the same, include a middle initial or some other distinguishing initial.
- **Recorder** – Record the initials of the person recording data.
- **Date** – mm/dd/yyyy.
- **Page #** – Record the page # and the total number of data pages for each transect.

2. Selection of 18 sampling points.

A total of 18 systematic samples are selected along the three transects. Locations will be generated by the Principle Investigator at the beginning of the season for each plot, and the list of locations provided to field crew members. Record sampling locations (points) under “Pos” on the data sheet. Always sample at least 5 cm from any vegetation measurement line. Include subsurface samples if you are interested in soil erodibility after disturbance. Use one box to collect only surface samples or two boxes to collect surface and subsurface samples.

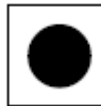
3. Determine the dominant cover class.

Determine the dominant cover class over the random point and enter this into the “Veg” column on the data sheet. The area to be classified is effectively as large as the sample area (6-8 mm in diameter). Record the dominant cover class in the “Veg” column:

NC = no perennial grass, shrub or tree canopy cover
G = perennial grass canopy and grass/shrub canopy mixture
F = perennial forb
Sh = shrub canopy
T = tree canopy

4. Collect a surface sample.

Excavate a small trench (10-15 mm deep) in front of the area to be sampled (Fig. 1). Lift out a soil fragment and trim it (if necessary) to the correct size. The soil fragment should be 2-3 mm thick and 6-8 mm in diameter (Figs. 2 and 3). This is the diameter of a wood pencil eraser. Try to fit sample in dot below (6-8 mm diameter).



Collect samples at the exact point. Move the sample point only if it has been disturbed during previous measurements or the soil surface is protected by a rock or embedded litter. Move the point a standard distance (1 m) and note this change on the data sheet. Minimize shattering by: a) slicing the soil around the sample before lifting; b) lifting out a larger sample than required, and trimming it to size in the palm of your hand; or c) misting the sample area before collection. If the soil sample is too weakly structured to sample (falls through the sieve), mist it lightly with deionized water (use an atomizer or equivalent) and then take a sample. Perfume and plastic hair spray bottles work well for this. If the sample still will not hold together, record a “1” on the data sheet. If the soil surface is covered by a lichen or cyanobacterial crust, include the crust in the sample. If the sample is covered by moss, collect the sample from under the moss. Gently place the sample in a dry sieve (Fig. 4); place sieve in the appropriate cell of a dry box.

5. Collect a subsurface sample (optional, see Step 1).

The Principle Investigator will determine if subsurface samples are to be collected on a plot. If samples are to be taken, extract samples directly below the surface sample. Use the flat, square (handle) end of the scoop to gently excavate the previous trench (in front of the surface sample) to a depth of 3-4 cm. Directly below the surface sample, remove soil so that a “shelf” is created with the top step 2-2.5 cm below the soil surface (Fig. 5). Use the scoop to lift out a subsurface sample from below (Fig. 6). The soil fragment should be 2-3 mm thick and 6-8 mm in diameter. If you encounter a rock, record “R” and move to the next sample. Place the sample in a dry sieve; place sieve in the dry box. Leave box lid open (Fig. 7).

6. Make sure the surface and subsurface samples are dry.

Samples must be dry before testing. If samples are not dry after collecting, allow to air dry with the lid off. Do not leave lid closed on samples for more than 1 minute on hot or sunny days. Excessive heat can artificially increase or decrease stability.



Figure 1. Excavate small trench.



Figure 2. Collect surface sample.



Figure 3. Ensure correct sample size.



Figure 4. Place sample in sieve.



Figure 5. Excavate trench for subsurface sample.



Figure 6. Collect subsurface sample.



Figure 7. Complete soil stability kit with water and samples.

7. Fill the empty (no sieves) box with deionized or distilled water (Fig. 7).

Fill each compartment to the top. The water should be approximately the same temperature as the soil.

8. Test the samples.

Lower the first sieve with the sample into the respective water-filled compartment— upper left corner of sample box to upper left corner of water box (Fig. 8). From the time the sieve screen touches the water surface to the time it rests on the bottom of the box, 1 second should elapse. Start the stopwatch when the first sample touches the water. Use Table 1 to assign samples to stability classes (also see Fig. 9). After five minutes, follow the sequence of immersions on the data sheet, adding one sample every 15 seconds. Beginners may want to immerse a sample every 30 seconds. This allows nine samples to be run in 10 minutes, so it takes 20 minutes to test one box of 18 samples. Observe the fragments from the time the sample hits the water to 5 min (300 sec) and record a stability class based on Table 1. Raise the sieve completely out of the water and then lower it to the bottom without touching the bottom of the tray. Repeat this immersion a total of five times. Do this even if you have already rated the sample a 1, 2 or 3 (you are allowed to change your rating if after sieving > 10% of soil remains on sieve). It should take 1 second for each sieve to clear the water's surface and 1 second to return to near the bottom of the box. Hydrophobic samples (float in water after pushed under) are rated 6. Record the coded stability class on the data sheet under 'Rating'.



Figure 8. Place first sample in water.

Table 1. Stability class ratings.

Stability class	Criteria for assignment to stability class
1	50% of structural integrity lost (melts) within 5 seconds of immersion in water, OR soil too unstable to sample (falls through sieve).
2	50% of structural integrity lost (melts) 5-30 seconds after immersion.
3	50% of structural integrity lost (melts) 30-300 seconds after immersion, OR < 10% of soil remains on the sieve after five dipping cycles.
4	10–25% of soil remains on the sieve after five dipping cycles.
5	25–75% of soil remains on the sieve after five dipping cycles.
6	75–100 % of soil remains on the sieve after five dipping cycles.

Sequence for stability class = 1.



Original sample



After 5 seconds



After 5 minutes



After 5 dips

Sequence for stability class = 4



Original sample



After 5 seconds



After 5 minutes



After 5 dips

Sequence for stability class = 5.



Original sample



After 5 seconds



After 5 minutes



After 5 dips

Sequence for stability class = 6.



Original sample



After 5 seconds



After 5 minutes



After 5 dips

Figure 9. The photos above illustrate the key steps of testing a soil sample for four different stability rankings. Some of the fragments shown in these samples may appear large. They are for illustration only. Be sure to follow the size guidelines (6-8 mm) in step 4.

References:

- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005a.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp. [available online at http://usda-ars.nmsu.edu/jer/monit_assess/monitoring.htm]
- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005b.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume II: Design, supplementary methods and interpretation. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 200 pp.

Appendix A. Soil Stability Test Data Form

Park: _____ Plot ID: _____ Observer: _____
Date: _____ Recorder: _____

Circle One: Surface sample – Subsurface sample

Pos. – location (m) of sample on transect

Veg cover= **NC** (no perennial canopy), **G** (grass or grass/shrub mix), **F** (forb), **Sh** (shrub), **T** (tree)

Rating values = 1-6. Circle values if samples are hydrophobic.

Transect 1				Transect 2				Transect 3			
Dip time	Pos.	Veg	Rating	Dip time	Pos.	Veg	Rating	Dip time	Pos.	Veg	Rating
5:00				5:15				5:30			
5:45				6:00				6:15			
6:30				6:45				7:00			
7:15				7:30				7:45			
8:00				8:15				8:30			
8:45				9:00				9:15			
Comments:											

Stability class

Criteria for assignment to stability class

- | | |
|----------|--|
| 1 | 50% of structural integrity lost (melts) within 5 seconds of immersion in water, OR soil too unstable to sample (falls through sieve). |
| 2 | 50% of structural integrity lost (melts) 5-30 seconds after immersion. |
| 3 | 50% of structural integrity lost (melts) 30-300 seconds after immersion, OR < 10% of soil remains on the sieve after five dipping cycles. |
| 4 | 10–25% of soil remains on the sieve after five dipping cycles. |
| 5 | 25–75% of soil remains on the sieve after five dipping cycles. |
| 6 | 75–100 % of soil remains on the sieve after five dipping cycles. |

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 12

Site Impact Assessment

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Added instructions for conducting impact assessment around a macroplot	Expanded site impact assessment from just upslope to all area around a macroplot	1.1

This SOP provides instructions for qualitatively detecting and describing on-site and off-site impacts on long term ecological monitoring plots, and for filling in the “Site Impact Assessment Data Sheet”. This assessment is conducted every site visit.

Procedures

Use the following guidelines to record disturbances on the Site Impact Assessment data sheet (Appendix A) that could potentially impact the site. For efficiency and to minimize trampling, this SOP can be accomplished while recording quadrat (SOP#21) measurements. See SOP#21 for guidance on how to integrate this SOP with quadrat and other plot-level measurements. If this SOP can not be accomplished during other plot measurements, Site Impact Assessment should be completed after all other measurements.

1) Fill out the information at the top of the data sheet including:

- **Park Unit** – Standard 4-letter code.
- **Plot ID** – Pre-assigned, unique number.
- **Recorder** – Record the initials of the person(s) recording data.
- **Date** – mm/dd/yyyy.
- **Page #** – Record the page # and the total number of pages for each macroplot.

2) On-site disturbances

The purpose of this section is to document the occurrence of on-site factors which may affect ecological processes within the macroplot. Examples include land uses or natural or anthropogenic landscape alterations which alter hillslope hydrological processes or wind- or water-driven erosional processes. Such alterations may affect runoff patterns or sediment deposition within the macroplot. Common types of disturbances are listed on the bottom of the data sheet. Include any other type of disturbance that appears significant at a site.

Look for disturbances in the area sampled by transects and in the 25-m zone bordering all sides of the transects. If the area around the macroplot is visible from a transect, then record the required information without additional walking around the plot. Otherwise, walk along all three transects and note any disturbances. Make sure you are walking on the downhill side of the transects and not trampling the areas sampled by quadrats and line-point intercept transects. Also walk around the perimeter of the macroplot to examine the 25 m bordering the transects on all sides. For each disturbance encountered, describe the size of the area affected in m^2 , the position of the disturbance relative to the transects, and the severity of the impact. Additionally, you may use the figure at the bottom of the data sheet to sketch the approximate size and location of the disturbance. Answer the questions on the data sheet to assess potential effects of the disturbance and provide additional information to help describe the disturbance. Each data sheet only has space to record one on-site and one off-site disturbance. Use additional data sheets as necessary.

At sites with physical and/or biological soil crusts, it is important not to impact soil stability any more than is absolutely necessary. Do not create additional tracks and paths to assess on-site disturbance.

3) Off-site disturbances - Upslope

The purpose of this section is to document the occurrence of off-site (i.e. outside the macroplot), upslope (gravitational) factors which may affect ecological processes within the macroplot. Concepts and examples are the same as for on-site influences.

If the area 500-m upslope from the plot is readily visible, then there is no need to walk upslope, instead questions regarding disturbance can be assessed by standing on the plot. Additionally, if physical and/or biological soil crust dominates the upslope area, find a vantage point near the macroplot, and do your best to estimate upslope disturbances up to 500 m away. Otherwise, start about 25 m upslope of the 25-m position on transect 1 (Fig. 1). Turn on the GPS unit and make sure it is marking the waypoint for the macroplot centroid. Begin walking upslope perpendicular to the transects looking for disturbances within 25-m of both sides of your path. Continue walking upslope until you reach a hilltop or are 500 m from the centroid, whichever happens first. Use the GPS to determine your distance from the macroplot. For each disturbance encountered, describe the type of disturbance, the size of the area affected in m^2 , the distance upslope from the macroplot, and the severity of the impact. Answer the questions on the data sheet to assess potential effects of the disturbance and provide additional information to help describe the disturbance. Use additional data sheets as necessary.

4) Off-site disturbances – Other than Upslope

Assessment of disturbances at orientations other than upslope is more general and is conducted without leaving the macroplot area. Looking down slope and across slope, record noticeable disturbances, the approximate direction and distance from the macroplot edge, and the approximate aerial extent of the disturbance.

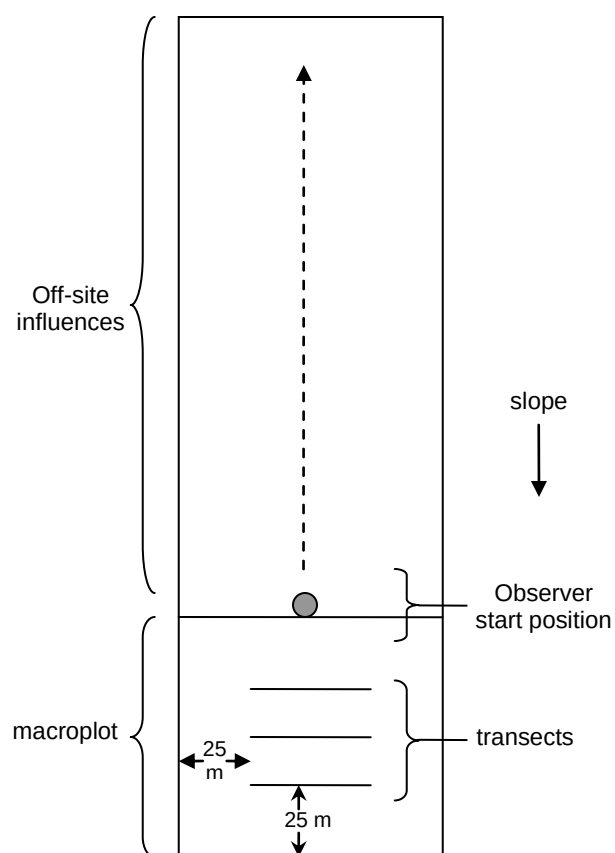


Figure 1. Diagram of area evaluated for on-site and off-site disturbances.

Appendix A

Data Sheets

Site Impact Assessment Data Sheet

Park: _____ Plot ID: _____ Recorder: _____ Date: _____ Page ___ of ___

On-site Disturbances

Disturbance type: _____

Size of area affected (m²): _____

Position of disturbance relative to transects: _____

How has this disturbance affected wind- or water-driven erosional processes on the macroplot? Describe in detail. _____

How could this disturbance alter fire behavior on the macroplot? Increased fuel loads? Fire breaks created? _____

Additional description: _____

Off-site Disturbances - Upslope

Disturbance type: _____

Size of area affected (m²): _____

Distance upslope from macroplot (m): _____

How has this disturbance affected wind- or water-driven erosional processes on the macroplot? Describe in detail. _____

How could this disturbance alter fire behavior on the macroplot? Increased fuel loads? Fire breaks created? _____

Additional description: _____

Off-site Disturbances – Other Than Upslope

Disturbance type: _____

Size of area affected (m²): _____

Distance from macroplot (m): _____ Direction from macroplot (azimuth-degrees) _____

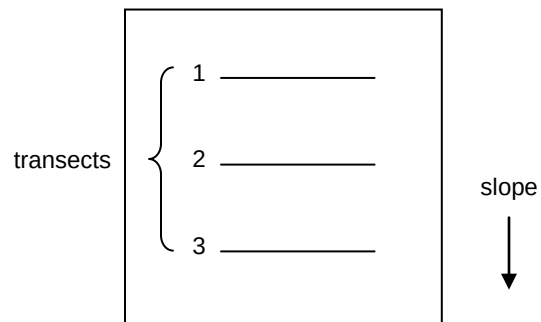
How has this disturbance affected wind- or water-driven erosional processes on the macroplot? Describe in detail. _____

How could this disturbance alter fire behavior on the macroplot? Increased fuel loads? Fire breaks created? _____

Additional description: _____

Example disturbance types:

dirt road	fire
paved road	water
OHV activity	wind
foot/bikepath	small rodents
campsite	
livestock trailing	
livestock grazing	
livestock watering point	
other large mammal activity	



Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 17

After the field season

Version 1.0 (August 2006)

Revision History Log:

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

This SOP provides information to close out the field season, assuring that equipment maintenance, data management, and reporting procedures are followed.

Procedures

- I. Equipment maintenance. Make certain that all equipment is in good working order, or repair or replace if necessary.
- II. Supplies inventory. To ensure that adequate supplies are on hand for the next field season, order supplies if needed.
- III. Complete ID of unknowns. The field-crew leader is responsible to ensure complete resolution of all unknown plants. Plants are identified to species, family, or at least life form.
- IV. Data management. The field crew leader is responsible to ensure that all data sheets are completed properly, and that all 35-mm film is sent-out for processing.
- V. New Species. The crew leader is responsible to ensure that plant species not on current park list to are submitted for update to NPSpecies. This requires a voucher specimen which the crew leader is responsible to acquire.
- VI. Protocol review procedures. Prior to the departure of the field crew, the Principle Investigator will implement the annual Protocol Review procedures, which queries the field crew for problems, issues, and recommendations regarding the extant upland protocol.

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 18

Data Management

Version 1.0 (March 2007)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) describes data management procedures for all data derived from upland monitoring in Northern Colorado Plateau Network (NCPN) park units. The procedures for data management given in this SOP follow guidelines and standards that are described in the NCPN Data Management Plan (Beer et al 2005).

1 Definitions and Acronyms

<i>NPS</i>	National Park Service
<i>NCPN</i>	Northern Colorado Plateau Network
<i>I&M</i>	Inventory & Monitoring Program of the National Park Service
<i>SOP</i>	Standard Operating Procedure
<i>GIS</i>	Geographic Information Systems
<i>GPS</i>	Global Positioning System
<i>PDF</i>	Portable Document Format
<i>TIFF</i>	Tagged Image File Format
<i>JPG</i>	Joint Photographic Experts Group File Format
<i>DLL</i>	Dynamic Link Library
<i>FGDC</i>	Federal Geographic Data Committee. The interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.
<i>Tabular dataset</i>	A dataset organized in a table or group of tables where each column and row has a specific interpretation; often produced by Microsoft (MS) Excel, MS Access, database, or statistical software, and managed as text, spreadsheet, or relational databases.
<i>Spatial dataset</i>	A dataset that is natively read by mapping software; often produced by mapping software, such as ESRI ArcMap and ArcInfo; also includes georeferenced imagery, geodatabases, as well as hardcopy aerial photographs, satellite imagery and maps.

<i>Primary dataset</i>	The dataset that is the most comprehensive and representative of the data associated with a project. This dataset can normally be used independently of other project datasets and is often distributed to external users. The primary dataset can be tabular or spatial. For most NCPN monitoring projects, the primary dataset will be either an MS Access database or a geodatabase.
<i>Raw data</i>	Data that have not been subjected to either quality control or documentation procedures; includes data recorded by hand on hard-copy forms, digital files from handheld devices, GPS receivers, telemetry data loggers, etc.
<i>Certified data</i>	Finalized project data, i.e., data that have undergone thorough quality assurance and screening as well as complete documentation.
<i>Working database</i>	A project-specific database for entering and processing data for the current season (or other logical period of time). This might be the only database for short-term projects where there is no need to distinguish working data for the current season from the full set of validated project data.
<i>Master database</i>	Project-specific database for storing the full project data set, used for viewing, summarizing, and analysis. Only used to store certified data.
<i>Data products</i>	Information that is derived from certified project data.
<i>Project level metadata</i>	A metadata record associated with the primary project dataset that contains cross references to all project data products and is uploaded to the NPS Data Store.
<i>Quality assurance (QA) procedures</i>	Procedures used to maintain a defined level of quality throughout all stages of data development.
<i>Quality control (QC) procedures</i>	Procedures used to monitor or evaluate the quality of data products.

2 Database Design

The primary dataset associated with the NCPN upland monitoring project is a tabular dataset stored in a Microsoft (MS) Access database, referred to subsequently as the upland database. The upland database is written in Access 2002, and has a frontend/backend file structure:

- *Upland.mdb*: This frontend file contains all queries, forms, reports, and associated Visual Basic (VB) application code.
- *Upland_be.mdb*: This backend file contains the database tables.

The frontend/backend file structure allows multiple users to enter data in a network environment, and allows for easy backup and transfer of the data tables. Users typically launch the frontend file, and a utility will prompt them to establish a link to the backend file. Detailed instructions for launching the frontend file, linking to the backend file, as well as other data entry operations are provided in the user's guide in Appendix B. The

user's guide is also available as a standalone document in the same folder location as the working copy of the upland database:

X:\Active_Monitoring_Projects\Upland\Data\Current

The upland database was developed following the NPS Natural Resource Database Template (NRDT), which is based on a location record, one or more related event records, and observation data elements linked to each event. Figure 1 shows the relationships between the primary upland database tables (all tables are not shown).

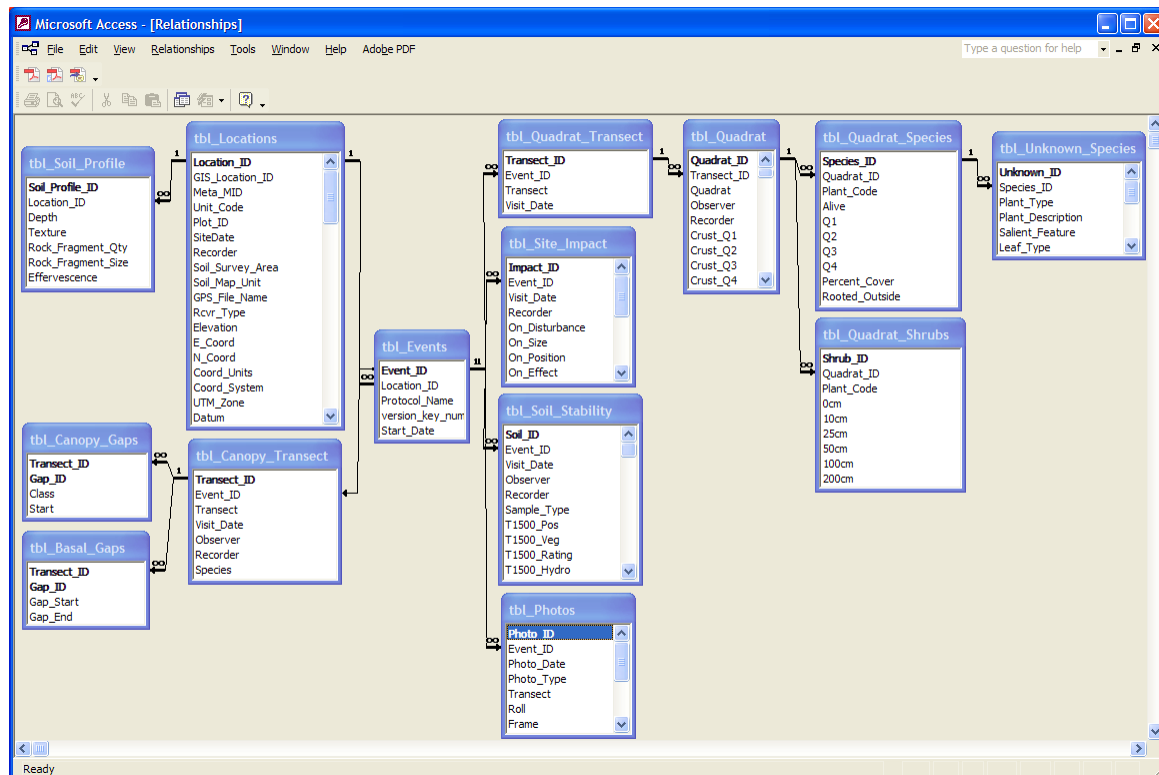


Figure 1 Data Model for Upland Database

Each upland monitoring site or plot has a record in *tbl_Locations*, which stores basic location information as well as soil and vegetation characteristics that are recorded during site characterization and plot establishment. Each plot can have many site visits, which are recorded in *tbl_Events*. During each site visit, several different types of observations are recorded, including:

- Measurements of nested frequency and cover of live vegetation, soil-surface features, and shrub density, are obtained and recorded in *tbl_Quadrat_Transsect*, *tbl_Quadrat*, *tbl_Quadrat_Species*, *tbl_Quadrat_Shrebs*, and *tbl_Unknown_Species*. These measurements are made for each of the 5 quadrats within each of the 3 transects associated with each plot.
- For each of the 3 transects associated with a plot:

- gap intercept estimates between plant canopies are obtained and recorded in *tbl_Canopy_Transect* and *tbl_Canopy_Gaps*, and
- gap intercept estimates between plant bases are obtained and recorded in *tbl_Canopy_Transect* and *tbl_Basal_Gaps*.
- Estimates of soil aggregate stability are obtained and recorded in *tbl_Soil_Stability*.
- Several photos are taken during each site visit and are recorded in *tbl_Photos*.
- On-site and off-site impacts are assessed and recorded in *tbl_Site_Impact*.

Each site visit is linked to tables *tbl_master_version* and *tbl_SOP_version* (not shown in the figure), which together define the narrative and suite of SOP versions in effect at the time of the site visit. Documentation of all tables and fields in the upland database is provided in Appendix A.

3 Populating the Upland Database

Prior to each field season, the working database for the upland monitoring protocol is prepared for the upcoming field season's data entry. The working database is initially an empty database, i.e., it contains no observation data, just populated lookup tables and certain "static" plot information (e.g., location, site characterization information). The working database is used for data entry, verification, and validation for a given field season. After the dataset in the working database is certified, it is merged into the master upland database. For the remainder of this document, the term "upland database" refers to the working database.

The upland database will be populated via a combination of data import and data entry.

3.1 Data Import

All upland monitoring plot records should be initially established in the database by importing plot location data collected via GPS units. This allows the location data in the database to be populated with corrected GPS data and eliminates the need to manually enter several location-related fields. Table 1 lists the fields either imported or derived from GPS data (see Appendix A for field descriptions). Thus, importing is the preferred method for establishing plot records in the database because it reduces the data entry effort, which in turn, improves the accuracy of the data.

Table 1 Fields Imported/Derived from GPS Data into *tbl_Locations*

T1_Elevation	T2_Elevation	T3_Elevation	Unit_Code
T1O_UTME	T2O_UTME	T3O_UTME	Plot_ID
T1O_UTMN	T2O_UTMN	T3O_UTMN	GPS_File_Name
T1E_UTME	T2E_UTME	T3E_UTME	Rcvr_Type
T1E_UTMN	T2E_UTMN	T3E_UTMN	Elevation
E_Coord	Plot_E_Coord	Max_PDOP	Coord_Units
N_Coord	Plot_N_Coord	Max_HDOP	Coord_System
UTM_Zone	Datum		

Plot location data is expected to be relatively static over time. However, if the location information for a given plot changes for some reason (e.g., a rebar gets lost and it's not possible to establish the new rebar at the same location), it will need to be re-imported

from the GPS files. When imported, plot location data will be imported from corrected GPS files into *tbl_Locations*.

To ensure that the plot location data import process operates smoothly, the following procedures will be followed:

- Upon returning from the field, the field crew lead or project lead gives the GPS units to the GIS specialist.
- The GIS specialist, project lead, and data manager all agree upon the date by which the GPS data must be imported into the database.
- Once the plot location data have been imported into the database, the data manager will notify the project lead.
- If the GIS specialist and/or data management staff is unable to meet the deadline for importing the data, the project lead is notified. The project lead may choose to have the plot location data entered manually rather than wait for it to be imported. However, there is a greater risk of data errors with this approach. While the location data will be checked against corrected GPS data as part of Quality Assurance (QA)/Quality Control (QC) procedures (refer to Section 4), there is some risk involved in relying on QA/QC procedures to correct errors in the data. Thus, importing is the preferred method for populating the location data.

3.2 Data Entry

The majority of data in the upland database will be populated via data entry. Data entry should occur as soon as possible after data collection is completed, before the next observation occurs, and by the person who collected the data or someone who is familiar with the project and data. If new plot establishment data were collected, these data should be imported into the database before starting data entry for the reasons given in Section 3.1. The primary goal of data entry is *to transcribe the data from paper records into the computer with 100% accuracy*.

The upland database user's guide (refer to Appendix B) provides data entry instructions as well as other helpful information. The project lead makes certain that persons performing data entry understand how to enter data and follow the protocols, and are familiar with the user's guide. Data entry technicians are responsible for becoming familiar with the field data forms, the database software, database structure, and any standard codes for data entry. The data manager, in conjunction with the project lead, will ensure that the user's guide is kept current as new features are implemented in the database and/or as data entry procedures change.

Before beginning a data entry session, the user should create a backup of the backend data file. This backup will ensure that the initial data starting point can be recovered should irreversible errors or problems occur during the data entry session. Refer to Section 4 of the user's guide in Appendix B for backup procedures.

QA/QC measures for data entry will be built into the database forms to automatically validate data where possible. Data entry forms will maximize the use of auto-filled fields, range limits, pick lists, and spelling checks. Error messages will alert the operator

to correct mistakes. Any errors or omissions that become apparent during data entry should be resolved as soon as possible. In such cases, the data entry technician should contact the person who collected the data for clarification. The appropriate modifications should then be made to the field sheets according to the instructions provided in Section 4.

Since the upland database is currently not designed to support distributed data entry, these data entry procedures assume that all data entry occurs using a single backend database file. To support distributed data entry with the current version of the upland database, special procedures will need to be established. An upgrade of the database that will support distributed data entry is planned for FY 2008.

4 Data Verification and Validation

To ensure that upland monitoring data are of the highest possible quality, verification and validation of upland monitoring data will be performed according to the procedures described in the NCPN Quality Assurance and Quality Control Guidance Document (NCPN-NPS 2008c, in development). *Data verification* checks that data entered into a secondary (i.e., electronic) format match the source data, while *data validation* checks that the data make sense.

4.1 Data Verification

Data verification immediately follows data entry and involves checking the accuracy and completeness of the computerized records against the hard copy field records and identifying and correcting any errors. The following verification methods will be used to verify upland data:

1. **Visual review at data entry.** The person doing data entry verifies each and every record after input and immediately corrects any errors.
2. **Visual review after data entry.** All records (or a pre-determined subset of records) entered during a data entry session¹ are compared to the original data source. Each data field on the corresponding electronic data entry form is compared with the original values from the hard copy, preferably by a second person who did not perform the data entry. Any errors that are discovered are corrected in the database as soon after data entry as possible. To achieve the highest possible level of data quality, all records entered during a data entry session would be reviewed by the project lead. However, this ideal case may not always be feasible due to limited resources, especially given the amount of data entry required for upland. Thus, one of two broad variations of this verification method will be followed, depending on the circumstances:
 - a. Best practice: All records entered during a data entry session will be reviewed, preferably by a second person who did not perform the data entry (ideally the project lead). This procedure must be followed when

¹ Since it may not always be possible to perform verification after each data entry session, other grouping schemes may be used to group records for verification.

new staff enters data, and should continue until the project lead is confident of the person's data entry skills. It may take several data entry sessions for new staff to become proficient with all the upland data entry forms.

- b. Good practice: At a minimum, 10% of the records entered during a data entry session will be reviewed (preferably by a second person who did not perform the data entry). If any errors are found in this review, 100% of the records from that data entry session will be reviewed.
3. **Summary queries and tallies.** Queries are run that detect broad errors such as duplicate or omitted records. Examples of such queries for upland data are given below. A more complete set of queries is provided in Appendix C (QA/QC Procedures).
 - a. Listing and count of the monitoring plots established by park by year.
 - b. Listing and count of the monitoring plots visited by park by year.
 - c. For each year/park/plot combination, a listing and count of the transect/quadrat combinations having observations recorded.
 - d. For each year/park/plot combination, a count of the number of photo points recorded.
4. **Visual review of spatial data.** Using GIS, upland monitoring plot data are visually inspected for accuracy. This review will take place at the end of the field season.

Detailed verification procedures are provided in Appendix C (QA/QC Procedures).

4.2 Data Validation

While many errors are prevented by including validation routines that function during data entry, additional review of the data by the project lead is needed to detect generic and specific errors that fall outside the scope of automated validation.

Invalid data commonly consist of slightly misspelled names, the wrong date, or out-of-range errors in parameters with well-defined limits (e.g., elevation). Other errors consist of unreasonable metrics or associations. For example, suppose a species was dominant on a plot during the current year's visit, but there was no observation recorded during the previous year's visit. Such data seem questionable and might indicate a species identification error. These types of logic errors (or potential errors) can be challenging to resolve, and in some cases it may not be possible to resolve them during the current year. Such questionable data will be flagged for future resolution.

Validation queries will be of two types: one type will present tabular data in ways that records can be reviewed for content and context; the other type will perform specific calculations or routines to detect logic or range errors. Corrections to errors detected during validation require notations in the *original paper field records* about how and why the data were changed. Modifications to the field records should be clear and concise while preserving the original data entries or notes. Validation efforts should also include

a check for the completeness of a data set since field sheets or other sources of data could easily be overlooked.

Detailed validation procedures are provided in Appendix C (QA/QC Procedures).

4.3 Data Quality Review and Communication

The project lead and any personnel involved in data collection or entry will meet several times during the field season to discuss data quality problems and issues. Procedures may need revision if verification and validation processes reveal an unacceptable level of data quality. Quality checks may also reveal the need to modify field or computer forms if data transcription or entry errors are frequent.

Once validation has been completed, metadata will be created for the upland dataset (refer to Section 7 for details on metadata). An important part of this metadata is data quality documentation, which consists of the verification and validation results (see Appendix C for QA/QC documentation procedures). This data quality documentation, along with the project data certification form, will be used to notify end users and other project personnel of project data quality. For example, any questionable data that have been flagged will be identified. The project data certification form will be completed by the project lead to indicate that the data are complete, they have passed quality assurance checks, and they are documented and ready for archiving, posting and distribution. The data certification form can be found in the NCPN Project Data Life Cycle Guidance Document (NCPN-NPS 2007e). The data quality documentation and data certification form will be stored in the upland project archive folder.

5 Version Control

Version control is the process of managing copies of changing files over the course of a project. Change includes any alteration to the structure or content of the files, which should not be made without the ability to fully recover a dataset as it existed before changes were made. NCPN uses several techniques to help ensure proper version control: data archiving (refer to Section 6 for data archiving details), directory structure conventions, backup procedures (refer to Section 4 of the user's guide in Appendix B), and database versioning.

5.1 Directory Structure Conventions

NCPN has adopted directory structure conventions for I&M project folders (NCPN-NPS 2007b). Based on these conventions, each project has an active folder for storing all current or working project files and an archive folder for storing archived project files. In general, the active project folder stores only the most recent project files (e.g., data and reports from current year, current protocol version). All active project folders are stored on the NCPN shared drive (X:). The active upland project folder is in the following location:

X:\Active_Monitoring_Projects\Upland

The structure of the active project folder is as follows (all folders are not shown):

- **Admin:** Contains all administrative documents, including agreements, invoices, correspondence, permits, proposals, scopes of work, and meeting-related documents (e.g., agendas, presentations).
- **Analysis_Tools:** Contains analytical tools (e.g., custom programs, R code, SAS code) associated with analyzing and reporting the data.
- **Data:**
 - **Current:** Contains the working database (current year data) and user's guide.
 - **Master:** Contains the master database (complete data record) frontend file, which links to the master backend file stored in the upland archive folder (described in Section 6.1).
 - **GPS_Downloads:** Contains corrected data downloaded from GPS units.
 - **Requirements_Docs:** Contains documents related to database requirements.
 - **Site_Selection:** Contains files related to site selection.
 - **Working_Backup:** Contains one or more backup copies of database files made during data entry (not retained permanently).
- **Project_Life_Cycle:** Contains files related to project data life cycle tracking for current year, e.g., data certification form, data quality documentation (refer to Section 7 for more details on the project data life cycle).
- **Protocol:**
 - **PDF:** Contains PDF of current version of protocol.
 - **Native_Format:** Contains source files for current version of protocol.
- **Protocol_Review:** Contains current documents associated with operational protocol reviews.
- **Reports:**
 - **PDF:** Contains PDF version of current annual project report and any other reports produced during current year.
 - **Native_Format:** Contains source files used to create current year report(s).

For additional details on NCPN directory structure conventions, refer to the [NCPN Directory Structure Guidance Document](#) (NCPN-NPS 2007b).

5.2 Database Versioning

Database versioning refers to the process of tracking modifications to the database structure or application code, which can occur independently of modifications to the data. NCPN uses a version numbering scheme to track database modifications, in which modifications are grouped into software releases. Major releases are those involving significant changes to the database and are designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). For releases with only minor database changes (e.g., bug fixes), version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, etc). Database version information is maintained within the database, and can be viewed by choosing the **About** tab on the upland main menu page, and then choosing **View release history**. Whenever a database version change occurs, copies of the database files are placed in the appropriate archive location (refer to Section 6).

6 Data Archiving

Archiving is a critical step in ensuring the long-term preservation of data. Upland data will be archived on an annual basis, after the current year data have been certified and annual report completed. Archiving of certain data may occur more frequently, e.g., if a protocol version change occurs. Archiving will be done for both digital and hard copy data.

6.1 Digital Data Archiving

All digital upland data will be archived on the NCPN read-only shared drive (R:) in the upland archive folder (R:\Archive\Monitoring_Archive\Upland\). Table 2 lists the upland monitoring digital data files that require archiving, along with their respective archive folder locations. Detailed procedures for digital data archiving, including roles and responsibilities, are provided in the NCPN Digital Data Archiving Guidance Document (NCPN-NPS 2007a).

Table 2 Upland Digital Data Archiving Summary

Data Product(s)/ File(s)	Archive Location²	Comments
Database	Data\<year ³ >\Database\	Contains certified database files for a given year, master database files, and metadata
GPS Data	Data\<year>\GIS_Data\GPS_Data\	Contains both uncorrected and corrected GPS data files for a given year
Protocol	Protocol\<version ⁴ >\	Contains archived protocol files (PDF and source files) for a given version
Protocol Review	Protocol_Review\<version>\	
Reports	Reports\<year>\	Contains archived report files (PDF and source files) for a given year
Field Forms	Data\<year>\Raw_Data\	Contains digital field forms (PDF) for a given year
Photos	R:\Archive\NCPN_Photos_Archive\NCPN_Photos\Monitoring	- Archive location is an absolute path - Renamed photo files archived as part of NCPN photo database processing - refer to <u>NCPN Photo Management Guidelines</u> (Appendix E, Beer et al 2005) for details
Original Photos	R:\Archive\NCPN_Photos_Archive\Raw_Photo_Data_Archive\Upland\<year>\	- Archive location is an absolute path - Contains original, unedited (e.g., not rotated) photo files - Archived as part of photo database processing
Analysis Tools	Analysis_Tools\< year>\	Contains archived versions of analysis tools for a given year
Project Data Life Cycle Files	Project_Life_Cycle\<year>\	Contains archived files related to project data life cycle tracking for a given year

² Archive location is relative to R:\Archive\Monitoring_Archive\Upland\ unless stated otherwise.

³ <year> indicates year in yyyy format.

⁴ <version> indicates protocol version number, e.g., Version_1-00

6.2 Hard Copy Data Archiving

All hard copy upland data will be archived in NPS-approved storage facilities (e.g., park museums, the Western Archeological and Conservation Center). Table 3 lists the upland monitoring hard copy data files that require archiving, along with a summary of archiving procedures. Detailed procedures for hard copy data archiving, including roles and responsibilities, are provided in the NCPN Hard Copy Data Archiving Guidance Document (NCPN-NPS 2007c). Digital copies of applicable items in Table 3 are also provided to parks for their working files (see the NCPN Hard Copy Data Archiving Guidance Document for details).

Table 3 Upland Hard Copy Data Archiving Summary

Data Product(s)/File(s)	Comments
Field Forms	• Original field forms provided to parks in which data collected • Archival copy of field forms stored in NCPN archives
Reports	• Archival copies of reports stored in NCPN archives and provided to parks included in upland monitoring project
Protocol	• Archival copies of protocol stored in NCPN archives and provided to parks included in upland monitoring project
Protocol Review	• Archival copies of protocol reviews stored in NCPN archives
Photos	• Slides or selected prints stored in NCPN archives and provided to parks in which data collected (a subset of prints will be selected for archiving due to limited museum storage space)
Data/Metadata Printouts	• Archival copy of project-level metadata stored in NCPN archives and provided to parks included in upland monitoring project • Above applies to any other data/metadata printouts deemed critical to long-term upland monitoring
Project Data Life Cycle Files	• Archival copies of project data life cycle files stored in NCPN archives

7 Metadata

Metadata, which is defined as structured information about the content, quality, condition, and other characteristics of data, is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. Metadata can take many different forms, including formal FGDC-compliant metadata, NatureBib records, and protocol version information.

To comply with NPS metadata requirements, metadata for upland datasets will be created following NCPN metadata procedures (NCPN-NPS 2007d):

- An NPS Data Store metadata record and a Dataset Catalog record will be created for the upland database (since it is considered the *primary dataset* for the upland monitoring project). The Data Store metadata record, also referred to as the project level metadata, will be updated annually.

- All other upland datasets and data products (see **Dataset/Data Product** column in Table 4) will be documented as cross-reference citations in the project level metadata record.

Another type of metadata specific to NCPN is the Project Data Life Cycle (PDLC) checklist, which helps to ensure that all data management activities (e.g., data verification/validation, metadata, archiving) are completed each year for monitoring projects. In accordance with this requirement, a PDLC checklist will be completed each year for upland monitoring data. For further details related to the PDLC checklist, refer to the NCPN Project Data Life Cycle Guidance Document (NCPN-NPS 2007e).

Table 4 summarizes the metadata tasks required for upland monitoring datasets and data products, and Table 5 describes the tasks and provides references where more detailed procedures are described.

Table 4 Summary of Metadata Tasks for Upland Monitoring Data

Dataset/ Data Product	Data Store	Dataset Catalog	X-Ref Citation	PDLC Check- list	Nature Bib	MVT	Photo DB	DB Doc
Database	X	X		X				X
GIS Data			X	X				
Report(s)			X	X	X			
Protocol			X	X	X	X		
Photos			X	X			X	
Field Forms			X	X				

Table 5 Metadata Task Descriptions

Metadata Task	Metadata Task Description	Reference(s)
Data Store	An NPS Data Store record is created and then updated annually.	Metadata Guidance Document (NCPN-NPS 2007d)
Dataset Catalog	A Dataset Catalog record is created.	Dataset Catalog Guidelines (Appendix C, Beer et al 2005)
X-Ref Citation	A cross reference citation is added to the project level metadata record.	Metadata Guidance Document (NCPN-NPS 2007d)
PDLC Checklist	The PDLC checklist is completed, which includes adding product records to the NCPN Project Tracking Database.	Project Data Life Cycle Guidance Document (NCPN-NPS 2007e), Project Tracking Guidance Document (NCPN-NPS 2008a, in development)
NatureBib	A record is added to NatureBib.	NatureBib Guidelines (Appendix B, Beer et al 2005)
MVT	The Master Version Table is updated as needed.	Protocol Versioning Guidance Document (NCPN-NPS 2008b, in development)
Photo DB	Photo records are added to the NCPN Photo Database.	Photo Management Guidelines (Appendix E, Beer et al 2005)
DB Doc	Database table and field documentation is updated as needed.	Appendix A

A metadata questionnaire has been developed to assist in gathering the information needed for metadata creation (see the NCPN Metadata Guidance Document (NCPN-NPS 2007d)).

The complete protocol for this project (Protocol Narrative and SOP #s 1-21) is an integral component of the project metadata. All narrative and SOP version changes are noted in a Master Version Table (MVT), which is maintained in SOP #20. Any time the narrative or an SOP version change occurs, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The Version Key number is essential for project information to be properly interpreted and analyzed. *The protocol narrative, SOPs, and data should not be distributed independently of this table.*

8 References

- Beer, M., E. Nance, A. Wight, M. Powell, and R. DenBleyker. 2005. Northern Colorado Plateau Network, data management plan. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT. 86 pp plus appendices.
- NCPN-NPS 2007a. Digital Data Archiving Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2007b. Directory Structure Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2007c. Hard Copy Data Archiving Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2007d. Metadata Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2007e. Project Data Life Cycle Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008a. Project Tracking Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008b. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008c. Quality Assurance and Quality Control Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

Appendix A Documentation of Database Tables

Table Name: tbl_Basal_Gaps

Description: Table of basal gaps by transect

Field Name	Field Description	Field Type	Field Width
Transect_ID	Foreign key to tbl_Canopy_Transect	dbText	50
Gap_ID	Gap ID - Unique record identifier within a transect	dbInteger	2
Gap_Start	Gap start	dbInteger	2
Gap_End	Gap end	dbInteger	2

Table Name: tbl_Canopy_Gaps

Description: Table of canopy gaps by transect

Field Name	Field Description	Field Type	Field Width
Transect_ID	Foreign key to tbl_Canopy_Transect	dbText	50
Gap_ID	Gap ID - Unique record identifier within a transect	dbInteger	2
Class	Segment class: g=gap, s=shrub, v=other vegetation	dbText	1
Start	Start position of segment in centimeters	dbInteger	2

Table Name: tbl_Canopy_Transect

Description: Table of transect information for gap intercepts

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	M. Link to tbl_Events	dbText	50
Transect	Transect number - 1, 2, or 3	dbByte	1
Visit_Date	Date of visit.	dbDate	8
Observer	Name of person observing canopy gaps	dbText	50
Recorder	Name of person recording observations	dbText	50
Species	Shrub species on transect	dbMemo	0

Table Name: tbl_Db_Meta

Description: M. Database description and links to I&M metadata tools.

Field Name	Field Description	Field Type	Field Width
Db_Meta_ID	M. Local primary key (Db_Meta_ID)	dbText	50
Db_Desc	M. Description of the database purpose (Db_Desc)	dbMemo	0
Meta_MID	M. Link to NR-GIS Metadata Database (Meta_MID)	dbText	50
DSC_GUID	M. Link to I&M Dataset Catalog desktop metadata tool (DSC_GUID)	dbText	50

Table Name: tbl_Db_Revisions

Description: M. Database revision history data.

Field Name	Field Description	Field Type	Field Width
Revision_ID	M. Database revision (version) number or code (Rev_ID)	dbText	50
Revision_Contact_ID	MA. Link to tlu_Contacts (Rev_Cnt_ID)	dbText	50
Db_Meta_ID	M. Link to tbl_DB_Meta (Db_Meta_ID)	dbText	50
Revision_Date	M. Database revision date (Rev_Date)	dbDate	8
Revision_Reason	M. Reason for the database revision (Rev_Reason)	dbMemo	0
Revision_Desc	M. Revision description (Rev_Desc)	dbMemo	0

Table Name: tbl_Events

Description: M. Sampling events.

Field Name	Field Description	Field Type	Field Width
Event_ID	M. Event identifier (Event_ID)	dbText	50
Location_ID	M. Link to tbl_Locations (Loc_ID)	dbText	50

Field Name	Field Description	Field Type	Field Width
Protocol_Name	M. The name or code of the protocol governing the event (Protcl_Nam)	dbText	100
version_key_number	Master protocol version key	dbLong	4
Start_Date	M. Starting date for the event (Start_Date)	dbDate	8

Table Name: tbl_Locations

Description: Site and plot definition table

Field Name	Field Description	Field Type	Field Width
Location_ID	M. Location identifier (Loc_ID)	dbText	50
GIS_Location_ID	MA. Link to GIS feature, equivalent to NPS_Location_ID (GIS_Loc_ID)	dbText	50
Meta_MID	MA. Link to NR-GIS Metadata Database (Meta_MID)	dbText	50
Unit_Code	Park Code.	dbText	4
Plot_ID	Plot identifier	dbInteger	2
SiteDate	Date site characterized	dbDate	8
Recorder	Person recording data	dbText	50
Soil_Survey_Area	Soil survey corresponding to park unit and plot	dbMemo	0
Soil_Map_Unit	Soil map unit in which the centroid lies	dbText	10
GPS_File_Name	GPS file name for centroid coordinates	dbText	50
Rcvr_Type	GPS unit type	dbText	50
Elevation	Elevation of site origin in meters	dbInteger	2
E_Coord	UTM East of Centroid (X_Coord)	dbDouble	8
N_Coord	UTM North of Centroid (Y_Coord)	dbDouble	8
Coord_Units	M. Coordinate distance units (Coord_Unit)	dbText	50
Coord_System	M. Coordinate system (Coord_Syst)	dbText	50
UTM_Zone	MA. UTM Zone (UTM_Zone)	dbInteger	2
Datum	M. Datum of mapping ellipsoid (Datum)	dbText	5
Max_PDOP	Horizontal accuracy	dbDouble	8
Max_HDOP	Positional accuracy	dbDouble	8
Updated_Date	MA. Date of entry or last change (Upd_Date)	dbText	50
Geologic_Setting	Geologic setting on site.	dbText	100
Landform	Landform on site.	dbText	100
Hillslope_Position	Hillslope position that describes location - summit, shoulder, backslope, footslope, toeslope, or low level	dbText	10
Slope_Complexity	Relative uniformity of ground surface leading down slope - complex or simple	dbText	7
Slope_Shape_Down	Slope shape down slope - linear, concave, convex	dbText	7
Slope_Shape_Across	Slope shape across slope - linear, concave, convex	dbText	7
Percent_Slope	Percent slope at centroid - tenths	dbSingle	4
Soil_Texture	Particle size distribution of fine earth fraction and clay particles	dbText	50
Sand_Modifier	Predominant size class of sand if sand is a major part of the soil texture - very fine, fine, medium, coarse, very coarse, n/a	dbText	50
Rock_Fragment_Qty	Rock fragment quantity modifier - n/a, none, very, extremely, >90%	dbText	50
Rock_Fragment_Size	Rock fragment size modifier - none, gravelly, cobbly, stony, bouldery, channery, flaggy, gravel, cobble, stone, boulder	dbText	50
Effervescence	Quanty and surface area of carbonate compounds in the soil - none, very slight, slight, strong, violent	dbText	50
Depth	Depth to bedrock - very shallow, shallow, moderately deep,	dbText	50

Field Name	Field Description	Field Type	Field Width
	deep, very deep, unknown		
Dominant_Vegetation	Dominant vegetation at site. This field is used to help field crew determine correct ecosite. It is not quality checked.	dbMemo	0
Soil_Assessment	Is it a soil assessment target match	dbBoolean	1
Probable_Component	Probable soil component	dbText	50
Soil_Comments	Additional soil comments	dbMemo	0
Veg_Assessment	Is it a vegetation assessment target match	dbBoolean	1
Veg_Comments	Vegetation assessment comments	dbMemo	0
Primary_Eco_Site	Primary ecological site name	dbText	50
Primary_Percent	Percentage of macroplot comprised of primary site type - 1 decimal	dbSingle	4
Other_Eco_Site	Other ecological site name	dbText	50
Other_Percent	Percentage of macroplot comprised of other site type - 1 decimal	dbSingle	4
Transect_Length	Estimated total length of transect in meters that falls outside the target ecological site	dbInteger	2
Site_Selection	Site accepted or rejected	dbBoolean	1
Site_Selection_Comments	Additional site selection comments	dbMemo	0
Soil_Profile_Samples	Number of soil profile samples collected	dbInteger	2
2cm_Samples	Number of 0-2 cm composite samples collected	dbInteger	2
10cm_Samples	Number of 2-10 cm composite samples collected	dbInteger	2
Plot_Date	Date plot established if different from site characterization date	dbDate	8
Plot_E_Coord	UTM East of Centroid if plot established on different visit from site characterization	dbDouble	8
Plot_N_Coord	UTM North of Centroid (Y_Coord) if plot established on different visit from site characterization	dbDouble	8
Observer	Person establishing plot	dbText	50
Plot_Slope	Plot slope in percent - 1 decimal	dbSingle	4
Plot_Aspect	Plot aspect in degrees - 1 decimal	dbSingle	4
Azimuth	Direction from origin to end of center transect in degrees - 1 decimal	dbSingle	4
T1O_UTME	UTM East of Transect 1 origin	dbDouble	8
T1O_UTMN	UTM North of Transect 1 origin	dbDouble	8
T1O_Rebar	Distance from origin of rebar in meters - 1 decimal	dbSingle	4
T1E_UTME	UTM East of Transect 1 end	dbDouble	8
T1E_UTMN	UTM North of Transect 1 end	dbDouble	8
T1E_Rebar	Distance from end of rebar in meters - 1 decimal	dbSingle	4
T1_Elevation	Elevation in meters of transect 1	dbInteger	2
T2O_UTME	UTM East of Transect 2 origin	dbDouble	8
T2O_UTMN	UTM North of Transect 2 origin	dbDouble	8
T2O_Rebar	Distance from origin of rebar in meters - 1 decimal	dbSingle	4
T2E_UTME	UTM East of Transect 2 end	dbDouble	8
T2E_UTMN	UTM North of Transect 2 end	dbDouble	8
T2E_Rebar	Distance from end of rebar in meters - 1 decimal	dbSingle	4
T2_Elevation	Elevation in meters of transect 2	dbInteger	2
T3O_UTME	UTM East of Transect 3 origin	dbDouble	8
T3O_UTMN	UTM North of Transect 3 origin	dbDouble	8
T3O_Rebar	Distance from origin of rebar in meters - 1 decimal	dbSingle	4
T3E_UTME	UTM East of Transect 3 end	dbDouble	8
T3E_UTMN	UTM North of Transect 3 end	dbDouble	8

Field Name	Field Description	Field Type	Field Width
T3E_Rebar	Distance from end of rebar in meters - 1 decimal	dbSingle	4
T3_Elevation	Elevation in meters of transect 3	dbInteger	2
Plot_Directions	Directions to plot	dbMemo	0

Table Name: tbl_master_version

Description: Table of protocol version information

Field Name	Field Description	Field Type	Field Width
project_ID	Project ID number to ensure uniqueness across all projects	dbLong	4
version_key_number	Protocol version key number (maintained in SOP # 20)	dbLong	4
version_key_date	Date of protocol version key number	dbDate	8
narrative_version	Version of protocol narrative	dbDecimal	16
version_comments	Comments regarding version, if any	dbMemo	0

Table Name: tbl_Photos

Description: Table of Event photos

Field Name	Field Description	Field Type	Field Width
Photo_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Photo_Date	Date photograph taken.	dbDate	8
Photo_Type	Type of photo: digital, film, movie, other	dbText	50
Transect	Transect - quadrat number	dbText	15
Roll	Roll for film photos	dbText	10
Frame	Frame for film photos	dbInteger	2
Digital_File	Digital file name	dbText	50
Photographer	Photographer	dbText	50
Direction	Direction of photograph	dbText	3
Location	Location of photo point along transect in meters	dbInteger	2
Other_Identifier	Other digital photo identifier	dbText	50
Comments	Photo comments	dbMemo	0

Table Name: tbl_Quadrat

Description: Table of quadrat information for 10 m2 quadrats

Field Name	Field Description	Field Type	Field Width
Quadrat_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_Quadrat_Transect	dbText	50
Quadrat	Quadrat number - 1 to 5	dbByte	1
Observer	Name of person observing canopy gaps	dbText	50
Recorder	Name of person recording observations	dbText	50
Crust_Q1	Undifferentiated crust nested quadrat 0.01 m2	dbBoolean	1
Crust_Q2	Undifferentiated crust nested quadrat 0.1 m2	dbBoolean	1
Crust_Q3	Undifferentiated crust nested quadrat 1 m2	dbBoolean	1
Crust_Q4	Undifferentiated crust nested quadrat 10 m2	dbBoolean	1
Crust_Cover	Percent undifferentiated crust cover 10 m2 quadrat. Used only in 2006 due to method change.	dbText	3
Crust_Cover_1M2	Percent undifferentiated crust cover 1 m2 quadrat. Used in 2007 and beyond due to method change.	dbText	3
Cyan_Q1	Cyanobacteria nested quadrat 0.01 m2	dbBoolean	1
Cyan_Q2	Cyanobacteria nested quadrat 0.1 m2	dbBoolean	1
Cyan_Q3	Cyanobacteria nested quadrat 1 m2	dbBoolean	1
Cyan_Q4	Cyanobacteria nested quadrat 10 m2	dbBoolean	1

Field Name	Field Description	Field Type	Field Width
Cyan_Cover	Percent cyanobacteria cover in 10 m2 quadrat. Used only in 2006 due to method change.	dbText	3
Cyan_Cover_1M2	Percent cyanobacteria cover in 1 m2 quadrat. Used in 2007 and beyond due to method change.	dbText	3
Lichen_Q1	Lichen nested quadrat 0.01 m2	dbBoolean	1
Lichen_Q2	Lichen nested quadrat 0.1 m2	dbBoolean	1
Lichen_Q3	Lichen nested quadrat 1 m2	dbBoolean	1
Lichen_Q4	Lichen nested quadrat 10 m2	dbBoolean	1
Lichen_Cover	Percent lichen cover in 10 m2 quadrat. Used only in 2006 due to method change.	dbText	3
Lichen_Cover_1M2	Percent lichen cover in 1 m2 quadrat. Used in 2007 and beyond due to method change.	dbText	3
Moss_Q1	Moss nested quadrat 0.01 m2	dbBoolean	1
Moss_Q2	Moss nested quadrat 0.1 m2	dbBoolean	1
Moss_Q3	Moss nested quadrat 1 m2	dbBoolean	1
Moss_Q4	Moss nested quadrat 10 m2	dbBoolean	1
Moss_Cover	Percent moss cover in 10 m2 quadrat. Used only in 2006 due to method change.	dbText	3
Moss_Cover_1M2	Percent moss cover in 1 m2 quadrat. Used in 2007 and beyond due to method change.	dbText	3
Lscat_Q1	Livestock scat nested quadrat 0.01 m2	dbBoolean	1
Lscat_Q2	Livestock scat nested quadrat 0.1 m2	dbBoolean	1
Lscat_Q3	Livestock scat nested quadrat 1 m2	dbBoolean	1
Lscat_Q4	Livestock scat nested quadrat 10 m2	dbBoolean	1
Lscat_Cover	Percent livestock scat cover in 10 m2 quadrat	dbText	3
Wscat_Q1	Wildlife scat nested quadrat 0.01 m2	dbBoolean	1
Wscat_Q2	Wildlife scat nested quadrat 0.1 m2	dbBoolean	1
Wscat_Q3	Wildlife scat nested quadrat 1 m2	dbBoolean	1
Wscat_Q4	Wildlife scat nested quadrat 10 m2	dbBoolean	1
Wscat_Cover	Percent wildlife scat cover in 10 m2 quadrat	dbText	3
Ant_Q1	Ant mound nested quadrat 0.01 m2	dbBoolean	1
Ant_Q2	Ant mound nested quadrat 0.1 m2	dbBoolean	1
Ant_Q3	Ant mound nested quadrat 1 m2	dbBoolean	1
Ant_Q4	Ant mound nested quadrat 10 m2	dbBoolean	1
Ant_Cover	Percent ant mound cover in 10 m2 quadrat	dbText	3
Bicycle_Q1	Bicycle disturbance nested quadrat 0.01 m2	dbBoolean	1
Bicycle_Q2	Bicycle disturbance nested quadrat 0.1 m2	dbBoolean	1
Bicycle_Q3	Bicycle disturbance nested quadrat 1 m2	dbBoolean	1
Bicycle_Q4	Bicycle disturbance nested quadrat 10 m2	dbBoolean	1
Bicycle_Cover	Percent bicycle disturbance cover in 10 m2 quadrat	dbText	3
Htrail_Q1	Human track/trail nested quadrat 0.01 m2	dbBoolean	1
Htrail_Q2	Human track/trail nested quadrat 0.1 m2	dbBoolean	1
Htrail_Q3	Human track/trail nested quadrat 1 m2	dbBoolean	1
Htrail_Q4	Human track/trail nested quadrat 10 m2	dbBoolean	1
Htrail_Cover	Human track/trail disturbance cover percentage in 10 m2 quadrat	dbText	3
Ltrail_Q1	Livestock track/trail nested quadrat 0.01 m2	dbBoolean	1
Ltrail_Q2	Livestock track/trail nested quadrat 0.1 m2	dbBoolean	1
Ltrail_Q3	Livestock track/trail nested quadrat 1 m2	dbBoolean	1
Ltrail_Q4	Livestock track/trail nested quadrat 10 m2	dbBoolean	1
Ltrail_Cover	Livestock track/trail disturbance cover percentage in 10 m2 quadrat	dbText	3
Vehicle_Q1	Motor vehicle track nested quadrat 0.01 m2	dbBoolean	1

Field Name	Field Description	Field Type	Field Width
Vehicle_Q2	Motor vehicle track nested quadrat 0.1 m2	dbBoolean	1
Vehicle_Q3	Motor vehicle track nested quadrat 1 m2	dbBoolean	1
Vehicle_Q4	Motor vehicle track nested quadrat 10 m2	dbBoolean	1
Vehicle_Cover	Motor vehicle disturbance cover percentage in 10 m2 quadrat	dbText	3
Wildlife_Ex_Q1	Wildlife excavation nested quadrat 0.01 m2	dbBoolean	1
Wildlife_Ex_Q2	Wildlife excavation nested quadrat 0.1 m2	dbBoolean	1
Wildlife_Ex_Q3	Wildlife excavation nested quadrat 1 m2	dbBoolean	1
Wildlife_Ex_Q4	Wildlife excavation nested quadrat 10 m2	dbBoolean	1
Wildlife_Ex_Cover	Wildlife excavation disturbance cover percentage in 10 m2 quadrat	dbText	3
Wtrail_Q1	Wildlife track/trail nested quadrat 0.01 m2	dbBoolean	1
Wtrail_Q2	Wildlife track/trail nested quadrat 0.1 m2	dbBoolean	1
Wtrail_Q3	Wildlife track/trail nested quadrat 1 m2	dbBoolean	1
Wtrail_Q4	Wildlife track/trail nested quadrat 10 m2	dbBoolean	1
Wtrail_Cover	Wildlife track/trail disturbance cover percentage in 10 m2 quadrat	dbText	3
Other_Q1	Other anthropogenic nested quadrat 0.01 m2	dbBoolean	1
Other_Q2	Other anthropogenic nested quadrat 0.1 m2	dbBoolean	1
Other_Q3	Other anthropogenic nested quadrat 1 m2	dbBoolean	1
Other_Q4	Other anthropogenic nested quadrat 10 m2	dbBoolean	1
Other_Cover	Other anthropogenic disturbance coverpercentage in 10 m2 quadrat	dbText	3
Undiff_Q1	Undifferentiated disturbance nested quadrat 0.01 m2	dbBoolean	1
Undiff_Q2	Undifferentiated disturbance nested quadrat 0.1 m2	dbBoolean	1
Undiff_Q3	Undifferentiated disturbance nested quadrat 1 m2	dbBoolean	1
Undiff_Q4	Undifferentiated disturbance nested quadrat 10 m2	dbBoolean	1
Undiff_Cover	Undifferentiated disturbance cover percentage in 10 m2 quadrat	dbText	3
Cover_Shrub	Percentage shrub & dwarf-shrub cover in 10 m2 quadrat	dbText	3
Cover_Annual	Percentage annual grass cover in 10 m2 quadrat	dbText	3
Cover_Perennial	Percentage perennial grass cover in 10 m2 quadrat	dbText	3
Cover_Forbs	Percentage forbs/herbs cover in 10 m2 quadrat	dbText	3
Cover_Soil	Percentage bare soil (loose) cover in 10 m2 quadrat	dbText	3
Cover_Litter	Percentage litter cover in 10 m2 quadrat	dbText	3
Cover_Woody	Percentage woody debris (>2.5cm) cover in 10 m2 quadrat	dbText	3
Cover_Small_Rock	Percentage small rock cover (2-20mm) in 10 m2 quadrat	dbText	3
Cover_Large_Rock	Percentage large rock (>2cm) cover in 10 m2 quadrat	dbText	3
Cover_Bedrock	Percentage bedrock cover in 10 m2 quadrat	dbText	3
Cover_Biocrust	Percentage biocrust cover in 10 m2 quadrat	dbText	3
Cover_Crust_Undiff	Percentage undifferentiated crust cover in 10 m2 quadrat	dbText	3
Comments	10 m2 quadrat comments	dbMemo	0

Table Name: tbl_Quadrat_Shrubs

Description: Table of shrub counts by quadrat

Field Name	Field Description	Field Type	Field Width
Shrub_ID	Unique record identifier - primary key	dbText	50
Quadrat_ID	Foreign key to tbl_Quadrat_Transect	dbText	50
Plant_Code	Plant code from lookup table	dbText	10
0cm	number of shrubs 0-10 cm	dbInteger	2
10cm	number of shrubs 10-25 cm	dbInteger	2
25cm	number of shrubs 25-50 cm	dbInteger	2
50cm	number of shrubs 50-100 cm	dbInteger	2
100cm	number of shrubs 1-2 m	dbInteger	2
200cm	number of shrubs >2 m	dbInteger	2

Table Name: tbl_Quadrat_Species

Description: Table of plant species by quadrat

Field Name	Field Description	Field Type	Field Width
Species_ID	Unique record identifier - primary key	dbText	50
Quadrat_ID	Foreign key to tbl_Quadrat_Transect	dbText	50
Plant_Code	Plant code from lookup table	dbText	50
Alive	Is plant alive?	dbText	3
Q1	Present in 0.01 m2 quadrat?	dbBoolean	1
Q2	Present in 0.1 m2 quadrat?	dbBoolean	1
Q3	Present in 1 m2 quadrat?	dbBoolean	1
Q4	Present in 10 m2 quadrat?	dbBoolean	1
Percent_Cover	Percent cover in 10 m2 quadrat	dbText	3
Rooted_Outside	Is plant rooted outside quadrat?	dbBoolean	1

Table Name: tbl_Quadrat_Transect

Description: Table of transect information for 10 m2 quadrats

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect number - 1, 2, or 3	dbByte	1
Visit_Date	Date of visit.	dbDate	8

Table Name: tbl_Site_Impact

Description: Table of site impact assessment information

Field Name	Field Description	Field Type	Field Width
Impact_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Visit_Date	Date of visit.	dbDate	8
Recorder	Person recording site impact information	dbText	50
On_Disturbance	On-site disturbance type	dbText	50
On_Size	Size of area affected in m2	dbInteger	2
On_Position	Position of disturbance relative to transects	dbText	255
On_Effect	Effect of disturbance on erosional processes on macroplot	dbMemo	0
On_Fire	Alteration of fire behavior on macroplot caused by disturbance	dbMemo	0
On_Additional	Additional on-site disturbance description	dbMemo	0
Off_Disturbance	Off-site disturbance type	dbText	50
Off_Size	Size of area affected in m2	dbInteger	2
Off_Distance	Distance upslope from macroplot in meters	dbInteger	2
Off_Effect	Effect of disturbance on erosional processes on macroplot	dbMemo	0
Off_Fire	Alteration of fire behavior on macroplot caused by disturbance	dbMemo	0
Off_Additional	Additional off-site disturbance description	dbMemo	0
Site_Sketch	BLOB of site sketch or jpg picture of disturbance..	dbLongBinary	0

Table Name: tbl_Soil_Profile

Description: Table of Soil Profiles for Plots

Field Name	Field Description	Field Type	Field Width
Soil_Profile_ID	Unique record identifier	dbText	50
Location_ID	M. Link to tbl_Locations (Loc_ID)	dbText	50
Depth	Sample depth	dbText	9
Texture	Soil texture	dbText	100
Rock_Fragment_Qty	Rock fragment quantity modifier - n/a, none, very, extremely, >90%	dbText	9

Field Name	Field Description	Field Type	Field Width
Rock_Fragment_Size	Rock fragment size modifier - none, gravelly, cobbly, stony, bouldery, channery, flaggy, gravel, cobble, stone, boulder	dbText	8
Effervescence	Effervescence	dbText	11

Table Name: tbl_Soil_Stability

Description: Table of soil stability measurements

Field Name	Field Description	Field Type	Field Width
Soil_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Visit_Date	Date of visit.	dbDate	8
Observer	Name of person observing	dbText	50
Recorder	Name of person recording observations	dbText	50
Sample_Type	Sample type: 1=surface, 2=subsurface	dbLong	4
T1500_Pos	Transect 1 5 minute position	dbInteger	2
T1500_Veg	Transect 1 5 minute Vegetation: NC, G, F, Sh, T	dbText	2
T1500_Rating	Transect 1 5 minute Rating 1-6	dbLong	4
T1500_Hydro	Is rating hydrophobic?	dbBoolean	1
T1545_Pos	Transect 1 5:45 minute position	dbInteger	2
T1545_Veg	Transect 1 5:45 minute Vegetation: NC, G, F, Sh, T	dbText	2
T1545_Rating	Transect 1 5:45 minute Rating 1-6	dbLong	4
T1545_Hydro	Is rating hydrophobic?	dbBoolean	1
T1630_Pos	Transect 1 6:30 minute position	dbInteger	2
T1630_Veg	Transect 1 6:30 minute Vegetation: NC, G, F, Sh, T	dbText	2
T1630_Rating	Transect 1 6:30 minute Rating 1-6	dbLong	4
T1630_Hydro	Is rating hydrophobic?	dbBoolean	1
T1715_Pos	Transect 1 7:15 minute position	dbInteger	2
T1715_Veg	Transect 1 7:15 minute Vegetation: NC, G, F, Sh, T	dbText	2
T1715_Rating	Transect 1 7:15 minute Rating 1-6	dbLong	4
T1715_Hydro	Is rating hydrophobic?	dbBoolean	1
T1800_Pos	Transect 1 8:00 minute position	dbInteger	2
T1800_Veg	Transect 1 8:00 minute Vegetation: NC, G, F, Sh, T	dbText	2
T1800_Rating	Transect 1 8:00 minute Rating 1-6	dbLong	4
T1800_Hydro	Is rating hydrophobic?	dbBoolean	1
T1845_Pos	Transect 1 8:45 minute position	dbInteger	2
T1845_Veg	Transect 1 8:45 minute Vegetation: NC, G, F, Sh, T	dbText	2
T1845_Rating	Transect 1 8:45 minute Rating 1-6	dbLong	4
T1845_Hydro	Is rating hydrophobic?	dbBoolean	1
T2515_Pos	Transect 2 5:15 minute position	dbInteger	2
T2515_Veg	Transect 2 5:15 minute Vegetation: NC, G, F, Sh, T	dbText	2
T2515_Rating	Transect 2 5:15 minute Rating 1-6	dbLong	4
T2515_Hydro	Is rating hydrophobic?	dbBoolean	1
T2600_Pos	Transect 2 6:00 minute position	dbInteger	2
T2600_Veg	Transect 2 6:00 minute Vegetation: NC, G, F, Sh, T	dbText	2
T2600_Rating	Transect 2 6:00 minute Rating 1-6	dbLong	4
T2600_Hydro	Is rating hydrophobic?	dbBoolean	1
T2645_Pos	Transect 2 6:45 minute position	dbInteger	2
T2645_Veg	Transect 2 6:45 minute Vegetation: NC, G, F, Sh, T	dbText	2
T2645_Rating	Transect 2 6:45 minute Rating 1-6	dbLong	4
T2645_Hydro	Is rating hydrophobic?	dbBoolean	1
T2730_Pos	Transect 2 7:30 minute position	dbInteger	2
T2730_Veg	Transect 2 7:30 minute Vegetation: NC, G, F, Sh, T	dbText	2

Field Name	Field Description	Field Type	Field Width
T2730_Rating	Transect 2 7:30 minute Rating 1-6	dbLong	4
T2730_Hydro	Is rating hydrophobic?	dbBoolean	1
T2815_Pos	Transect 2 8:15 minute position	dbInteger	2
T2815_Veg	Transect 2 8:15 minute Vegetation: NC, G, F, Sh, T	dbText	2
T2815_Rating	Transect 2 8:15 minute Rating 1-6	dbLong	4
T2815_Hydro	Is rating hydrophobic?	dbBoolean	1
T2900_Pos	Transect 2 9:00 minute position	dbInteger	2
T2900_Veg	Transect 2 9:00 minute Vegetation: NC, G, F, Sh, T	dbText	2
T2900_Rating	Transect 2 9:00 minute Rating 1-6	dbLong	4
T2900_Hydro	Is rating hydrophobic?	dbBoolean	1
T3530_Pos	Transect 3 5:30 minute position	dbInteger	2
T3530_Veg	Transect 3 5:30 minute Vegetation: NC, G, F, Sh, T	dbText	2
T3530_Rating	Transect 3 5:30 minute Rating 1-6	dbLong	4
T3530_Hydro	Is rating hydrophobic?	dbBoolean	1
T3615_Pos	Transect 3 6:15 minute position	dbInteger	2
T3615_Veg	Transect 3 6:15 minute Vegetation: NC, G, F, Sh, T	dbText	2
T3615_Rating	Transect 3 6:15 minute Rating 1-6	dbLong	4
T3615_Hydro	Is rating hydrophobic?	dbBoolean	1
T3700_Pos	Transect 3 7:00 minute position	dbInteger	2
T3700_Veg	Transect 3 7:00 minute Vegetation: NC, G, F, Sh, T	dbText	2
T3700_Rating	Transect 3 7:00 minute Rating 1-6	dbLong	4
T3700_Hydro	Is rating hydrophobic?	dbBoolean	1
T3745_Pos	Transect 3 7:45 minute position	dbInteger	2
T3745_Veg	Transect 3 7:45 minute Vegetation: NC, G, F, Sh, T	dbText	2
T3745_Rating	Transect 3 7:45 minute Rating 1-6	dbLong	4
T3745_Hydro	Is rating hydrophobic?	dbBoolean	1
T3830_Pos	Transect 3 8:30 minute position	dbInteger	2
T3830_Veg	Transect 3 8:30 minute Vegetation: NC, G, F, Sh, T	dbText	2
T3830_Rating	Transect 3 8:30 minute Rating 1-6	dbLong	4
T3830_Hydro	Is rating hydrophobic?	dbBoolean	1
T3915_Pos	Transect 3 9:15 minute position	dbInteger	2
T3915_Veg	Transect 3 9:15 minute Vegetation: NC, G, F, Sh, T	dbText	2
T3915_Rating	Transect 3 9:15 minute Rating 1-6	dbLong	4
T3915_Hydro	Is rating hydrophobic?	dbBoolean	1
Comments	Soil stability comments	dbMemo	0

Table Name: tbl_SOP_version

Description: Table of SOP version information

Field Name	Field Description	Field Type	Field Width
version_key_number	Protocol version key number (maintained in SOP # 20)	dbLong	4
SOP_number	SOP number	dbLong	4
SOP_version_number	SOP version number	dbDecimal	16
active_flag	Yes indicates SOP is active	dbBoolean	1

Table Name: tbl_Unknown_Species

Description: Table of unknown plant species by quadrat.

Field Name	Field Description	Field Type	Field Width
Unknown_ID	Unique record identifier - primary key	dbText	50
Species_ID	Foreign key to tbl_Quadrat_Species	dbText	50
Plant_Type	Plant type: herb, shrub, tree, grass, sedge, other	dbText	50
Plant_Description	General description	dbMemo	0
Salient_Feature	Most salient feature	dbText	255

Field Name	Field Description	Field Type	Field Width
Leaf_Type	Leaf type: compound/simple, arrangement	dbText	50
Margin	Leaf margin	dbText	50
Other_Characteristics	Other leaf characteristics: pubescence, sap, stipules	dbText	255
Stem_Characteristics	Stem characteristics: shape, pubescence, bud	dbText	255
Flower_Characteristics	Flower characteristics: color location floral formula	dbText	255
General_Characteristics	General and microhabitat characteristics	dbText	255
Collected	Was plant collected	dbBoolean	1
Best_Guess	Best guess species name	dbText	50
Confirmed	Confirmed species name	dbText	50

Table Name: tlu_Contacts

Description: O. Contact data for project-related personnel.

Field Name	Field Description	Field Type	Field Width
Contact_ID	M. Contact identifier (Contact_ID)	dbText	50
Last_Name	M. Last name (Cnt_Last)	dbText	50
First_Name	M. First name (Cnt_First)	dbText	50
Middle_Init	M. Middle initial (Cnt_MI)	dbText	4
Organization	M. Organization or employer (cntorg)	dbText	50
Position_Title	M. Title or position description (cntpos)	dbText	50
Address_Type	M. Address (mailing, physical, both) type (addrtype)	dbText	50
Address	M. Street address (cntaddr)	dbText	50
Address2	MA. Address line 2, suite, apartment number (Cnt_Addr2)	dbText	50
City	M. City or town (city)	dbText	50
State_Code	M. State or province (state)	dbText	8
Zip_Code	M. Zip code (postal)	dbText	50
Country	M. Country (country)	dbText	50
Email_Address	MA. E-mail address (cntemail)	dbText	50
Work_Phone	MA. Phone number (cntvoice)	dbText	50
Work_Extension	MA. Phone extension (Work_Ext)	dbText	50
Contact_Notes	MA. Contact notes (Cnt_Notes)	dbMemo	0

Table Name: tlu_Cover_Class

Description: Lookup table of veg cover classes for soil stability.

Field Name	Field Description	Field Type	Field Width
Cover_Class	Veg Cover Class	dbText	2
Cover_Description	Cover class description	dbText	25

Table Name: tlu_Disturbance

Description: Lookup table of disturbance types

Field Name	Field Description	Field Type	Field Width
Disturbance	Disturbance type	dbText	50

Table Name: tlu_Effervescence

Description: Lookup table of soil effervescence

Field Name	Field Description	Field Type	Field Width
Effervescence	Soil effervescence	dbText	11

Table Name: tlu_Hillslope_Position

Description: Lookup table of hillslope position

Field Name	Field Description	Field Type	Field Width
Position	Hillslope position	dbText	9

Table Name: tlu_NCPN_Plants

Description: Master NCPN Plant Species Table

Field Name	Field Description	Field Type	Field Width
Master_Family	Master_Family	dbText	50
Master_PLANT_Code	Master Species PLANTS Code	dbText	10
Master_Species	Master Species (ITIS)	dbText	50
UT_Family	Utah Family	dbText	50
CO_Family	Colorado Family	dbText	50
WY_Family	Wyoming Family	dbText	50
Utah_PLANT_Code	Utah Species PLANTS Code	dbText	10
Utah_Species	Utah Species (Welsh et al 2003)	dbText	50
Co_PLANT_Code	Colorado Species PLANTS Code	dbText	10
Co_Species	Colorado Species (Weber & Wittmann 2001)	dbText	50
Wy_PLANT_code	Wyoming species PLANTS code	dbText	10
Wy_Species	Wyoming Species (Dorn 2001)	dbText	50
Add_Synonyms	Additional Synonyms	dbMemo	0
Taxonomic_Notes	Taxonomic Notes	dbMemo	0
Master_Common_Name	Master Common Name	dbText	50
ARCH	Park presence descriptor for ARCH	dbText	15
BLCA	Park presence descriptor for BLCA	dbText	15
BRCA	Park presence descriptor for BRCA	dbText	15
CANY	Park presence descriptor for CANY	dbText	15
CARE	Park presence descriptor for CARE	dbText	15
CEBR	Park presence descriptor for CEBR	dbText	15
COLM	Park presence descriptor for COLM	dbText	15
CURE	Park presence descriptor for CURE	dbText	15
DINO(UT)	Park presence descriptor for DINO - Utah	dbText	15
DINO(CO)	Park presence descriptor for DINO - Colorado	dbText	15
FOBU	Park presence descriptor for FOBU	dbText	15
GOSP	Park presence descriptor for GOSP	dbText	15
HOVE(UT)	Park presence descriptor for HOVE - Utah	dbText	15
HOVE(CO)	Park presence descriptor for HOVE - Colorado	dbText	15
NABR	Park presence descriptor for NABR	dbText	15
PISP	Park presence descriptor for PISP	dbText	15
TICA	Park presence descriptor for TICA	dbText	15
ZION	Park presence descriptor for ZION	dbText	15
New_Record	Is it a new record?	dbBoolean	1

Table Name: tlu_Parks

Description: Look-up table of parks in the Northern Colorado Plateau Network

Field Name	Field Description	Field Type	Field Width
ParkCode	Four-letter abbreviation for park code	dbText	5
ParkName	Full name of park where data were collected	dbText	50
ParkState	State code.	dbText	2

Table Name: tlu_Profile_Depth

Description: Lookup table of soil profile depths

Field Name	Field Description	Field Type	Field Width
Depth	Soil profile depth	dbText	9

Table Name: tlu_projects

Description: Table of NCPN project information

Field Name	Field Description	Field Type	Field Width
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Field Name	Field Description	Field Type	Field Width
project_ID	Project ID number to ensure uniqueness across all projects	dbLong	4
project_name	Project name	dbText	50
project_linkfile	Path and file name of project database	dbText	255
project_include_flag	True indicates project is to be included in query results	dbBoolean	1
project_comments	Comments regarding project, if any	dbMemo	0

Table Name: tlu_Rock_Frag_Q

Description: Lookup table of rock fragment quantity modifiers

Field Name	Field Description	Field Type	Field Width
Quantity	Rock fragment quantity modifier	dbText	9
Descriptor	Modifier descriptor	dbText	12

Table Name: tlu_Rock_Frag_Size

Description: Lookup table of rock fragment size modifiers

Field Name	Field Description	Field Type	Field Width
Size	Rock fragment size modifier	dbText	8

Table Name: tlu_Sand_Modifier

Description: Lookup table of sand modifiers

Field Name	Field Description	Field Type	Field Width
Modifier	Sand modifier	dbText	25

Table Name: tlu_Slope_Shape

Description: Lookup table of slope shapes

Field Name	Field Description	Field Type	Field Width
Shape	Slope Shape	dbText	7

Table Name: tlu_Soil_Depth

Description: Lookup table of soil depth to bedrock

Field Name	Field Description	Field Type	Field Width
Depth	Soil Depth	dbText	50

Appendix B Integrated Upland Database User's Guide

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1 Introduction

The NCPN Integrated Upland Monitoring database was written to store Upland monitoring data for NCPN network parks. It was written using the draft version of the NRDT version 3.1 database template. It is written in Access 2002 and consists of the following files:

- *Upland.mdb*: This frontend file contains all data entry forms, queries, reports, and associated Visual Basic (VB) application code.
- *Upland_be.mdb*: This backend file contains the database tables.
- *ijl15.dll*: This DLL file is required by the disturbance sketch save function.
- *SOP_18_App_B_Users_Guide.pdf*: This instructions document.

All of the above files are located in the following folder on the NCPN I&M network drive:

X:\Active_Monitoring_Projects\Upland\Data\Current

This folder will always contain the current working copy of the database (with a few exceptions, to be discussed subsequently).

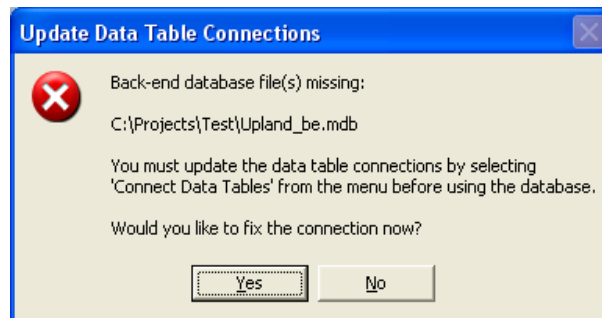
2 Installation

For performance considerations, it is recommended that you save the frontend file, *Upland.mdb*, on your local hard drive. The file *ijl15.dll* must be saved in the **Windows\System** folder of any computer on which you run the Upland database. It is required by the disturbance sketch save function. The backend database, *Upland_be.mdb*, is the database that will contain your data and, as such, should be saved on a computer that is backed up regularly, preferably a network computer. If the backend database is kept on a

network computer, multiple front ends can be linked to it so that multiple data entry sessions can be conducted concurrently.

3 Getting Started

To start the Upland database, open *Upland.mdb*. The first time you open *Upland.mdb*, you will see this message:

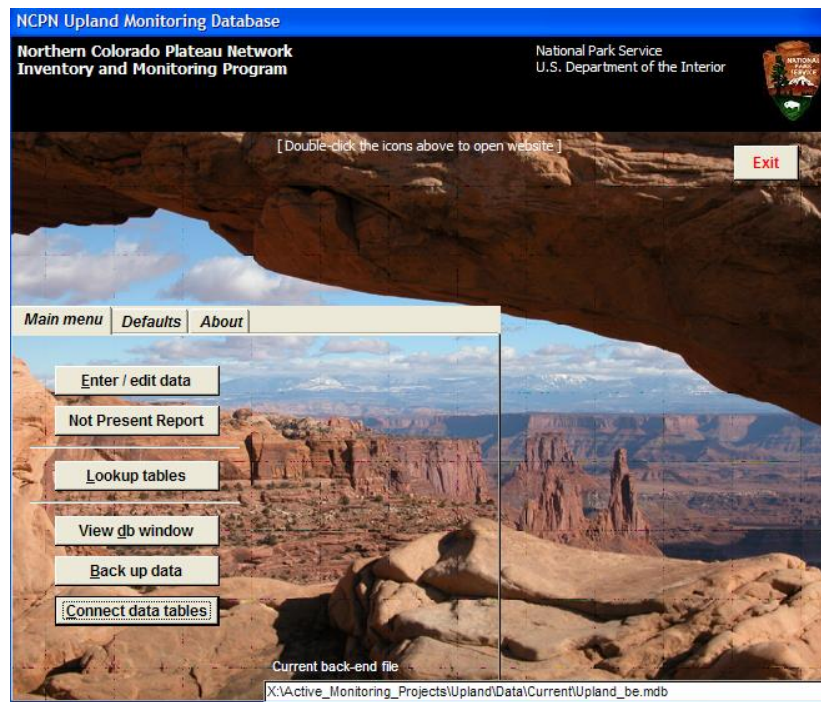


This message is generated because the frontend database does not yet know the location where your backend database is saved. This message may also appear if the database has been “locked” by Data Management staff. This usually occurs when Data Management staff needs to perform maintenance on the database. If the database is indeed locked, it will have “HOLD” appended to the file name (e.g., *Upland_be_HOLD.mdb*). If the database is locked, do not start a data entry session! You may view the records in the database, but do not make any changes as they may be lost. To connect to the backend data file, reply “Yes” to the above message. You will then see the Update Data Table Connections form:

A screenshot of the "Update Data Table Connections" form. The title bar says "Update Data Table Connections". The main heading is "Update links to back end database tables". Below this is a green box with the text: "Data tables are stored in one or more separate database files. Check the filename and location on your computer for the following and use the browse button to change the file". To the right of this box are two buttons: "Close form" and "Update links". The form has a section titled "Back-end data" with a label "NRDT back-end database file". It contains two rows of input fields. The first row is labeled "Current name:" and has the value "Upland_be.mdb". The second row is labeled "Path:" and has the value "C:\Projects\Test\Upland_be.mdb". Below these are two more input fields labeled "New file:" and "Path:". To the right of the "New file:" field is a "Browse" button.

You can click the “Browse” button to navigate to the location of your backend database (the current working folder on the X drive if you are working in the NCPN office at ARCH). Click “Update Links” and the database will link to all the tables in the new location. You will then see the message box: “Update complete!”. Click “OK” to close this box.

It is important that your frontend database be linked to the correct copy of the backend database (again, the current working copy on X if you are working in the ARCH office). The location of the current linked backend database can be viewed at the bottom of the main menu page (see the **Current back-end file** box below). ***Before starting a data entry session, always check the location of the backend database.***



The Main Menu form contains a tab control with three tabs. The first tab (see above figure) contains navigation buttons for the primary database functions. The “Enter / edit data” button provides access to the data entry functions. The “Not Present Report” button displays a report of species not recorded as present in a park (which may help field crews target species for collection if collections are permitted in a given park). The “Lookup tables” button allows editing of lookup tables associated with the pick lists in the database. The “View db window” button displays the Access database window. The “Back up data” button provides a convenient interface for making backup copies of the backend data files. The “Connect data tables” button will bring up the Update Data Connections form to allow you to change back-end databases.

The second tab displays the current database default settings. The project name, current user, park code, datum, and zone are shown and can be changed by clicking the “Change” button. If this is your first time using the database, you may not be listed in the user drop-down box. Instructions for adding a new user are given in Section 5.1. There are also checkboxes on the tab to select optional automated functions which are available.



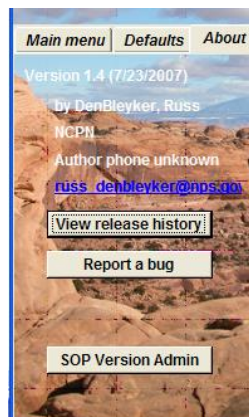
The screenshot shows the 'Defaults' tab of a software application. At the top are three tabs: 'Main menu', 'Defaults', and 'About'. Below the tabs is a 'Current defaults' section with a 'Change' button. The defaults are listed as follows:

Field	Value
Project	NCPN Upland Monitoring
User	Ballenger_Liz
Park	CANY
Datum	NAD83
Zone	12

Below the defaults are four checkboxes:

- ☐ Prompt for backup on startup
- ☐ Prompt for backup on exit
- ☒ Compact back-end on exit
- ☒ Verify table links on startup

The third tab displays information about the database. The “View release history” button allows you to view the version history of the database which details enhancements and upgrades. In the unlikely event that you encounter a bug in the database, you can email the developer with details. The “SOP Version Admin” button allows you to view and update the protocol SOP history of this database. Procedures for this process are detailed in the *NCPN Protocol Versioning Guidance Document* (NCPN-NPS 2007, in development). The current master SOP version key for this protocol is stored in each new visit event record added to the database.



The screenshot shows the 'About' tab of the application. It contains the following information:

Version 1.4 (7/23/2007)
By DenBleyker, Russ
NCPN
Author phone unknown
[russ denbleyker@nps.gov](mailto:russ_denbleyker@nps.gov)

Below the text are three buttons:

- View release history
- Report a bug
- SOP Version Admin

4 Backing Up the Database

Before starting an upland data entry session, the user should create a backup of the backend database file (*Upland_be.mdb*). A backup can be created from within the database by clicking the “Back up data” button on the main menu. Backups should be named as follows:

Upland_be_yyyymmdd_hhmm_xy.mdb, where *yyyyymmdd* represents the current date, *hhmm* the current time, and *xy* represents the initials of the individual creating the backup (e.g., *Upland_be_20070703_1150_ht.mdb*).

The “Back up data” button will name the backup file using the above-given naming convention, with the exception of the initials, which need to be added to the file name. Including the user’s initials in the filename can be helpful in subsequent troubleshooting (e.g., if a backend file becomes corrupt and needs to be restored) and in file management (e.g., determining which backup copies can be deleted). Note that if multiple users click the “Back up data” button simultaneously, an Access “write conflict” error may

occur. Thus, if there are multiple users doing data entry at the same time, only one user should make a backup. Backups should be stored in the active project folder in **Data\Working_Backup**. Data management staff, in consultation with the project lead, will periodically review the **Working_Backup** folder and remove any unnecessary backup files.

In general, there is no need for users to back up the frontend database file (*Upland.mdb*). One exception might be if a user has created one or more queries that they want to save. Most backups of the frontend database file will be created by data management staff prior to making changes to this file. A backup of the frontend file is created by copying the file (using Windows Explorer) to the **Working_Backup** folder, and naming it using the same naming convention as given above (*Upland_yyyymmdd_hhmm_xy.mdb*).

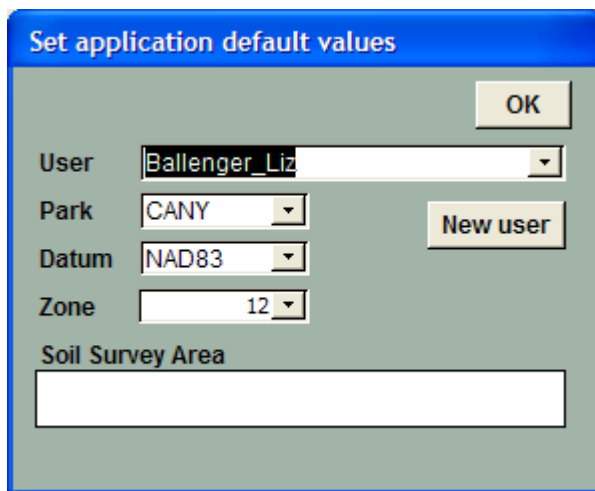
5 Data Entry

Below are some important items to consider before starting a data entry session:

- There is a known issue with mice that have scroll wheels. When entering data on a data entry form in MS Access, scrolling with the mouse wheel can inadvertently insert new records and/or cause other unintended behavior. Data management staff is currently researching this issue to find a long term solution. Until such a solution is found, it is highly recommended that you use a mouse without a scroll wheel when working with the Upland database. There are several such mice available at the NCPN office at ARCH.
- Make sure that the data sheets for each plot are sorted in ascending order by transect and quadrat before you start entering data. This will help prevent you from entering the wrong data for a given transect/quadrat.

5.1 Setting Application Default Values

To begin data entry, click the “Enter / edit data” button on the Main Menu tab. You will see this pop-up form:



Verify that the application defaults are correct, especially that the park is set to the one for which you will be entering data. Change any values as needed. If you are a new user and you are not listed in the User drop-down box, click “New user” to add a record for yourself. The “View and edit contact information” form displays the first record in the Contacts table. Click “New record” and the “View and edit contact information” form displays with a blank record. Enter your first name and last name, and choose *NCPN* as the organization, as shown below:

View and edit contact information

Filter: ☒ View all contacts ☐ Filter by search Search:

First name

Middle initial Address Type

Last name Address 1

Organization Address 2

Position/title City

Work phone ext State Code Zip Code

Email Country

Comments

Contact ID

Record: of 11

Click “Done” and then “Close”. The “Set application default values” form displays again. Select your user name in the user drop-down box and set the appropriate values for park, datum, and zone. Once all application defaults are correct, click the “OK” button.

5.2 Data Gateway Form

The Data Gateway form appears:

Data Gateway

* Double-click on the field label to change sort order. Double-click on a Plot ID to open the Site form for that record.

Filter by park:

Unit*	Plot ID*	Entered/updated*	Selected for Monitoring		
CANY	3	7/12/2007 12:36:35 PM	☒	View Visits	Add New Visit
CANY	5	6/6/2007 5:50:30 PM	☒	View Visits	Add New Visit
CANY	6	7/31/2007 1:17:53 PM	☒	View Visits	Add New Visit
CANY	9	4/3/2007 1:39:57 PM	☒	View Visits	Add New Visit
CANY	10	4/23/2007 4:41:20 PM	☒	View Visits	Add New Visit
CANY	13	6/6/2007 11:33:01 AM	☒	View Visits	Add New Visit
CANY	14	7/31/2007 1:21:49 PM	☒	View Visits	Add New Visit
CANY	18	10/4/2007 9:37:56 AM	☒	View Visits	Add New Visit
CANY	22	7/31/2007 1:21:10 PM	☒	View Visits	Add New Visit

The Data Gateway form displays plots by park. Double-clicking on a column header will sort by that column. By default, the Data Gateway lists only the plots for your default park. To see plots for all parks, click the filter button next to the “Filter by park” drop-down. The filter button is a toggle, so clicking the filter button again and selecting a park in the drop-down will display plots for only that park.

5.3 Plot Establishment and Site Characterization

In most cases, plot establishment and site characterization data will have been imported into the database prior to your data entry session. Thus, you will probably not need to add new plot records most of the time, but if needed, you can do so by clicking the “Add a new site” button.

The Edit/Add Site Characterization form displays. Once this form has been completed, including checking the “Site Selection (Check if accepted)” box, you may add a plot establishment record by clicking the “Plot Establishment” button. After entering the plot establishment data, close the Plot Establishment form and the Edit/Add Site Characterization form to return to the Data Gateway form. If you added a new plot and it does not appear on the Data Gateway, click the “Refresh” button.

To add a new visit event, click the “Add New Visit” button on the Data Gateway form. The main data entry form opens (see Section 5.4 for more information about this form). Clicking on the “View Visits” button will open the Visit List pop-up form which lists all visits to the selected site:

Select a Visit to Edit	
Visit Date	Close Form
9/23/2006	Edit Visit
6/14/2007	Edit Visit

Record: [Navigation Buttons] 1 of 2 (Filtered)

To add observational data to an existing visit record, click on the “Edit Visit” button for that visit. The main data entry form opens and displays the existing data (see Section 5.4 for more information about this form).

5.4 Main Data Entry Form

Clicking “Edit Visit” on the Visit List form or “Add New Visit” on the Data Gateway form will open the main data entry form:

Data Entry Form - Filter by sampling event

Site 5 Edit This Site Plot Establishment Add New Site

UTM E/N E: 600403.466 N: 4251908.502 Park CANY

Start Date 6/14/2007 Close

Gap Intercepts Presence Cover Density Soil Stability Site Impact Photos

Transect 1 Visit Date 6/14/2007 Observer Topp Recorder Condie Shrub Species Ephedra viridis

Canopy Gaps Basal Gaps

Class	Start (cm)	Class	Start (cm)	Class	Start (cm)	Class	Start (cm)	Class	Start (cm)
v	0	v	1345	v	2821				
g	22	g	1404	g	2853				
v	44	v	1424	s	2901				
g	135	g	1483	v	2912				
v	225	v	1540	g	2933				
g	242	g	1551	s	3012				
v	275	s	1661	g	3025				
g	300	v	1672	v	3421				
v	330	g	1721	g	3538				
g	351	g	1731	v	3706				
v	539	v	1771	g	3730				
g	586	s	1787	v	3814				
v	627	g	1799	g	3853				
g	648	s	1910	v	4021				
v	687	g	1919	g	4082				
g	712	s	1974	v	4104				
s	743	g	2012	g	4164				
g	752	v	2089	s	4222				
s	779	g	2102	g	4303				
v	790	v	2190	s	4347				
s	813	g	2201	g	4382				
v	840	v	2305	v	4440				
s	855	g	2333	s	4511				
g	861	v	2516	v	4530				
s	917	s	2527	g	4555				
g	949	g	2537	s	4578				
v	990	v	2575	g	4594				

Refresh

5.4.1 Visit Information

If this is a new visit, enter the visit date in the “Start Date” field. **Start Date is required before any data entry can be done.** You can click the “Add New Site” button to add a new site, the “Edit this Site” button to edit the current site information, or the “Plot Establishment” button to edit plot establishment information for the current site.

5.4.2 Observations

Observations are divided into tabs which match the Upland data field sheets. Date fields corresponding to the “Visit Date” field on each field form are required. Each of the observation tabs is described in the sections that follow.

5.4.2.1 Gap Intercepts

Basal and Canopy gaps are entered under the “Gap Intercepts” tab. This tab contains transect navigation buttons to any of the three transects. Each transect contains sub-tabs for entering basal or canopy gaps for that transect. The procedures delineated in the Gap Intercept Sampling SOP (SOP #9) must be followed. For instance, you cannot have consecutive entries in canopy gaps with the same class.

In some cases, gaps < 20 cm were recorded on the field data sheets. When entering such values on the data entry form, a message box will appear indicating that gaps < 20 cm are not allowed. You can click “OK” to bypass this message and continue to the next field.

If you accidentally enter a number that is lower than the previous one (canopy gaps) or higher than the previous one (basal gaps), a message box will appear indicating the error. Click “OK” and correct the error. Sometimes, after you correct the error, you may get the same message again. Click the “Refresh” button in the upper right corner of the form to continue.

5.4.2.2 Presence Cover Density

Under the “Presence Cover Density” tab, you also have buttons to navigate three transects. In addition, under each transect, you have buttons to navigate to each of 5 quadrats. For each quadrat, you are required to enter observer and recorder name.

Plant species codes entered should follow the NCPN Master Species List names. The data entry form allows you to select species from the Master Species List by either the species name or code recorded on the data sheet. If the name or code does not match a Master name or code, the state code or name may appear. If the state name or code matches the intended species, select the entry. **Regardless of whether you select Master name/code or state name/code in the drop-down list, the Master name and code will be stored in the database.** Once a name or code has been selected for a given species record, the Master name and code are displayed on the form (in blue).

Species - You may select by PLANT Code or Species Name		Alive ?	Nested quadrats [m2]				Percent Cover	Rooted Outside ?
			0.01	0.1	1	10		
STCO	Master Species	Yes	☒	☐	☐	☐	15	☐ Unknown Species
Utah PLANT Code	Utah Species							
STCO	Stipa comata							
STCO6	Streptanthus cordatus							
STCO6XXX	Stipa comata var. comata							
STCO8	Stipa coronata var. depauperata							
STCO1	Stipa comata var. intermedia							
STCOP2	Stipa coronata var. parishii							
STEX	Stephanomeria exigua							

Surface features	.01	0.1	1	10	1 m2
Crust, undifferentiated	☐	☒	☐	☐	75
Cyanobacteria	☐	☐	☒	☐	2

Disturbance	.01	0.1	1	10	10 m2
ant mound	☐	☐	☐	☐	0
bicycle	☐	☐	☐	☐	0

Total live vegetation	
shrub_dwarf-shrub	1
annual grass	0

If neither a state or master name or code is found on the Master Species List for the species, the species will need to be added to the list (see Section 5.5.1 for instructions on adding species to the Master Species List). This may require temporarily skipping over the entry, noting the need to resolve the species name, extracting the name from the USDA Plant List (following the instructions in Section 5.5.1), and then entering the species record at a later time. If you have started entering a species record but the name or code is not on the Master Species List, you will not be able to save the species record without entering a species code/name. You have two options:

1. Minimize the data entry form, add the species to the Master Species List, maximize the data entry form, and finish entering the species record, or
2. Close the data entry form (using the red X in the upper right hand corner of the form), add the species to the Master Species List, re-open the data entry form, and enter the species record.

The second option will generate some error messages indicating that Access cannot save the record, and require you to click “OK” to these messages. Use the first option if possible to avoid this inconvenience.

If you want additional details for a species (e.g., state codes/names for CO) or to look up a species by family or common name, you can use the Master Species Reference. Click the “Master Species” button (to the right of the plant code and name drop-down boxes on the Presence Cover Density tab) and this form opens:

Choose one of the sorting options in the “Sort List by MASTER” group of buttons and then use the drop-down box to select a species record and view the details.

If a species is unknown, click the “Unknown Species” button (on the Presence Cover Density tab) and complete the Unknown Plant Species form. Since you are required to enter a species code/name, the following codes and names should be employed:

Code	Name
UNKS	unknown shrub
UNKG	unknown graminoid
UNKF	unknown forb
UNKT	unknown tree
UNKH	unknown herb (forb or grass)
UNK	unknown species (unknown life form)

5.4.2.3 Soil Stability

The “Soil Stability” tab provides fields for entry of soil stability sampling data for each transect.

Data Entry Form - Filter by sampling event

Site 5 [Edit This Site](#) [Plot Establishment](#) [Add New Site](#)

UTM E/N E: 600403.466 N: 4251908.502 Park CANY

Start Date 6/14/2007 [Close](#)

[Gap Intercepts](#) [Presence Cover Density](#) [Soil Stability](#) [Site Impact](#) [Photos](#)

Date 6/14/2007 Observer Topp Recorder Condie

Sample Type Surface

Transect 1					Transect 2					Transect 3				
Dip Time	Pos.	Veg	Rating	HP	Dip Time	Pos.	Veg	Rating	HP	Dip Time	Pos.	Veg	Rating	HP
5:00	7	G	6	☐	5:15	7	G	1	☐	5:30	7	NC	3	☐
5:45	8	G	6	☐	6:00	8	NC	3	☐	6:15	8	NC	5	☐
6:30	17	G	6	☐	6:45	17	NC	4	☐	7:00	17	G	6	☐
7:15	27	NC	5	☐	7:30	27	Sh	6	☐	7:45	27	G	3	☐
8:00	37	F	4	☐	8:15	37	NC	6	☐	8:30	37	NC	3	☐
8:45	47	NC	3	☐	9:00	47	G	6	☐	9:15	47	NC	3	☐

Comments

Note that the “position” values are stored as integers in the database. If any of these values were recorded with decimals on the field data sheets, round them to integers.

5.4.2.4 Site Impact

The “Site Impact” tab contains text fields for entry of site impact information. In addition, one .jpg scanned site sketch or .jpg photograph for each visit may be added to the database via the “Disturbance sketch/photo” button. Clicking this button opens the Load JPG form:

Intel(R) JPEG Library: [1.5.4]

[Load Jpeg from disk](#) [Save this map in site record](#) [Load site map from this record](#) [Save this image as Jpeg disk file](#) Image Size: 1x 1/2 1/4 1/8

2005 NPS - COLORADO PLATEAU SPRING ECOSYSTEM SURVEY - SITE DESCRIPTION

SITE SKETCH MAP Site Code: _____ - S Site Name: _____

Clicking on the “Load Jpeg from disk” button will open a browse window which will allow you to select a .jpg file to load into the form. Clicking on the “Save this map in site record” button will then save the map in the record for this site. The “Load site map from this record” button will load an existing site sketch from the record into the form to view and/or save. The “Save this image as Jpeg disk file” button will allow you to save the .jpg to a new disk file of your choosing. As noted in the installation instructions, the file ij15.dll must be saved in the Windows\System folder of your computer in order to run this form.

5.4.2.5 Photos

The “Photos” tab lets you document all photographs taken during the visit:

Be sure to enter the photo records for all plot photo points. Photograph procedures changed as of the 2007 field season (see SOP #7 for repeat photograph procedures). To associate each photo record with the appropriate photo point, use the Transect drop-down box on the Photos tab. The Transect drop-down contains codes that correspond to each photo point on the data sheet:

Transect Codes	Photo Point
1	Transect 1 (upper)
2	Transect 2 (center)
3	Transect 3 (lower)
1stQuadT1	Quadrat 1, transect #1
3rdQuadT2	Quadrat 3, transect #2
5thQuadT3	Quadrat 5, transect #3
CR1stQuadT1	Crust, Quadrat 1, transect #1
CR3rdQuadT2	Crust, Quadrat 3, transect #2
CR5thQuadT3	Crust, Quadrat 5, transect #3

5.5 Editing Lookup Tables

If there is a need to edit the values associated with the pick lists in the database, you can click the “Lookup tables” button on the Main Menu. The Manage Lookup Tables form displays. Select the table to edit in the drop-down box, and the table will open for editing. Click “Close” when finished.

5.5.1 Editing the Master Species List

To edit the Master Species List, choose *tlu_NCPN_Plants* in the Table drop-down list. The current Master Species List records will display. You can make changes, deletions, and additions, so be careful when editing this table.

To add a new name, open a web browser and go to the USDA Plant list (<http://plants.usda.gov/>). Bookmark this page (if you have not done so already) so you can refer to it later. Once there, type in the name of the new plant in the search box. A list of accepted names will appear for you to choose from. Each name will have the NCPN plant code next to it. Be sure to spell the name correctly, or you’ll get no matches. Check the spelling in *A Utah Flora* (Welsh et al. 2003). Choose the name that was entered on the plot form and note the species 4-letter code.

On the Master Species List lookup table (*tlu_NCPN_Plants*), go to the last row and enter the information required to create a new record. Be aware that not all master family names match the names found in *A Utah Flora*. All master family names end in –aceae. Some Welsh family names end in –ae or –eae and will be entered with that name rather than the master family name in the field for Utah family name. Refer to the green copy of *A Utah Flora* for Utah family names.

For the species name, if the master species name and the Utah name match, the Utah species code will be the same as the master species code. Hopefully any “different” Utah species names have been addressed already and are in the NCPN Master Species List. Most of what you will find in terms of names which need to be added will be genus and species names recorded on plot sheets *without* a variety, or genus names without a species, or family names. In the case of family name only, use the full family name, *in caps*, names ending in –aceae, e.g., Poaceae or Asteraceae.

6 References

- NCPN-NPS 2007. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- Welsh, S. L., N. D. Atwood, S. Goodrich and L. C. Higgins. 2003. *A Utah flora*, 3rd edition. Brigham Young University, Provo, UT.

Appendix C Quality Assurance (QA)/Quality Control (QC) Procedures

This appendix describes the QA/QC procedures used in certifying upland monitoring data. Unless stated otherwise, all procedures will be performed by either the project lead or other staff designated by the project lead. Procedures are presented as follows: Section 1 describes general QA/QC procedures, Section 2 verification procedures, Section 3 QA/QC for quantitative data, and Section 4 QA/QC for qualitative data.

1 General QA/QC Procedures

This section describes general procedures that apply to all types of QA/QC performed. Any specific variations are described in subsequent sections. All queries mentioned in this document are stored in the frontend file of the upland database unless stated otherwise.

In general, the procedures below are followed for all QA/QC:

- A program or query is run to check a specified condition. For example, a program may be run to check for database records or entries having no shrub density values (i.e., shrub density field is null).
- The result output indicates success or failure for each database record evaluated.
- Records that fail a check are flagged for resolution.
- Flagged records are resolved, which usually requires editing the database (though this is not always the case). Resolution also usually requires that the project lead review the flagged records to determine the appropriate course of action.
- After resolving all possible problems, the QA/QC procedures are re-run to ensure that any database edits made were successful and to document the final results.
- The final results are stored in the project archive folder (more details on documentation are given subsequently).

It is important to document the QA/QC performed on the upland data, including the methods used and the final results (e.g., erroneous data that are corrected, potentially erroneous data that are flagged). This documentation represents critical metadata that may help subsequent users interpret the data. As such, it will be retained for the long term in the project archive folder:

R:\Archive\Monitoring_Archive\Upland\Project_Life_Cycle\<yyyy>\Data_Quality,
where <yyyy> denotes the data collection year.

For the current year, working QA/QC documentation will be stored in the active project folder:

X:\Active_Monitoring_Projects\Upland\Project_Life_Cycle\Data_Quality

The specific contents of the QA/QC documentation will vary for each QA/QC procedure, but in general should include the following:

- A description of all conditions checked.
- For each condition checked, a list of all flagged records. For each such flagged record, the park, plot, and year should be included, as well as any other identifying information applicable to the condition checked (e.g., transect, quadrat, species).

- There are no specific required formats for QA/QC documentation, other than including the information specified above and being in a commonly accepted file format (e.g., text, Word, Excel). To document the results of an Access query, there are two options:
 1. Exporting to Excel: With the query in datasheet view, go to the **File** menu and select **Export**. In the Export Query dialog box, choose “Microsoft Excel 97-2002 (*.xls)” as the file type, give it a file name and location, and then click “Export All”.
 2. Exporting to Word: With the query in datasheet view, go to the **Tools** menu and select **Office Links**, then **Publish it with Microsoft Word**. The query results will be saved in a table in an RTF formatted document, which is given the query name and stored in your default database folder. To change your default database folder, go to **Tools => Options** and change it on the General tab.

2 Verification Procedures

Data verification is performed after data entry and checks the accuracy and completeness of the computerized records against the hard copy field records. Verification procedures for upland data include visual review at data entry, visual after data entry (Section 2.1), summary queries and tallies (Section 2.2), and visual review of spatial data (Section 4.1.2).

2.1 Visual Review After Data Entry

If possible, review all records entered during each data entry session. If it is not possible to review all records, then review a random sample of at least 10% of the records entered. If any errors are found in this review, review 100% of the records from that data entry session. Correct any missing or incorrectly entered values. While it is not necessary to document every correction made in the database, the verification methods should be documented (e.g., verified all records, or verified a randomly selected sample of 10% of records). Since it may not always be possible to perform verification after each data entry session, other grouping schemes may be used to group records for verification. The visual review should also include a check to ensure that any site impact sketches (see the Site Impact Assessment datasheet) were scanned and loaded into the database.

For plot establishment/site characterization data, all records should be verified. Since there are not that many of these records each year, it is not a significant effort to verify all of them. In addition, since there may be many blank values in this data, this is an efficient and systematic way to check whether these values should be blank. For plot establishment data, *only* the following fields are verified against the datasheets: Date, Observer, Slope, Aspect, Azimuth, Directions to Plot, and Rebar Location (origin and end fields for each transect). The remaining fields (all UTM coordinates and elevation fields) are verified against the corrected GPS data or other GIS data (see Section 4.1.2).

2.2 Summary Queries and Tallies

The queries in Table 1 are run to detect missing records or other data entry errors. The final results of each query are documented. Similar types of verification queries are provided in other sections of this document for location data (Section 4.1.2) and photo data (Section 4.2.1).

Table 1 Summary Queries and Tallies for Data Verification

Condition Checked	Query Name	Comments/Instructions
Listing of all plots established by Park, Plot, and Establishment Date	QC_Plots_Established	• Verify that the total number of plots established is correct. • Resolve any issues.
Plots without visits	QC_Plots_without_Visits	• This query checks for plots not having any visit data. If any plots are identified in the query results, check whether field datasheets for each plot exist and were overlooked during data entry. • Resolve any issues.
Listing of all plots visited by Park, Plot, and Visit Date	QC_Plots_with_Visits	• Run this query after any issues identified above have been resolved and save the results. • Verify that the total number of plots visited is correct. • Document the reasons for any plots not having visit data.
Plot visits without site impact records	QC_Visits_without_Site_Impact	• A site impact record is required for all visits, even if there is nothing to report. • Resolve any visits without site impact records.
Plot visits without soil stability records	QC_Visits_without_Soil_Stability	• A soil stability record is required for all visits. • Resolve any visits without soil stability records.
Plot visits without canopy gap records	QC_Visits_without_Canopy_Gaps	• Canopy gap records are required for all visits. • Resolve any visits without canopy gap records.
Plot visits without quadrat records	QC_Visits_without_Quadrats	• Quadrat records are required for all visits. • Resolve any visits without quadrat records.
Quadrats visited with no species recorded	QC_Quadrats_without_Species	• It is possible that there are no species on a quadrat, but any such instances should be examined for potential problems. • Resolve any issues.
Quadrats visited with no shrubs recorded	QC_Quadrats_without_Shrubs	• This query checks for quadrats visited with no shrub density data recorded. It is possible that there are no shrubs on a quadrat, but any such instances should be examined for potential problems. • Resolve any issues.

3 QA/QC for Quantitative Data

The procedures in this section should be performed after verification is complete. Error/issue documentation includes a short description of the error, the park, plot, year, transect, and quadrat notation. Species code is also included where applicable. All files mentioned in this section are stored in the active project folder:

X:\Active_Monitoring_Projects\Upland\Project_Life_Cycle\Data_Quality

The quality checks described in this section are currently implemented in custom-developed programs (external to the database) since this was the most efficient implementation method for the initial upland data analysis. These custom-developed programs are used not only for data quality checking, but also for scaling field measures to plot-level values. It is expected that all of these checks will be incorporated into (or at least more tightly integrated with) the database in the future.

QA/QC procedures for quantitative data are presented as follows: Section 3.1 provides a reference for all queries and programs used, Section 3.2 describes quality checks performed for species data, Section 3.3 describes quality checks for data completeness, and Section 3.4 describes quality checks for measurement data.

3.1 Query and Program Descriptions

This section provides a reference of all queries, programs, and other files used in the quantitative QA/QC procedures. These queries, programs, and files were developed not only for QA/QC purposes, but also to facilitate analysis of the upland data. Table 2 lists the queries used to extract the information needed for specific assessments, while Figure 1 lists the output of each query.

Table 2 Queries Used in Quantitative QA/QC Procedures

Query Name	Description
Querybasalgaps	Extracts basal-gap measures
Querycanopygaps	Extracts canopy-gap measures
Querylifecov	Extracts percent cover for life forms and surface features
Querynames	Extracts plant species codes
Queryphysicalterse	Extracts ecological site and physical attributes of a macroplot
Querysiteimpact	Extracts site impact records
Queryshrubdensity	Extracts shrub-density measures
Querysoilstab	Extracts soil stability measures
Queryspfreqcov	Extracts plant species frequency and cover measures
Querysplist	Extracts plant codes from the master species list
Querysurfdist	Extracts frequency and percent cover for surface and disturbance features
Queryvisits	Extracts plot IDs and date of monitoring events

Figure 1 Output Formats of Queries Used in Quantitative QA/QC Procedures

Output format of Querybasalgaps. Gap start and end are cm along a transect.

Unit Code	Start date	Plot ID	Transect no.	Gap start	Gap end
-----------	------------	---------	--------------	-----------	---------

Output format of Querycanopygaps. Class features are g (gap), s (shrub), v(non-shrub vegetation). Start is cm along a transect.

Unit Code	Start date	Plot ID	Transect no.	Class (feature type)	Start
-----------	------------	---------	--------------	----------------------	-------

Output format of Querylifecov. Percent cover values are recorded in 10m² quadrats.

Unit Code	Start date	Plot ID	Transect	Quadrat	Shrub cover	Annual grass cover	Perennial grass cover	Forbs/ herbs cover	Bare soil cover	Litter cover	Woody debris (>2.5cm) cover	Small rock (2-20mm) cover	Large rock (>2cm) cover	Bedrock cover	Biocrust cover	Undifferentiated cover
-----------	------------	---------	----------	---------	-------------	--------------------	-----------------------	--------------------	-----------------	--------------	-----------------------------	---------------------------	-------------------------	---------------	----------------	------------------------

Output format of Querynames.

Unit Code	Start date	Plot ID	Transect no.	Quadrat	Plant_code
-----------	------------	---------	--------------	---------	------------

Output format of Queryphysicalterse. Elevation is in meters, slope is percent, aspect is azimuth.

Unit Code	Plot ID	Primary EcoSite	Elevation	Plot Slope	Plot Aspect
-----------	---------	-----------------	-----------	------------	-------------

Output format of Querysiteimpact. On, off pertain to on site, off site.

Unit Code	Start date	Plot ID	On Disturbance	On size	On position	On effect	On fire	On additional	Off disturbance	Off size	Off distance	Off effect	Off fire	Off additional
-----------	------------	---------	----------------	---------	-------------	-----------	---------	---------------	-----------------	----------	--------------	------------	----------	----------------

Output format of Queryshrubbydensity. Height classes contain enumeration of stems.

Unit code	Start date	Plot ID	Transect	Quadrat	Plant code	0cm	10cm	25cm	50cm	100cm	200cm
-----------	------------	---------	----------	---------	------------	-----	------	------	------	-------	-------

Output format of Querysoilstab. Position through Hydro are repeated for a total of 18 sets of measures, resulting in a total of 76 columns in the output file.

Unit code	Start date	Plot ID	Sample type	Position	Veg	Rating	Hydro
-----------	------------	---------	-------------	----------	-----	--------	-------

Output format of Queryspfreco. Q1-Q4 records the first nested quadrat in which a species was detected. Percent cover is within the 10-m² quadrat.

Unit code	Start date	Plot ID	Transect	Quadrat	Plant code	Alive	Q1	Q2	Q3	Q4	Percent cover	Rooted outside
-----------	------------	---------	----------	---------	------------	-------	----	----	----	----	---------------	----------------

Output format of Querysplist.

Master plant code

Output format of Querysurfdist. Q1-Q4 records the first nested quadrat (0.01, 0.1, 1.0, 10.0 m²) in which a species was detected. Records from Q1 to the last shown are repeated for Undifferentiated crust, cyanobacteria, lichen, and moss. Data from 2006 will only contain records for 10m². Data after that will only contain records for 1m². Following moss, fields Q1 through Percent cover 10m² are repeated for disturbance categories; Percent cover 1m² is not repeated. In order, these categories are livestock scat, wildlife scat, ant mound, bicycle, human track/trail, livestock track/trail, motor vehicle, wildlife excavation, wildlife track, other anthropogenic, and undifferentiated. In total there are 84 columns in the output file.

Unit code	Start date	Plot ID	Transect	Quadrat	Q1	Q2	Q3	Q4	Percent cover 10m ²	Percent cover 1m ²
-----------	------------	---------	----------	---------	----	----	----	----	--------------------------------	-------------------------------

Output format of Queryvisits.

Unit code	Start date	Plot ID
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Table 3 lists the programs used in the quantitative QA/QC procedures. The data quality checks performed by these programs are described in Section 3.4.

Table 3 Programs Used in Quantitative QA/QC Procedures

Program Name	Description
Splist.exe	Used to evaluate the master species codes used in the database, the plant codes recorded for frequency and cover, and shrub species recorded in the shrub density measures.
Checkdata.exe	Checks completeness of data records.
basalgap.exe	Generates plot-level measures of basal gap measures.
cangap.exe	Generates plot-level measures of canopy gap measures
lifcov.exe	Generates plot-level measures of percent cover for life form and surface features.
shrubden.exe	Generates plot-level measures of shrub density.
soilstab.exe	Generates plot-level measures of soil-aggregate stability.
spfregcov.exe	Generates plot-level measures of plant-species frequency and percent cover.
surfdist.exe	Generates plot-level measures of frequency and percent cover of surface and disturbance features.

Table 4 lists other files used in the quantitative QA/QC procedures.

Table 4 Other Files Used in Quantitative QA/QC Procedures

Program Name	Description
biophys.dat	Output from Queryphysicalterse. This file contains a record of the ecological site type and physical features of a monitoring plot.
mvisits.dat	Output from Queryvisits. This file records the date of every monitoring event for every plot. Using this file and biophys.dat, visits.exe provides a summary of the number of plots by ecological site, park unit, and year.
specieslist.dat	This file is derived from an offline master species list (i.e., a master species list stored outside of the upland database in a file called NCPN_MASTER_VegCodesAndNames.xls). It contains species code, lifeform, duration, nativity, trinomial code (0=N, 1=T), and unique species code (1=N, 0=Y). The latter two fields were created to facilitate evaluation of naming convention and data processing. The unique species code indicates if the plant code represents a unique species, or if it is simply a family or genus code. Most summaries only deal with unique species. Thus, this code is used to determine which records to include and exclude in certain analyses.

3.2 Species Data Validation

The master species list in the database, referred to subsequently as the *online master species list*, is updated with new plant species codes as needed during the data entry process. These new species codes are identified by comparing the online master list to an offline master list (see specieslist.dat entry in Table 4). Data validation procedures performed on the online master list and on the species observation data in the database are described in Table 5. The Splist.exe program is run to perform these validation procedures.

Table 5 Species Data Validation Procedures

Condition Checked	Table Name: Field Name(s)	Program Name	Comments/Instructions
New species codes in online master list	tlu_NCPN_Plants: Master_Plant_Code	Splist.exe	• Run Splist.exe to compare online master species list (represented by Querysplist output) with offline master list (represented by specieslist.dat) and identify new species codes (i.e., not in offline master list). • Compare each new species code with USDA PLANTS list to determine whether code is valid: ○ If valid, derive lifeform, nativity, duration, trinomial and unique species codes and add to offline master list. ○ If invalid, resolve species code and update database.
New species codes and trinomials in species observation data	tbl_Quadrat_Species: Plant_Code	Splist.exe	• Run Splist.exe to compare species observation data (represented by Querynames output) with offline master list (represented by specieslist.dat) and identify new species codes and trinomials. • Trinomials are problematic. There are some species which can be identified to the trinomial level, and they should be recorded using this nomenclature. In some cases, a trinomial code is recorded when in fact it is next to impossible to identify a species to that level in the field. In most cases, this represents a data entry error, and the species should have been recorded using binomial nomenclature. The list of trinomial names must be manually evaluated to determine if the code is valid, or if it should be changed. • Resolve species codes and update database.
New species codes and trinomials in shrub species observation data	tbl_Quadrat_Shrubs: Plant_Code	Splist.exe	• Same as previous procedure except Splist.exe compares shrub species observation data (represented by first 6 columns of Queryshrubbydensity output) with offline master list to identify new species codes and trinomials.

After species codes are evaluated and the database has been modified with corrected species names, all queries involving species codes are executed on the ‘clean’ database. Also, where new species codes were used, the offline master species list is updated, and specieslist.dat is re-created.

3.3 Data Completeness

Plot-level routines (described in Section 3.4) are written with the expectation of a specific number of non-blank fields. Before these routines are run, the completeness of data records is examined using a program called CheckData.exe. This program counts the number of columns of data produced by a specific query. CheckData.exe operates on the files produced by the primary

queries (see Table 2). Each of the query files is processed separately. A keyword is required in running CheckData.exe, which indicates the query results being evaluated and also determines the number of expected columns. Data records with insufficient fields are written to an error file for resolution. Errors are resolved within the database, queries are re-run, and then CheckData.exe is used as a general verification of edits and to provide a final record of unresolved errors. In some cases, these ‘errors’ are actually due to the lack of observations. For example, where shrubs are lacking on a transect, incomplete records are output by the shrub-density query. In this case, CheckData.exe functions to notify the analyst that shrub observations were not recorded. Every time CheckData.exe is run, the complete records are output to a separate file, providing a ‘clean’ dataset used in subsequent processing.

3.4 Measurement Data Validation

Most field measures are acquired on sub-plots, and must be scaled to the plot level for analyses. Routines were developed to perform this scaling, as well as various data logic checking. All routines use the ‘clean’ data generated with CheckData.exe. For data logic checking, these routines record errors and warnings for further resolution. After running a routine, errors are evaluated, resolved, and the database is updated. The associated query must be repeated, and the query output run through CheckData.exe. The output from CheckData.exe is then used in the routine to produce the final plot-level measures. Checks inside CheckData.exe and each routine collectively provide an account of errors in the database. All errors and warnings are tagged with park unit, date, plot ID, transect, and quadrat. Where applicable, values of attributes are recorded as part of an error or warning message. As an additional check, mvisits.dat is used to determine if data for all monitoring events were processed. If not, a warning is recorded. This warning is especially important where attributes were not recorded at all on a plot (e.g., shrub density). Table 6 describes the specific data logic checks performed by each routine.

Table 6 Measurement Data Quality Checks

Measurement Type	Program Name	Condition Checked	Condition Description	Table Name: Field Name(s)
Basal gaps	basalgap.exe (Required files: biophys.dat, mvisits.dat, CheckData.exe results for Querybasalgaps output)	Minimum gap size	Gaps <20 cm are flagged	tbl_Basal_Gaps: Gap_Start, Gap_End
		Gap-location sequence	Locations must consistently increase or decrease along a transect. If not, entry where location information first deviates from ‘proper’ sequencing is flagged.	tbl_Basal_Gaps: Gap_Start, Gap_End
Canopy gaps	cangap.exe (Required files: biophys.dat, mvisits.dat, CheckData.exe results for Querycanopygaps output)	Gap-location sequence	Locations must consistently increase or decrease along a transect. If not, entry where location information first deviates from ‘proper’ sequencing is flagged.	tbl_Canopy_Gaps: Start
		Different successive	Successive gap class codes must be different. If not, the	tbl_Canopy_Gaps: Class

Measurement Type	Program Name	Condition Checked	Condition Description	Table Name: Field Name(s)
		gap class codes	entries are flagged.	
Shrub density	shrubden.exe (Required files: biophys.dat, mvisits.dat, specieslist.dat, CheckData.exe results for Queryshrubdensity output)	New/invalid species codes	If a species code is not in the offline master species list (i.e., specieslist.dat), the record is flagged.	tbl_Quadrat_ Shrubs: Plant_Code
		Unique species	If a species code indicates a non-unique species, the record is flagged.	tbl_Quadrat_ Shrubs: Plant_Code
		Shrub species	If a species code is not a shrub, it is flagged.	tbl_Quadrat_ Shrubs: Plant_Code
Soil stability	soilstab.exe (Required files: biophys.dat, mvisits.dat, CheckData.exe results for Querysoilstab output)	Missing/ invalid vegetation codes	Valid vegetation codes are G (grass), Sh (shrub), T (tree), F (forb) or NC (no cover). NG indicates missing vegetation data. If NG is detected, a warning message is generated. If code is invalid, an error message is recorded.	tbl_Soil_Stability: T1500_Veg through T3915_Veg (18 fields)
Species frequency and percent cover	spfreco.exe (Required files: biophys.dat, mvisits.dat, specieslist.dat, CheckData.exe results for Queryspfreco output)	Multiple nested quadrats	If multiple nested quadrats are checked, the record is flagged.	tbl_Quadrat_ Species: Q1, Q2, Q3, Q4
		No nested quadrats	If no nested quadrats are checked and rooted-outside is not checked, the record is flagged.	tbl_Quadrat_ Species: Q1, Q2, Q3, Q4, Rooted_Outside
		Zero percent cover	If percent cover is zero, the record is flagged.	tbl_Quadrat_ Species: Percent_Cover
		New/invalid species codes	If a species code is not in the offline master species list (i.e., specieslist.dat), the record is flagged.	tbl_Quadrat_ Species: Plant_Code
		Duplicate species codes	If multiple live or multiple dead records of a species occur on a quadrat, the record is flagged (can only have 1 live and 1 dead record for same species per 10m2 quadrat).	tbl_Quadrat_ Species: Plant_Code, Alive
Surface and disturbance features frequency and percent cover	surfdist.exe (Required files: biophys.dat, mvisits.dat, CheckData.exe results for Querysurfdist output)	Multiple nested quadrats	If multiple nested quadrats are checked, the record is flagged.	tbl_Quadrat: surf_Q1, surf_Q2, surf_Q3, surf_Q4 (for surf = Crust, Cyan, Lichen, Moss), dist_Q1, dist_Q2, dist_Q3, dist_Q4, (for dist = Lscat, Wscat, Ant, Bicycle, Htrail,

Measurement Type	Program Name	Condition Checked	Condition Description	Table Name: Field Name(s)
				Ltrail, Vehicle, Wildlife_Ex, Wtrail, Other, Undiff)
		No nested quadrats	If no nested quadrats are checked and percent cover is >0, the record is flagged.	tbl_Quadrat: surf_Q1, surf_Q2, surf_Q3, surf_Q4 dist_Q1, dist_Q2, dist_Q3, dist_Q4, (see Multiple nested quadrats check above), surf_Cover, surf_Cover_1M2 (for surf = Crust, Cyan, Lichen, Moss), dist_Cover (for dist = Lscat, Wscat, Ant, Bicycle, Htrail, Ltrail, Vehicle, Wildlife_Ex, Wtrail, Other, Undiff)
		Zero percent cover	If percent cover is zero, and a nested quadrat is checked, the record is flagged.	tbl_Quadrat: same fields as No nested quadrats check above

4 QA/QC for Qualitative Data

The procedures in this section should be performed after verification is complete. Any questions related to errors or issues identified should be directed to the project lead. Many of the data quality checks in this section include checking text fields for invalid values and spellchecking. When performing either of these types of checks, values should be “standardized” and consistency maintained wherever possible. This includes ensuring only proper nouns are capitalized (e.g., use “obscured by soil” rather than “Obscured by soil” or “Obscured by Soil”). Standardizing values would also include ensuring commas are used as delimiters (e.g., use “valley, bench” rather than “valley/bench”).

QA/QC for qualitative data includes quality checks performed on plot establishment/site characterization data (Section 4.1), photo data (Section 4.2), and other textual data (Section 4.3).

4.1 Plot Establishment/Site Characterization Data

Plot establishment/site characterization data is stored in tbl_Location in the database. This table also stores location data, which are usually imported or derived from GPS and/or other GIS data. The QA/QC procedures for these two types of data are discussed separately since they require different methods and skill sets. Section 4.1.1 describes QA/QC procedures for plot

establishment/site characterization data, while Section 4.1.2 describes QA/QC procedures for location data.

4.1.1 Plot Establishment/Site Characterization Data Validation

The procedures in this section should be performed after the verification procedures described in Sections 2.1 and 2.2 have been completed. Table 7 lists the data quality checks performed for validating plot establishment/site characterization data, along with the query that implements the check. For each condition checked, the final results are documented (see Section 1 for QA/QC documentation procedures). For spellchecking, it is not necessary to document the query results. The final results in this case should just indicate that the spellcheck was completed. To spellcheck a field, select a column (while in datasheet view) and choose **Tools-Spelling** from the Access main menu.

Table 7 Plot Establishment/Site Characterization Data Quality Checks

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Invalid values	tbl_Location: Primary_Eco_Site	QC_Ecosite	- Query lists ecosite codes assigned to each plot. - Correct any invalid values.
Invalid values	tbl_Location: T1O_Rebar, T1E_Rebar, T2O_Rebar, T2E_Rebar, T3O_Rebar, T3E_Rebar	QC_Rebar	- Query identifies records with invalid values (values must be between -100 and 100). - Correct any invalid values.
Invalid values	tbl_Location: Soil_Survey_Area	QC_Soil_Survey_Area _<PARK>	- Query identifies invalid soil survey areas for each park. Valid values: - CANY: "Canyonlands Area" - CARE: "Capitol Reef NP" - Run query for each park and correct any problems.
Invalid values	tbl_Location: Soil_Map_Unit	QC_Soil_Map_Unit	Check that Assigned_Soil_Map_Unit column matches Soil_Map_Unit column; If not, set Assigned_Soil_Map_Unit = Soil_Map_Unit.
Invalid values	tbl_Location: Landform	QC_Landform	Correct any invalid values. Valid values are listed in SOP #5 (Site Characterization), Appendices B1 and B2.
Invalid values	tbl_Location: Hillslope_Position	QC_Hillslope_Position	- This query identifies values entered that are not on the pick list and subtle differences like "Low level" vs. "low level". - Correct any values in Hillslope_Position column that differ from Picklist_Position column. - For values not on pick list

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
			(Hillslope_Position has value but Picklist_Position does not), determine whether value needs to be added to pick list.
Invalid values	tbl_Location: Slope_Complexity	QC_Slope_Complexity	Correct any invalid values (must be “simple” or “complex”).
Invalid values	tbl_Location: Slope_Shape_Down	QC_Slope_Shape_Down	Compare Slope_Shape_Down and Shape column and correct discrepancies as needed. The Shape column contains the correct lookup table values.
Invalid values	tbl_Location: Slope_Shape_Across	QC_Slope_Shape_Across	Compare Slope_Shape_Across and Shape column and correct discrepancies as needed. The Shape column contains the correct lookup table values.
Invalid values	tbl_Location: Percent_Slope	QC_Percent_Slope	Correct any invalid values (values must be between 0 and 100).
Invalid values	tbl_Location: Soil_Texture	QC_Soil_Texture	Correct any invalid values; Values can be any of the following or any combination thereof: <i>fine, coarse, sandy, sand, loam, loamy, clay, clayey, silt.</i>
Invalid values	tbl_Location: Sand_Modifier	QC_Sand_Modifier	Compare Sand_Modifier and Modifier column and correct discrepancies as needed. The Modifier column contains the correct lookup table values.
Invalid values	tbl_Location: Rock_Fragment_Qty	QC_Rock_Fragment_Qty	Compare Rock_Fragment_Qty and Quantity column and correct discrepancies as needed. The Quantity column contains the correct lookup table values.
Invalid values	tbl_Location: Rock_Fragment_Size	QC_Rock_Fragment_Size	Compare Rock_Fragment_Size and Size column and correct discrepancies as needed. The Size column contains the correct lookup table values.
Invalid values	tbl_Location: Effervescence	QC_Effervescence	Compare the two Effervescence columns and correct discrepancies as needed. The tlu_Effervescence. Effervescence column contains the correct lookup table values.
Invalid	tbl_Location: Depth	QC_Depth	Compare the two Depth

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
values			columns and correct discrepancies as needed. The tlu_Soil_Depth.Depth column contains the correct lookup table values.
Misspelled words	tbl_Location: Geologic_Setting, Soil_Texture, Probable_Component, Soil_Comments, Veg_Comments, Other_Eco_Site, Site_Selection_Comments, Plot_Directions	QC_Location	Check each of the field names listed and correct any spelling errors.

4.1.2 Location Data Verification and Validation

The procedures in this section include both verification and validation of the location data. Thus, it is not necessary that the verification procedures described in Section 2 be completed prior to performing these procedures. All data quality checks in this section (see Table 8) are performed by data management/GIS staff. Prior to running the queries in this section, data management staff need to import the corrected GPS data into the database into temporary tables called GPS_Plot and GPS_Transect. This may require some reformatting of the corrected GPS data spreadsheets. The corrected GPS data files are stored in the active project folder:

X:\Active_Monitoring_Projects\Upland\Data\GPS_Downloads

Examples of reformatted spreadsheets are available in the GPS_Files_for_Import subfolder in the above location. Table 8 lists the data quality checks performed for location data, along with the query that implements the check. For each condition checked, the final results are documented (see Section 1 for QA/QC documentation procedures).

Table 8 Location Data Quality Checks

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Invalid/missing values for basic GPS data	tbl_Location: GPS_File_Name, Rcvr_Type, Coord_Units, Coord_System, UTM_Zone, Datum	QC_Location_GPS_Basic	- Run the query and verify that all values are valid: - GPS_File_Name: Not used currently, so should be blank. - Rcvr_Type: GeoXM - Coord_Units: Meters - Coord_System: UTM - UTM_Zone: 12 (13 for BLCA/CURE) - Datum: NAD83 - Correct any invalid/missing values. - If there are many invalid/missing values, the update query

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
			“Location_GPS_Basic_Update” can be used to update records in batch. Note that this query may need to be modified depending on the dataset (e.g., to ensure UTM zone is set properly).
Invalid/missing values for GPS plot data	tbl_Location: SiteDate, Elevation, E_Coord, N_Coord, Max_PDOP, Max_HDOP, Plot_Date, Plot_E_Coord, Plot_N_Coord	QC_Location_GPS_Plot, QC_Import_GPS_Plot	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. - If there are many invalid/missing values, the update query “Location_GPS_Plot_Update” can be used to update records in batch.
Invalid/missing values for GPS transect data: transect 1 – origin (T1O)	tbl_Location: T1_Elevation, T1O_UTME, T1O_UTMN	QC_Location_GPS_T1O, QC_Import_GPS_T1O	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. Query QC_Import_GPS_T1O contains the corrected GPS data values. - If there are many invalid/missing values, the update query “Loc_GPS_T1O_Update” can be used to update records in batch.
Invalid/missing values for GPS transect data: transect 1 – end (T1E)	tbl_Location: T1E_UTME, T1E_UTMN	QC_Location_GPS_T1E, QC_Import_GPS_T1E	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. Query QC_Import_GPS_T1E contains the corrected GPS data values. - If there are many invalid/missing values, the update query “Loc_GPS_T1E_Update” can be used to update records in batch.
Invalid/missing values for GPS transect data: transect 2 – origin (T2O)	tbl_Location: T2_Elevation, T2O_UTME, T2O_UTMN	QC_Location_GPS_T2O, QC_Import_GPS_T2O	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. Query QC_Import_GPS_T2O contains the corrected GPS data values. - If there are many invalid/missing values, the update query “Loc_GPS_T2O_Update” can be used to update records in batch.
Invalid/missing values for GPS transect data: transect 2 – end (T2E)	tbl_Location: T2E_UTME, T2E_UTMN	QC_Location_GPS_T2E, QC_Import_GPS_T2E	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. Query QC_Import_GPS_T2E contains the corrected GPS data values. - If there are many invalid/missing

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
			values, the update query “Loc_GPS_T2E_Update” can be used to update records in batch.
Invalid/missing values for GPS transect data: transect 3 – origin (T3O)	tbl_Location: T3_Elevation, T3O_UTME, T3O_UTMN	QC_Location_GPS_T3O, QC_Import_GPS_T3O	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. Query QC_Import_GPS_T3O contains the corrected GPS data values. - If there are many invalid/missing values, the update query “Loc_GPS_T3O_Update” can be used to update records in batch.
Invalid/missing values for GPS transect data: transect 3 – end (T3E)	tbl_Location: T3E_UTME, T3E_UTMN	QC_Location_GPS_T3E, QC_Import_GPS_T3E	- Run both queries and compare the values in the fields listed. - Correct any invalid/missing values. Query QC_Import_GPS_T3E contains the corrected GPS data values. - If there are many invalid/missing values, the update query “Loc_GPS_T3E_Update” can be used to update records in batch.
Invalid elevation values	tbl_Location: Elevation, T1_Elevation, T2_Elevation, T3_Elevation	QC_Elevation_<PARK>	- Run the query for each park (currently CANY and CARE only¹) and correct any problems. Elevation ranges (meters): - CANY (1130, 2200) - CARE (1175, 2735) - These queries also check for null values. If any missing elevation values are identified, retrieve the value from the GPS data if possible. If no elevation value is available in the GPS data, then obtain the value from the appropriate 10-meter digital elevation model (the GIS specialist will assist with this step).

After all data quality checks in Table 8 have been performed, a visual review of the upland monitoring plot data is performed using GIS software to ensure accuracy (e.g., all plot coordinates fall within park boundaries, all transect coordinates for a given plot are located in the plot vicinity). Any discrepancies found are resolved and, if needed, corrections made to the appropriate fields in tbl_Locations.

¹ Upland monitoring is currently planned for implementation in the following parks: ARCH, BLCA, CANY, CARE, CURE, DINO, and ZION (though it is possible that additional parks may be included in the future).

4.2 Photo Data

The QA/QC procedures in this section must be performed before the photo records are imported into the Photo Database.

4.2.1 *Initial Photo Data Verification*

Each plot visit should have 9 photos (with the exception of 2006 plot visits, which should have 3 photos). In this step, plot visits not having the required number of photos are identified and resolved. Table 9 describes the queries used to complete this step. These queries identify not only plots having too few photos, but also plots having too many photos since either case should be examined for possible problems. To resolve any identified problems, consult the datasheets and the Photo Comments field in the database (since discrepancies may be noted there, e.g., “discarded”). After all issues have been resolved with the plot visit photos, the query QC_Photos_Per_Visit is run and the results used to document the final number of photos for each plot visit.

Table 9 Photo Data Verification Queries

Condition Checked	Query Name	Comments/Instructions
Each plot visited in 2006 has 3 photos	QC_Plot_Photos_2006	Resolve and document any discrepancies.
Each plot visited in 2007 has 9 photos	QC_Plot_Photos_2007	Resolve and document any discrepancies.
Lists all plots visited and the number of photos	QC_Photos_Per_Visit	- Run this query after all issues have been resolved and save the results. - Document the reasons for plot visits not having the required number of photos.

4.2.2 *Comprehensive Photo Data Verification*

After initial verification is completed (Section 4.2.1), the photo data in the database is compared to the digital photos and any discrepancies are resolved.

- Copy the digital photos from the CD to the X drive (if not already on X). Photos not yet entered into the photo database will be in the folder locations below. Create a subfolder labeled with the roll number (e.g., UM1) and copy the photo files there.
X:\Archive\NCPN Photos\Monitoring_To_be_Entered\Upland_2006
X:\Archive\NCPN Photos\Monitoring_To_be_Entered\Upland_2007
- Open the QC_Photos query in the upland database (sort by Roll and Frame if needed). For each photo record, do the following:
 - Use the Roll and Frame numbers to locate the corresponding digital photo file. Verify that the two match. Correct any discrepancies and document those you cannot resolve.
 - For photos with a signboard, verify that the Photo Date, Transect, and Direction fields are correct using the signboard. Correct any discrepancies and document those you cannot resolve. Check the Photo Comments field since discrepancies may be noted there (e.g., “signboard should say SW”).

- For photos without a signboard (e.g., crust photos), use the datasheet to verify the data.
- Enter the digital photo file name in the Digital File Name field (the .jpg file extension is optional). Use copy/paste to avoid typos.
- Move the digital photo file from the roll number subfolder to the parent folder (e.g., from UM1 to Upland_2006).
- Rotate the digital photo if necessary so that the horizon is level.

4.2.3 Photo Data Validation

After all photo verification is completed (Section 4.2.2), additional data quality checks are performed (see Table 10). For each condition checked, the final results are documented (see Section 1 for QA/QC documentation procedures). For spellchecking, it is not necessary to document the query results. The final results in this case should just indicate that the spellcheck was completed. To spellcheck a field, select a column (while in datasheet view) and choose **Tools-Spelling** from the Access main menu.

Table 10 Photo Data Validation Queries

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Invalid values	tbl_Photos: Roll, Location	QC_Photos	• For each field name listed, sort ascending and check for valid values: ○ Roll values are valid (The field crew maintains a log of these values). ○ Location values are between -50 and 50 or Null.
Invalid values	tbl_Photos: Frame	QC_Photo_ Frame	• Frame values should be in the range of 1-38. • Correct any invalid values.
Invalid values	tbl_Photos: Direction	QC_Photo_ Direction	• Direction should be one of the following (n/a, N, S, E, W, NE, NW, SE, SW, SSW, etc.). • Correct any invalid values.
Misspelled words	tbl_Photos: Other_Identifier, Photo Comments	QC_Photos	• Check each of the field names listed and correct any spelling errors.

4.3 Other Textual Data Validation

Table 11 lists the quality checks performed for other textual data, along with the query that implements the check. For each condition checked, the final results are documented (see Section 1 for QA/QC documentation procedures). For spellchecking, it is not necessary to document the query results. The final results in this case should just indicate that the spellcheck was completed. To spellcheck a field, select a column (while in datasheet view) and choose **Tools-Spelling** from the Access main menu.

Table 11 Data Quality Checks for Other Textual Data

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Missing values	tbl_Site_Impact: On_Disturbance, On_Size, On_Position, On_Effect, On_Fire, On_Additional, Off_Disturbance, Off_Size, Off_Distance, Off_Effect, Off_Fire, Off_Additional	QC_Site_Impact	- For each field name listed: - Sort ascending. - Correct any missing values.
Misspelled words	tbl_Site_Impact: On_Disturbance, On_Position, On_Effect, On_Fire, On_Additional, Off_Disturbance, Off_Effect, Off_Fire, Off_Additional	QC_Site_Impact	Check each of the field names listed and correct any spelling errors.
Misspelled words	tbl_Unknown_Species: Plant_Description, Salient_Feature, Leaf_Type, Margin, Other_Characteristics, Stem_Characteristics, Flower_Characteristics, General_Characteristics, Best_Guess, Confirmed	QC_Unknown_Species	Check each of the field names listed and correct any spelling errors.
Invalid values	tbl_Unknown_Species: Plant_Type	QC_Plant_Type	Correct any invalid values (should be "herb", "shrub", "tree", "grass", "sedge", or "other").
Missing values	tbl_Quadrat: Observer, Recorder	QC_Quadrat	- For each field name listed: - Sort ascending. - Correct missing values if possible; document otherwise.
Misspelled words	tbl_Quadrat: Comments	QC_Quadrat	Check each of the field names listed and correct any spelling errors.
Missing values	Soil_Stability: Observer, Recorder	QC_Soil_Stability	- For each field name listed: - Sort ascending. - Correct missing values if possible; document otherwise.
Misspelled words	tbl_Soil_Stability: Comments	QC_Soil_Stability	Check each of the field names listed and correct any spelling errors.
Misspelled words	tbl_Soil_Profile: Texture	QC_Soil_Profile	Check each of the field names listed and correct any spelling errors.
Missing shrub species values	tbl_Canopy_Transect: Species	QC_Canopy_Transect	This query lists all shrub species values that are either blank or set to "none".

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
			For all such records, verify that “none” is the appropriate value and then set to “none” if needed.

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 19

Data Analysis and Reporting

Version 1.0 (March 2008)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) details the analysis and reporting procedures for data collected in the NCPN Integrated Upland Monitoring Protocol.

1.0 Introduction

Analytical and reporting procedures in the initial version of this SOP are relatively basic. Enhancements are expected over time as experience working with the upland data accumulates, and as the full suite of potentially supporting data provided by other vital signs monitoring (e.g., land condition) of the NCPN become available. The procedures described in this version, however, provide a solid basis for future enhancements.

The analysis and reporting efforts described in this SOP are illustrated in Fig. 1. These efforts first require the derivation of plot-level measures from the raw quadrat and transect observations. To ensure the quality of plot-level measures, data-logic assessments are performed. Data-entry procedures constrain entries to proper domain limits, and the use of acceptable species names (qv. SOP #18). However, a complementary effort is necessary to ensure reasonability of values relative to historical conditions on a plot. For instance, a measure may appear to be valid based on domain, but represent an unreasonable (and unlikely) change in plot conditions since the last monitoring event. The absence of a previously common species and the appearance of a new and dominant species over a relatively short time frame may indicate an interesting dynamic or the misidentification of a species. Logic comparisons are intended to identify suspect information. Further evaluation of this information is required to rule-out or correct transcription errors from data sheets to the database, and to identify further actions to resolve ‘unusual’ measures. To ensure timely resolution, data-quality assessments are performed on the plot-level measures of the most recent monitoring event immediately after data are entered into the upland database.

Once data quality issues are resolved and the database is updated to a 'clean' condition, analyses can be conducted. Three general types of analyses are performed: annual summaries of the most recent monitoring observations, variance estimation related to the overall sampling design, and a comprehensive assessment which includes evaluation of status and trends. To aid in understanding reasons for observed trends (or lack of trends), the comprehensive assessment involves integration of information from other vital signs monitoring efforts. Also, there may be instances where trends (directional change) are not apparent, but a pattern of multi-directional change is evident over time. In such cases, correlational methods are employed to help explain reasons for the oscillations in upland attributes. The comprehensive assessment should begin at least 5-yrs after initial implementation and possibly every year thereafter depending on the number of plots visited each year.

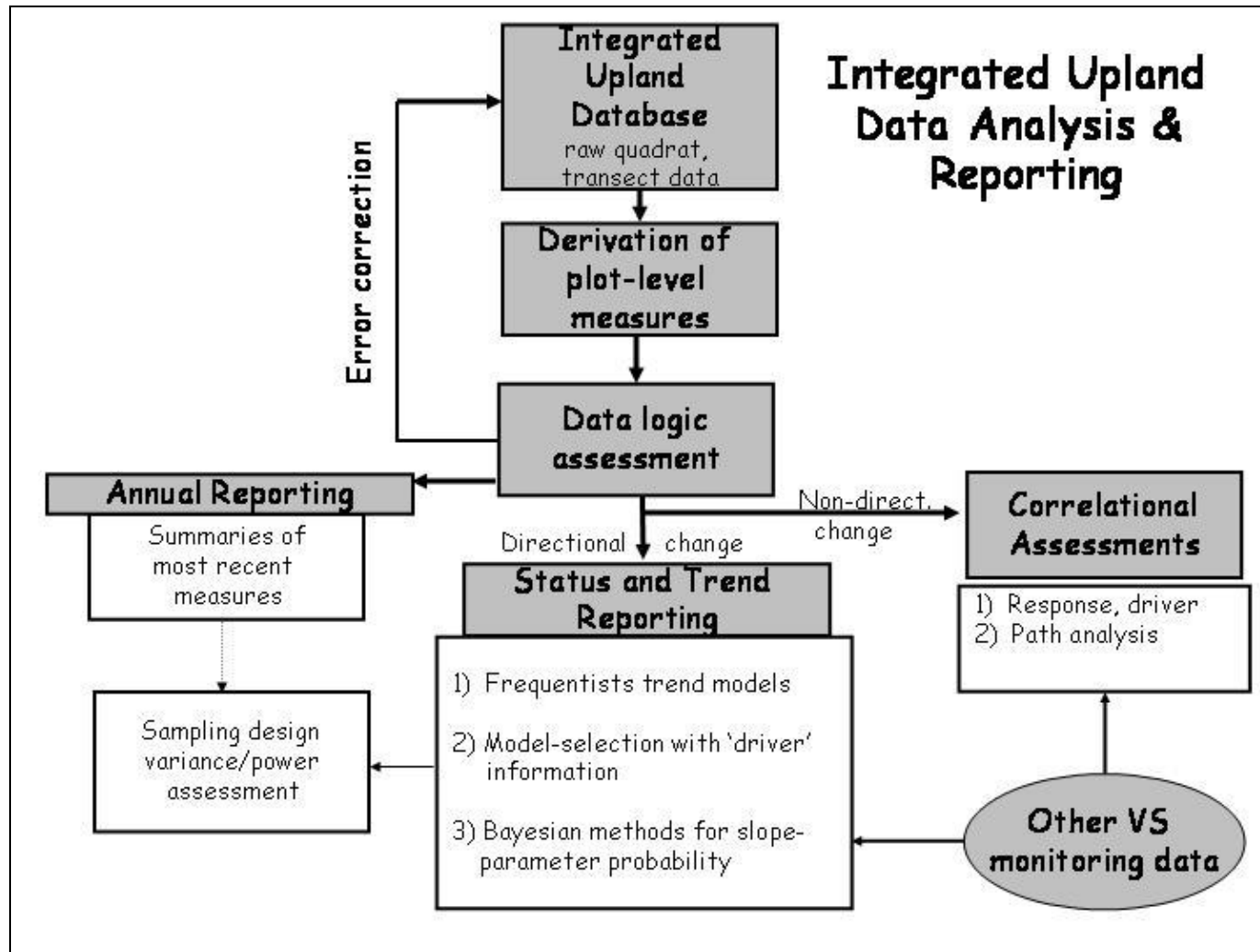


Figure 1. Schematic of data analysis and reporting.

2.0 Derivation of Plot-level Measures

The detailed observations recorded in quadrats and on transects are sub-samples of an upland plot. Plot-level measures, however, are the fundamental responses for all analyses, so the sub-samples must be scaled to this level. Plot-level measures are summarized in Table 1 for the Dryland systems monitoring, and in Table 2 for Forest and Woodland monitoring. Formula for deriving plot-scale measures are listed in Table 3.

Table 1. Forest and woodland plot-level measures.

Measure	Attribute or Context	Spatial scale(s) of observation
Percent frequency	Individual plant species	0.01, 0.1, 1.0, 10m ²
	Surface features (undifferentiated crust, cyanobacteria, lichen, moss)	0.01, 0.1, 1.0m ²
	Disturbance features (livestock and wildlife scat; ant mound, bicycle; human, livestock, wildlife track; motor vehicle; wildlife excavation; other).	0.01, 0.1, 1.0, 10m ²
Percent cover	Individual plant species	10m ²
	Surface features	1m ²
	Disturbance features (see above), and bare soil, litter, woody debris, small and large rock, bedrock, biological crust, and undifferentiated crust	10m ²
	LifeForm (shrubs; annual, perennial grasses; forbs/herbs)	10m ²
Density	Individual shrub species, and all shrub species combined	10m ²
Length of canopies (shrubs and non-shrub vegetation) and of canopy gaps; percent canopy and percent canopy gaps; mean canopy length and mean gap size; frequency distribution of canopy lengths and of gap size	Line-intercept length of canopies of shrubs and of non-shrub vegetation, and of canopy gaps	Along all three transects (150 m)
Length of basal areas (all vegetation combined) and of basal-area gaps; percent basal area and percent basal-area gaps; mean basal-area length and mean basal-area gap size; frequency distribution of basal-area lengths and of basal-area gap sizes	Line-intercept length of basal area of all vegetation combined (excluding annual grasses) and of basal-area gaps	Along all three transects (150 m)
Soil stability class (from protected and unprotected combined, from protected areas, from unprotected areas)	Slake test stability class (1-6) Protected-area samples are those collected under vegetation. Unprotected-area samples are	18 point samples across plot

	those lacking ‘overstory’ vegetation	
Plant species Richness (no. of species)	Lifeform, all species combined	all 10m ² quadrats on a plot
Plant species Diversity & Evenness	All species combined	all 10m ² quadrats on a plot

Table 2. Forest and woodland plot-level measures.

Measure	Attribute or Context	Spatial scale(s) of observation
Percent cover	Individual plant species	Point intercept
	Surface features (undifferentiated crust, cyanobacteria, lichen, moss)	Point intercept
	Disturbance features (livestock and wildlife scat; ant mound, bicycle; human, livestock, wildlife track; motor vehicle; wildlife excavation; other).	Point intercept
	LifeForm (shrubs; annual, perennial grasses; forbs/herbs)	Point intercept
	Overstory cover	Locations along belt transect
Density	Individual tree and shrub species, and all trees and shrub species combined	Plot scale for trees, two 2-m belt transects for shrub species
Fuel loading	fine and coarse woody debris volumes	four 15-m transects
Plant species Richness (no. of species)	Lifeform, all species combined	plot scale for trees, 2-m belt transect for shrubs and saplings, point intercept for understory
Plant species Diversity & Evenness	All species combined	plot scale for trees, 2-m belt transect for shrubs and saplings, point intercept for understory

2.1. Procedures

2.1.1 Dryland Monitoring Data

a) Percent frequency provides a measure of commonness. Percent frequency at nested scales affords detection of subtle changes that otherwise may not be apparent in percent-cover observations. Percent frequency is generated for each species, each ground cover attribute, and by lifeform (tree, shrub, grass [perennial, annual], forb [perennial, annual]). It is derived by summing the number of quadrats with occurrence of the attribute, dividing by the number of quadrats, and scaling the result to a percentage (eq. 1, Table 3). Percent frequency is derived for each of the nested quadrats (0.01, 0.1, 1.0, 10 m²).

b) Percent cover provides a measure of condition and dominance. Percent cover is derived for each species, ground cover attribute, and lifeform. It is derived by summing

the cover values from the 1- (BSC features) or 10-m² quadrat, and dividing by the number of quadrats (eq. 2, Table 3).

c) Shrub density is relatively straight forward. It is the sum of enumerated stems divided by 15 (the number of 10m² quadrats). This gives the density of shrub stems per 10m².

d) Intercanopy gap observations provide measures of the openness of the near-surface region, and relates to the susceptibility of soil erosion due to wind and rain. Intercanopy distances based on shrub species and on all vegetation species are recorded along the three 50-m transects. Intercanopy gap measures are summarized separately for these two features. Summary measures include: 1) percentage of inter-canopy gap lengths which is derived by summing the gap lengths, dividing by the total transect length, and scaling the result to a percentage (eq. 6, Table 3); and 2) mean gap size which is derived by simply averaging the inter-canopy distances recorded among the three transects (eq. 7, Table 3).

e) Basal-area gap parallel intercanopy gap observations in terms of utility and importance. The same two measures used to summarize intercanopy gap size apply to basal area gap size (eqs. 6 & 7, Table 3).

f) Soil-aggregate stability indicates the propensity for erosion due to wind and water. Surface and sub-surface samples are analyzed similarly, but separately. There are three calculations: 1) the average stability for all samples is derived by summing all stability values and dividing by the total number of samples; 2) the average stability for protected soil is derived in a similar manner but only using the samples associated with vegetation (Veg= G, F, Sh, or T as recorded on the data sheet in SOP#11; and 3) the average stability for unprotected soil is similarly derived but only using samples associated with no canopy (Veg = NC).

Table 3. Formula for deriving plot-level measures.

Percent Frequency

$$PF = ((f / n) * 100) \quad (1)$$

where;

n = the number of quadrats (of a specified size)

f = the number of quadrats (of a specified size) with occurrence of an attribute

PF = percent frequency

Percent Cover

$$PC = ((\sum_{i=1}^n c_i) / n) \quad (2)$$

where;

n = the number of quadrats

c_i = the recorded cover value for an attribute in quadrat i

PC = percent cover

Simpson's Diversity Index (infinite population)

$$1 - D = 1 - \sum_{i=1}^s [(n_i(n_i-1)) / (N(N-1))] \quad (3)$$

where;

N = sum of all n_i

n_i = percent cover of species i

s = number of species

1 - D = probability of picking two organisms at random that are different species

Evenness Measure (Modified Hill's ratio)

$$E = ((1/D) - 1) / (e^{H'} - 1) \quad (4)$$

where;

D is from eq. 3

E = evenness measure

H' = Shannon index

where;

$$H' = - \sum_{i=1}^s [(n_i/N) \ln (n_i/N)] \quad (5)$$

where;

N, n_i, and s are defined in eq. 3

Percentage of Transect Length in Gaps

$$PG = \left(\left(\sum_{i=1}^v g_i \right) / tl \right) * 100 \quad (6)$$

where;

tl = the total transect length in cm

g_i = gap size (cm) for gap i

v = the number of gaps

PG = percent gap length

Mean Gap Size

$$MG = \left(\sum_{i=1}^v g_i \right) / v \quad (7)$$

where;

v = the number of gap measures

g_i = gap size (cm) for gap i

MG = mean gap size (cm)

g) Richness, diversity, and evenness measures summarize the number and apportionment of species in a community. Richness can be derived in various ways, but can be as simple as the number of unique species. Unless the underlying sub-sample size varies (i.e., number of quadrats), the number of unique species is comparable among years within a plot, and among plots. Rarefaction methods should be employed if the number of sub-samples changes within or among monitoring plots (e.g., Krebs 1989, Ludwig and Reynolds 1988). Otherwise, richness by lifeform is derived by summing the number of unique, vascular plant species by lifeform recorded on a plot. Total richness is simply the sum across lifeforms. Richness excludes ground-cover features.

Diversity and evenness is typically derived from counts of individual species, or from biomass measures or estimates of individual plants. This protocol only enumerates shrub and tree species. Other species are recorded by percent cover. For general reporting purposes, diversity and evenness are based on percent cover. As a cautionary note, when comparing these metrics with those of other studies it is essential that the underlying basis of metrics are commensurate. That is, metrics based on percent cover are not comparable with those based on biomass or stem counts. There are numerous diversity and evenness metrics, each with inherent sensitivity to rare species (see Krebs 1989, Ludwig and Reynolds 1988). The Simpson's diversity index tends to be one of the more robust metrics, and is used to derive diversity (eq. 3, Table 3). This index ranges from 0 (low diversity) to 1 (high diversity). The modified Hill's ratio is used to derive a measure of evenness (eq. 4, Table 3). This ratio approaches zero as a single species becomes more dominant, uses the Simpson's diversity index, and is less sensitive to sample size compared to other methods (Ludwig and Reynolds 1988). Diversity and evenness are derived for vascular plant species only, which excludes components of Biological Soil Crust (BSC), and other ground-cover features.

2.1.2 Forest and Woodland Monitoring Data

a) Percent cover is the number of point-intercepts recording the species or a lifeform, divided by the total number of point-intercept readings across all three transects, times 100.

b) Overstory cover is the average of all densiometer readings on a plot.

c) Density of shrubs and samplings is the number of each species divided by the total area of the two 2-m belt transects, which gives density on a per 1m^2 basis. This number can be scaled to any level, such as number per ha. Tree density is simply the number of boles by species (or all trees combined). The basis of this density value would be the total plot area. Moreover, density per ha can be acquired by scaling from plot area to 1 ha ($10,000\text{m}^2$).

d) Fuel volumes are derived using the formula in Brown (1974).

e) Richness is simply the number of unique species on a plot. Diversity and Evenness are derived using eq. 3 and 4 in Table 3.

3.0 Data Quality Assessment

Data entry procedures include species-name validation and domain checks at the sub-sample level (qv. SOP#18). These procedures do not evaluate the reasonability of the level of change of plot-level measures, which should be evaluated as multi-year data becomes available. E.g., a change in shrub cover from 10% to 100% over a 1-yr interval is suspect, and would warrant evaluation of validity. Additionally, errors related to mis-identification of species and the omission of historically dominant species are not evaluated in data-entry procedures. The field crew is responsible for thorough recording of all species on quadrats and for correct species identification (e.g., actual name or codification as unknown), but observer error can and will occur. Identifying potential errors in species identification after the field season is problematic, but identification and resolution of at least suspect mis-identification and species' omission adds to the credibility of the monitoring data.

Suspect measures or species should be evaluated with field-crew members, by review of data sheets, by field verification if possible, and for new occurrence of a species, by comparison with park-level species list and by species-range limits. If the suspect information is determined to be in error, the database should be updated. If the issue at hand can not be resolved, the current measure or species should receive a low-confidence data-quality flag. This flag is considered in further analyses. Depending on the potential severity of the possible error, the information can be included or excluded from various analyses. Additionally, the measure or species in question should be brought to the attention of the field crew in the next monitoring visit. This ensures the acquisition of information for potential resolution of the suspect information.

The following data-quality assessments are performed for each plot included in the recent monitoring event:

3.1 Procedures

a) Plot-level measures are evaluated on the basis of a specified maximum rate of change. The rate of change is the difference between the current and previous measure divided by the time difference between the measurements. A rate can be negative (decreasing) or positive (increasing). Given a rate of change criterion, plot-level measures exceeding this criterion are noted for further consideration. The rate of change must be scaled to determine 'extremes', otherwise a plethora of observations will be listed as potential errors. The best rate of change for 'extremes' will require experience with 'acceptable' rates of change. It is important to remember that even large rates of change are not necessarily errors, but may indicate substantive and important change in a measure. The intent of this procedure is to highlight 'extremes' for further resolution. All measures listed in Tables 1 and 2 are screened on the basis of rate of change.

Key information output from this assessment is illustrated in Table 4. General plot-level information is recorded for reference (Table 4 - 1). The attributes outside the prescribed range of change and related information are recorded to aid in resolving suspect measures (Table 4 – 2).

Table 4. Output from the rate-of-change assessment.

4-1. Plot-level information.

Park	Ecological Site	PlotID	No. yrs visited	Yr of last visit	Yr of recent visit

4-2. List of attributes outside the prescribed, acceptable rate of change.

Attribute	Previous observation		Recent value	Rate of change limit	Rate of change
	Yr	Value			

b) The occurrence of newly recorded species and of historical species not recorded in the most recent monitoring event is not definitive evidence of errors. The lack of contemporary observations of a species can indicate localized extinction or simply phenological differences between pot visits. The observation of a species not previously recorded on a plot can be due to recent establishment. Listing of newly recorded species and of the lack of historical species in the recent monitoring event at least identifies ‘suspect’ observations. The list is further evaluated to determine acceptability of observations, or the need for more detailed consideration. The list of new and of ‘missing’ species is generated using the historical observations on a plot.

Key information included in this species-verification list is illustrated in Table 5. This information is generated for each plot included in the most recent monitoring event. General plot-level information is recorded for reference (Table 5 - 1). For newly recorded species, the name, lifeform, and plot-level cover and frequency measures are output to facilitate further evaluation (Table 5 - 2). For historical species not recorded in the recent event, information pertaining to the last observation is listed (Table 5 – 3). This information can provide evidence for why a species was not detected. For instance, it would be reasonable not to record a species if it occurred previously at low frequency and low cover.

Table 5. Output from the species verification procedure.

5-1. Plot-level information.

Park	Ecological Site	PlotID	No. yrs visited	Yr of last visit	Yr of recent visit

5-2. List of newly recorded species.

Species	Lifeform	% cover	% frequency			
			0.01 m ²	0.1 m ²	1.0 m ²	10.0 m ²

5-3. List of historical species not recorded in recent monitoring event.

Species	Lifeform	No. yrs with observations	Yr of last observation	Measures from last observation				
				% cover	% frequency			
					0.01 m ²	0.1 m ²	1.0 m ²	10.0 m ²

4.0 Annual Summaries & Report

The function of the annual summary report is to document accomplishments of the most recent monitoring event (i.e., field season), and to provide an overview of the data collected in the event. Data summaries are performed and reported at the Ecological Site level, which is treated as a stratum in NCPN Integrated Upland monitoring. An annual summary and report is done separately for each NCPN park unit with upland monitoring.

4.1 Procedures – Summarizing Annual Observations

4.1.1 Dryland Monitoring Data

a) Record the number of plots visited ecological site, and the number of years a plot has been monitored including the latest monitoring event (e.g., Table 6). In an appendix, list the NCPN PlotID of the monitoring plots visited in the reporting year. The PlotID is recorded in the NCPN Integrated Upland database. The ecological site codes and numbers are defined in this table, and can be used in subsequent tables.

Table 6. Upland monitoring sites visited in 2006.

Ecological Site (code and no.)	No. of plots	Re-visit interval
Semidesert shallow sandy loam (SDSSL236)	5	2
Semidesert sandy loam (SDSL215)	10	1
....		

b) An overview of the recorded data is provided by tabulating averages and ranges of plot-level measures. Summary information (e.g., mean and range) of measures is derived across monitoring plots of the same ecological site. Tables shown below should be generated for each park unit included in the most recent monitoring event.

i) Summarize the number of species by lifeform (e.g., Table 7), and total richness, diversity, and evenness (Table 8) by ecological site type.

Table 7. Mean (range) number of species by lifeform per monitoring plot by ecological site.

Ecological Site	No. of plots	Forbs				Graminoids				Dwarf Shrubs		Shrubs		Trees	
		Native		NonNative		Native		NonNative		Native	Non Native	Native	Non Native	Native	Non Native
		Perennial	Annual	Perennial	Annual	Perennial	Annual	Perennial	Annual						
SDSL215	11	6.0 (4-10)	2.0 (0-5)	0.0 (0-0)	0.4 (0-1)	5.8 (3-9)	0.2 (0-1)	0.0 (0-0)	0.1 (0-1)	2.5 (2-6)	0.0 (0-0)	3.5 (1-6)	0.0 (0-0)	0.1 (0-1)	0.0 (0-0)
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Table 8. Mean (range) plot-level species' richness, diversity, and evenness.

Ecological site (no. o f plots)	No. of species	Diversity	Evenness
SDSL215 (11)	20.6 (13.0-26.0)	4.7 (3.5-7.2)	0.6 (0.4-0.7)
...	...	...	...

ii) Summarize percent frequency and percent cover for only the dominant plant species. What constitutes ‘dominant’ may vary among ecological site, among years, and among park units. The intent is to summarize information about the plots without listing every species. Document the limits used to define dominant in the table header (e.g., Table 9). This summary is provided for every ecological site included in the monitoring event.

Table 9. Mean (range) percent frequency and cover values for ‘dominant’ plant species, by lifeform, by quadrat size, for the six monitoring plots located in the Semidesert Sandy Loam ecological site. Dominant is defined as occurring in at least 10 of the 15 quadrats on at least one of the monitoring plots.

Lifeform/ Species	No. of plots with occurrence	Percent frequency				Percent cover
		0.01 m ²	0.1 m ²	1.0 m ²	10.0 m ²	10.0 m ²
Perennial grass/ Genus species	n	xxx (yyy-zzz)	xxx (yyy-zzz)	xxx (yyy-zzz)	xxx (yyy-zzz)	xxx (yyy-zzz)
<i>Genus species</i>						
.....						
Annual grass/ Genus species						
Perennial Forbs/ Genus species						
Annual Forbs/ Genus species						
Shrubs/ Genus species						
Trees/ Genus species						

iii) Repeat the percent frequency and percent cover summary for exotic plant species only, and for any Threatened and Endangered (T&E) species. Given concerns for exotic-species invasions, all exotic and T&E species should be included regardless of their frequency or cover. This summary is provided for every ecological site included in the monitoring event.

iv) Summarize the cover measures of lifeforms, and of surface features, by ecological site type (Table 10).

v) Summarize cover of biological crust attributes, by ecological site type (Table 11).

vi) Summarize the gap measures by ecological site type, showing at least the percentage of the different measures (Table 12).

Table 10. Mean (range) percent cover of vegetative lifeforms, and of surface features, by ecological site type.

Ecological site (no. of plots)	Shrubs	Annual Grasses	Perennial Grasses	Forbs/Herbs	Bare soil	Litter	Woody debris	Small rock	Large rock	Bedrock	Biocrust	Undiff. Crust
SDSL215 (11)	7.9 (4.0-13.3)	0.1 (0.0-0.7)	11.9 (4.2-21.9)	0.4 (0.0-1.3)	2.7 (0.3-8.3)	6.8 (1.5-13.5)	0.2 (0.0-0.9)	1.1 (0.0-5.0)	0.3 (0.0-1.6)	0.0 (0.0-0.0)	11.6 (0.0-35.7)	64.9 (34.2-89.5)
...	...	...	...	...	...	...	...	...	...	...	...	...

Table 11. Mean (range) percent cover of crust measures by category, by ecological site type.

Ecological site (no. of plots)	Crust, undifferentiated	Cyanobacteria	Lichen	Moss
SDSL215 (11)	67.6 (33.8-88.5)	11.3 (0.0-38.1)	0.2 (0.0-0.8)	0.3 (0.0-1.1)
...	...	...	...	...

Table 12. Mean (range) percent canopy and basal measures, by ecological site type.

Ecological site (no. of plots)	Canopy			Basal	
	Gap	Non-shrub vegetation	Shrub	Gap	Basal area
SDSL215 (11)	64.4 (54.2-76.6)	31.9 (13.7-44.1)	3.6 (1.0-9.8)	80.8 (68.6-88.8)	19.2 (11.1-31.4)
...	...	...	...	...	...

vii) Summarize the shrub density measures by ecological site type (Table 13).

viii) Summarize the soil stability measures by ecological site type (Table 14).

Table 13. Density of shrub species per monitoring plot by ecological site type.

Ecological site (no. of plots)	Latin name	Common Name	No. of plots	Mean density (no./10m2)	Min. density	Max. density
SDSL215 (11)	<i>Atriplex canescens</i>	Four-wing saltbush	9	0.57	0.13	1.6
...	...	...	...	...	...	...

Table 14. Mean (range) soil-aggregate stability measures. Protected are samples collected under vegetation; unprotected are samples collected in the open.

Ecological site (no. of plots)	Total	Protected	Unprotected
SDSL215 (11)	4.5 (2.8-5.9)	4.9 (3.1-6.0)	4.2 (2.6-5.9)
..	..	..	..

4.1.2 Forest and Woodland Monitoring Data

- i) Generate Tables 6-8 (see above) for forest and woodland monitoring data.
- ii) Summarize percent cover for only the dominant plant species (similar to Table 9 above). Define dominant in the table heading (Table 15). This summary is provided for every ecological site included in the monitoring event.

Table 15. Mean (range) percent cover for ‘dominant’ species, by lifeform for the six monitoring plots located on the brushy loam ecological site. Dominant is defined as percent cover >30%.

Lifeform/Species	No. of plots with occurrence	Percent cover
Perennial grass/ <i>Genus species</i>	n	xxx (yyy-zzz)
<i>Genus species</i>		
... ..		
Annual grass/ <i>Genus species</i>		
Perennial Forbs/ <i>Genus species</i>		
Annual Forbs/ <i>Genus species</i>		
Shrubs/ <i>Genus species</i>		

- iii) Summarize the cover measures of lifeforms, and of surface features, by ecological site type. Table 10 (see above) can be used for this, but it needs to be modified to include an overstory category.
- iv) Summarize the shrub, sapling, and tree density measures. The format of Table 13 (see above) can be used for each of these attributes.
- v) Summarize fuel loadings by fine and coarse woody debris categories (Table 16).

Table 16. Mean (range) fuel loadings by size categories.

Ecological site (no. of plots)	Fine-woody debris volume (m ³ /ha)	Coarse-woody debris volume (m ³ /ha)

4.2. Procedures – Annual Summary Report

Existing annual reports should be consulted for the format of annual reports. Feedback from park staff may result in changes in report formats over time, and different park units may request or require slightly different formats from other park units. Extant annual reports are available on the NCPN web page.

5.0 Sampling-Design Variance Assessment & Report

The sampling designs for each ecological site in each NCPN park unit were to ensure early warning of system degradation, and in general, ecosystem health. Crafting these designs required estimates of variance components, specifically, site (plot), year, and residual variance (Larsen et al. 1995) for key attributes. These attributes vary among park units, but generally consist of percent cover of key lifeforms. Variance estimates were derived in various ways. But even the well-researched estimates can become obsolete over time due to substantive changes in system conditions, such as those resulting from climatic change. The Appendices of this protocol narrative contains details on the sampling designs for each park unit with upland monitoring. These appendices should be consulted to determine the proposed sampling objective of the current sampling design for each park unit.

To evaluate the efficacy of the extant sampling design, it is prudent to evaluate the realized levels of the variance components after at least 5-yrs of monitoring data. The recommended frequency of assessments thereafter will vary. Variance assessment is based on all data collected to date, not just observations of the current monitoring event. The utility of this assessment will depend on the number of plots with observations, the number of revisits, and the re-visit intervals. However, constant checking of the assumptions of the sampling design affords timely opportunity to invoke enhancements to meet the original monitoring and sampling objectives.

5.1 Procedures – Variance & Power-for-trend Assessment

The following procedures should use the key attributes employed in crafting the sampling design for an ecological site in a park unit:

a) Variance components are estimated using the Methods of Moments Estimation. In the SAS code for generating this estimation (Table 17), site and year are categorical variables coded to indicate the plot (site) and the year of a response (the measurement of an attribute). For simplicity, site should be the NCPN PlotID (recorded in the Integrated Upland database for each monitoring location) and year should be the calendar year when the observation was recorded. The Mean Square Error (MSE) and degrees of freedom (df) derived from the Methods of Moments Estimation model are used to generate values of variance for site, year, and year*site (residual or index variance). Derivation of variance from MSE and df are shown in Table 18.

b) Values of the variance components, the panel structure of the current sampling design, and the desired minimum detectable change level determine the power-for-trend. Power-for-trend is assessed using the Power-for-Trend R code (See Attachment A). Comparing the resulting power with the proposed power of the sampling design determines the degree to which the implemented design is achieving the stated sampling objective(s). Using procedures outlined in Attachment A, determine power-for-trend for the key

attributes considered in crafting the sampling design. Desired and realized power-for-trend for each key attribute are tabulated (e.g., Table 19).

Where necessary, alternative survey designs can be evaluated to determine necessary enhancements to achieve the original sampling objective. This involves using the empirically derived variance estimates with alternative numbers of panels, sample sizes, and re-visit schemes. Alternative survey designs are easily codified and entered into the power-for-trend function located in Attachment A. Power-for-trend results are used to determine survey designs which better met the original sampling objectives.

5.2 Procedure –Variance and Power-for-trend Report

The initial assessment of variance should be performed in the first detailed assessment of status and trends. Results of this initial assessment should be a section in the status and trends report. Results will consist of Table 19, and any alternative designs deemed more efficient in terms of the original sampling objective. Thereafter, if it is desirable to perform variance assessments more frequently than status and trend assessments, results should be included as a separate section in the annual summary, or as a separate report. Otherwise, variance assessment and power-for-trend is performed and reported in every status and trend report.

Table 17. SAS code for generating ln-transformed estimates of variance components based on Methods of Moments Estimation

```
DATA THEKS1;
  INFILE '<pathname\filename>';
  INPUT site year response; LogResp= log(response+1);
RUN;
TITLE "Methods of Moments Estimates";
PROC mixed method= type3 covtest asycorr;
  class year site;
  MODEL LogResp = ;
  random site year site*year;
RUN;
```

Table 18. Derivation of variance components from the Mean Square Errors (MSE) produced by Methods of Moments Estimation (Larsen et al. 1995).

σ^2_{site}	=	$(\text{MSE}_{\text{site}} - \text{MSE}_{\text{site}*\text{year}})/t$
σ^2_{year}	=	$(\text{MSE}_{\text{year}} - \text{MSE}_{\text{site}*\text{year}})/l$
$\sigma^2_{\text{residual}}$	=	MSE Residual
t	=	number of years (years df+1)
l	=	number of sites (site df+1)

Table 19. Assessment of realized power-for-trend for key attributes. Variance is based on natural log transformation of observations. (Table entries are contrived, and are provided for illustrative purposes).

Park unit	Eco. site	Attribute	No. of yrs	No. of unique sites	Desired minimum detectable change	Desired power-for-trend	Realized power-for-trend	Realized variance		
								site	year	residual
CANY	Desert Shallow Sandy Loam	% shrub cover	3	31	3%/10-yr period	0.80	0.85	0.1	0.001	21.0
...	...	...	...	...	...	...	...	...	...	...

6.0 Comprehensive Assessments & Reports

6.1 Status and Trends Assessments - Frequentists Methods

Status and trend analyses are performed after multiple years of data are collected. A minimum of 5-yrs of data are generally needed before statistical detection of trends using frequentists methods. Status and trend assessments are possible for each attribute listed in Tables 1 and 2. At a minimum, however, status and trends of the key attributes used in crafting the sampling design for a park unit and ecological site should be considered (see Appendices of the protocol narrative for specifics on sampling designs in each park unit).

The underlying motivation for using survey designs in monitoring upland features is the lack of assumptions in making inference to a finite, target population. Alternatively, model-based designs and assessments rely on modeled relationships, and thus tend to have inherent assumptions, and in some cases, limitations in terms of the scope of inference. However, model-based assessments may be useful to help explain reasons for trends observed in survey-design efforts. For instance, information from other vital signs monitoring (e.g., climate, air quality, land-use, land condition) or other sources may prove critical to interpreting observed upland trends. For this reason, two general procedures are used in status and trend assessments. The first is a ‘standard’ survey-design assessment in which trends are evaluated on the basis of time. The second involves model-selection procedures, which consider a range of potential factors influencing directional change in resource conditions. Even if a significant trend occurs as a function of time, the relationship between other explanatory variables and upland measures should be evaluated to determine potential ‘causal’ factors of trends. These other explanatory variables can include biophysical features of the monitoring plots as well as measures from other vital signs monitoring (e.g., climatic conditions). These two

approaches are complimentary, and collectively, enhance the overall assessment of resource change.

6.1.1 Procedure – Survey-Design Status and Trend Assessments

Procedures for a standard status and trend assessment of survey designs include the following:

a) Trend assessments of complex survey designs are performed using a mixed-effects ANOVA model (Larsen et al. 1995). Time is treated as the fixed effect, and site and year are the random effects. Site refers to the plot, and year is the same as time. Both site and year are treated as categorical variables. Site can be coded in any manner, but for consistency should be the NCPN PlotID. Time and year similarly can be represented by any coding scheme, but should be the actual year the response (i.e., the measure of an attribute) was recorded. The SAS code for evaluating trend is presented in Table 20. The output from this model is a measure of the intercept and slope, the significance of the slope and intercept being different from zero, and measures of the variance and covariance of the regression parameters. A significant slope indicates a significant trend at least at the alpha level used to assess significance. Trend assessments are performed separately for each ecological site type in a park unit. Trend assessments for measures shown in Tables 1 and 2 are straight forward. The plot-scale measures with corresponding time, site, and year values are directly used in the mixed-effects model.

Table 20. SAS code for a mixed-effects model to evaluate significance of trend.

```
INFILE '<pathname\filename>';
INPUT time site response; year=time; LogResp = log(response+1);
RUN;

PROC mixed method=type3;
class site year;
MODEL LogResp = time/cl covb ;
random site year ;
RUN;
```

b) Status is the condition of the attribute, and is derived in two ways. If the trend slope is not significantly different from zero, mean and variance of status is simply the mean and variance of all measures of the attribute up to the current time period. If the slope is significant, then status is the solution of the regression model for the latest time period of the data used to generate the trend line (eq. 8 in Table 21). Variance measures of mean status are derived from the covariance matrix of the regression coefficients (eq. 9 in

Table 21), which is output by the SAS model shown in Table 20 (i.e., via the covb option).

Table 21. Formula for deriving status and trend estimates.

Mean Status From a Trend Line															
$ST_t = b_0 + b_1 * t$												(8)			
where;															
t = the most recent time period of the data (in the same units used to generate b_0 and b_1)															
b_1 = the estimated slope parameter															
b_0 = the estimated intercept parameter															
ST_t = estimate of mean status at time = t															
Standard Error of Status															
$SeST_t = \sqrt{(\sigma_{b_0}^2 + 2t \sigma_{b_0b_1} + \sigma_{b_1}^2 t^2)}$												(9)			
where;															
t = the most recent time period of the data															
$\sigma_{b_1}^2$ = the variance of the slope parameter															
$\sigma_{b_0b_1}$ = the covariance of the regression parameters															
$\sigma_{b_0}^2$ = the variance of the intercept parameter															
$SeST_t$ = the standard error of the mean-status estimate at time = t															

c) For all attributes considered, the results of status and trend assessments are tabulated by park unit and ecological site for reporting (e.g., Table 22). Significant trends should be highlighted. For significant trends, reasons for these trends should be evaluated by literature reviews, contacting other networks and agencies conducting similar monitoring to determine occurrence of similar results, and additional assessments with ancillary information. The latter is described in the following Procedure section.

Table 22. Summary of trend and status assessments in park unit x, ecological site y.

Attribute	No. of yrs	No. of unique sites	Trend model			Intercept			Slope			Status	
			df	F	P	Estimate	Variance/Se	P	Estimate	Variance/Se	P	Mean	Se

d) Inference of status to the total monitored population in a park unit is made using the Horvitz-Thompson Estimator (Thompson 1992). When an inference is to be made based only on observations of the most recent monitoring period, the procedures outlined below

should be used. If inference is to be made using trend line status estimations, refer to Thompson (1992) for specific details on how this is performed.

The status inference is based on sampled observations across any number of ecological sites, but from the same time period. Thus, the inference is a measure of an attribute over the sum of target populations of all ecological sites included in a monitoring event. In general, samples are acquired from all ecological sites in a park unit each monitoring event. Derivation of the mean and variance for the Horvitz-Thompson Estimator is shown in Table 23 (eq. 10). Although the estimator provides an unbiased result, the variance can be large if π_i and y_i are not well related (Thompson 1992). In such case, the Generalized Horvitz-Thompson Estimator should be used (eq. 13, Table 23). The mean and standard error of status for the total monitored population in a park is included in the report.

Table 23. Formula for the variants of the Horvitz-Thompson Estimator.

Horvitz-Thompson Estimator

$$y_{\pi} = \left(\sum_{i=1}^v y_i / \pi_i \right) / N \quad (10)$$

where;

N = total number of unique monitoring plots (all strata combined)
 π_i = the inclusion probability that plot i is in the sample
 y_i = observed value for plot i
 v = the number of plots in the sample
 y_{π} = estimate of the mean

The inclusion probability, π_i , is derived from the selection probability of a plot, which is generated in the site-selection process (see Appendices of the narrative for details):

$$\pi_i = 1 - (1 - p_i)^n$$

where;

n = number of plots in a sample
 p_i = the selection probability of plot i

The variance of the mean is:

$$\text{var}(y_{\pi}) = \left[\sum_{i=1}^v \left(\frac{1}{\pi_i^2} - \frac{1}{\pi_i} \right) y_i^2 + 2 \sum_{i=1}^v \sum_{j>1}^v \left[\frac{1}{(\pi_i \pi_j)} - \frac{1}{\pi_{ij}} \right] y_i y_j \right] / N^2 \quad (11)$$

where;

π_{ij} = the inclusion probability that both plots i and j are in the sample.

where;

$$\pi_{ij} = \pi_i + \pi_j - [1 - (1 - \pi_i - \pi_j)^n]$$

The confidence interval using a t with v-1 degrees of freedom is:

$$y_{\pi} \pm t \sqrt{\text{var}(y_{\pi})} \quad (12)$$

Generalized Horvitz-Thompson Estimator

$$y_g = \sum_{i=1}^v (y_i / \pi_i) / \sum_{i=1}^v (1 / \pi_i) \quad (13)$$

$$\begin{aligned} \text{var}(y_g) = & \left[\sum_{i=1}^v ((1 - \pi_i) / \pi_i^2) (y_i - y_g)^2 \right. \\ & \left. + 2 \sum_{i=1}^v \sum_{j>1}^v [(\pi_{ij} - \pi_i \pi_j) / \pi_i \pi_j] [((y_i - y_g)(y_j - y_g)) / \pi_{ij}] \right] / N^2 \end{aligned} \quad (14)$$

The confidence interval using a t with v-1 degrees of freedom is given in eq. 12, but using y_g .

6.1.1.1 Trend Assessments of Plot-level Community and Multivariable Measures

a) In addition to plot-level measures noted in Tables 1 and 2, plant community measures are generated and evaluated in trend assessments. Changes in community composition and structure between time periods can be summarized by the average Euclidean distance between resemblance matrices, and the evaluation of trends in this distance measure for all pair-wise time periods determines the occurrence of significant changes (Collins 2000). Resemblance matrices consist of lists of species that occur in either of two time periods, and a measure for a species in each time period. Measures can be percent cover or percent frequency. If a species only occurred in one of the time periods, a value of zero is used for the other time period. For each monitoring plot, the average Euclidean distance for all possible pair-wise comparisons of time periods is derived and used in a

trend assessment. Associated with each pair-wise distance is the time lag, which is simply the time difference between the pair-wise samples. For trend assessments, the square-root of time lag is used to down-weight the smaller number of values for the longer time lags (which characteristically will be fewer than for shorter time lags). For all monitoring sites of an ecological site-type combined, the site, year (categorical form of the square root of time lag), and time (continuous value of square root of time lag) are used in eq. 8 to evaluate significance of trend in the average Euclidean distance. A significant trend indicates changes in community composition and structure over time. Where a significant trend occurs, further investigation is required to determine species loss or addition, or changes in the species measure (cover or frequency) resulting in the significant trend.

Euclidean distance between two samples is first derived using eq. 15 in Table 24. An average Euclidean distance (eq. 16, Table 24) is then derived, which compensates for increasing distance with increasing number of species.

b) Trends in size-class distributions also can be evaluated using the average Euclidean distance measure. For canopy and for basal gap measures, a frequency distribution of gap sizes or of canopy (or basal) sizes are generated for each monitoring event, and changes in this distribution evaluated using the same approach outlined above for plant communities. For each attribute, the size-class interval, however, must be constant among all years, and the sub-sample basis of the plot-level measure has to be constant (i.e., the same number and length of transects in all years and on all plots). A significant slope indicates a trend in the frequency of gap or canopy sizes, and further investigation is required to determine which class intervals increased or decreased in frequency over time.

c) Similarity metrics are an additional means to evaluate plant community change over time. A simple but useful measure is the Coefficient of Sorensen (eq. 17, Table 24). This coefficient is based on presence/absence of species, and more heavily weights matches in species composition than mismatches. When a plot has multiple years of observations, a Sorensen's similarity coefficient based on all recorded species and the associated time lag is derived for all pair-wise time periods. For all monitoring sites of an ecological site-type combined, the site, year (categorical form of the square root of time lag), and time (continuous value of square root of time lag) are used in eq. 8 to evaluate significance of trend in the similarity. A significant trend indicates changes in community composition. Where a significant trend occurs, further investigation is required to determine species loss or addition resulting in the significant trend.

Table 24. Formula for deriving measures of Euclidean distance, and similarity.

Euclidean Distance

$$Euc_{jk} = \sqrt{S (x_{ij} - x_{ik})^2} \quad (15)$$

where;

x_{ik} = attribute of category i in sample k

x_{ij} = attribute of category i in sample j

Euc_{jk} = the Euclidean distance between samples j and k

NOTE: an attribute could be percent cover or frequency, or frequency of size classes, and a category is either a species or a size class. E.g., if working with percent cover, then x_{ik} is percent cover of species i in sample k, and x_{ij} is percent cover of species i in sample j.

Average Euclidean Distance

$$AEuc_{jk} = \sqrt{Euc_{jk}^2 / n} \quad (16)$$

where;

n = the number of categories in samples

Euc_{jk} = the Euclidean distance between samples j and k (eq. 8)

$AEuc_{jk}$ = the average Euclidean distance between samples j and k

Sorenson's Similarity Coefficient

$$S_s = 2a / (2a + b + c) \quad (17)$$

where;

c = the number of species in sample 1 but not in sample 2

b = the number of species in sample 2 but not in sample 1

a = the number of species in both sample 1 and 2

S_s = Sorensen's similarity coefficient

6.1.2 Procedure - Model-Based Assessment of Trends

Model-based assessments of survey designs are recommended. Model selection methods (Burnham and Anderson 1998) are used to evaluate the explanatory power of different models of trends in upland measures. Multiple models are considered, each with different combinations of independent variables and interaction terms. All models should be based on hypothesized, ecologically meaningful relationships. Adjusted AIC values (Akaike's Information Criterion) generated with the mixed-effects model (Table 20) are used to determine the best predictive model as well as the importance of independent variables.

The primary model in this model-selection procedure is the response of interest vs. time (see above). Numerous other models can be considered. Models can be based on measures of climate, air quality, land use, and land condition, as well as other measures that may be considered important. The exact measures to consider will develop over time as other monitoring information becomes available, and with experience. For instance,

climate measures are an obvious choice, and measures of drought, precipitation, degree day, etc., are obvious attributes for consideration. However, the availability and the spatio-temporal resolution of this information is unclear at this point in time. When evaluating other variables, they are either included with time (i.e., to evaluate the interaction with time), or year is eliminated and time is replaced with the variable (Table 20). The exact form of alternative models will depend on the type of variable being considered. To be included as a fixed effect, the variable must be continuous. Otherwise, it must be treated as a covariate and included as a random effect.

The result of the model-selection procedure is the selection of the model (i.e., set of independent variables) which best predicts the trend of the response variable. This, in turn, aids in explaining reasons for the observed trend. For instance, if alternative models with one or more driver attributes (i.e., drought days) accounted for more variance than just using time, then trends may be attributed to these attributes (within the context of a correlational relationship, not necessarily a causal relationship). If alternatives to just time accounts for less variance, then other avenues of investigation should be considered to explain reasons for observed trends.

Model selection procedures are recommended, but exact guidelines are not provided. As data become available for trend assessments and as the full suite of NCPN monitoring data becomes more evident, model-selection procedures should be exercised. With experience, specific guidelines for using this approach should be developed and documented in this section of the SOP.

6.2 Bayesian Assessment of Trends

Bayesian methods for trend assessment identify the probability of different slope-parameter values (Gelman et al. 2000, Wade 2000) given the observed data. This differs from frequentist methods which calculate the probability of observing data given a specific value for a parameter, such as the null hypothesis. Assessing the probability of different slope values is potentially important for various reasons. First, sampling designs are largely based on a few key features. The minimum detectable trend at a reasonable power level for many of the other attributes listed in Table 1 likely will be considerably much higher. Estimating the probability of slope values may be the best way to provide insight into trends for these attributes. Second, even for the key features around which sampling designs were based, Bayesian methods may reveal the potential of declining trends before rejecting the null hypothesis that the regression slope equals 0 with conventional statistics.

The technical calculations of Bayesian methods are beyond the scope of this SOP. Wade (2000) provides a readable overview, and Gelman et al. (2000) provide indepth explanations of the underlying mathematics of various analytical methods. In short, a Likelihood distribution is generated from the sample data which provides the probability of observing the data for every possible parameter value. Combining this with a prior

distribution produces a posterior distribution which is used to make inference about parameters. The prior distribution reflects previous knowledge about the distribution of parameters. In the absence of such knowledge, a non-informative distribution can be used, which essentially is a uniform distribution across the range of the Likelihood distribution. In subsequent analysis, the posterior distribution of previous assessments is used as the prior distribution. The posterior distribution allows assessments of the probability of user-selected parameter values. The probability of various increasing and decreasing slopes should be evaluated based on the posterior distribution, and the consequences of not alerting management of a potential trend. The result of this assessment is the derivation of the probability of different levels of decline/increase. Even though conventional statistics may not reveal a significant trend, relatively high probabilities (e.g., ≥ 0.70) of trends with a Bayesian method may warrant special attention.

Bayesian methods for trend assessments are recommended, but exact guidelines are not provided. As data become available for trend assessments, Bayesian procedures should be developed. With experience, specific guidelines for Bayesian analysis of trend should be documented in this section of the SOP.

6.3 Correlational Assessments

There will be instances where a monitored attribute fails to exhibit a trend (i.e., a direction change), but instead may have periods of decline followed by recovery. In other words, natural variation may be more evident than a precipitous decline or increase, and mirror the variation in a key driver attribute. Discerning this variation and reasons for it can involve many complex procedures. As a first step, however, correlational methods can provide useful insight, and are relatively simple.

For attributes listed in Tables 1 and 2 which fluctuate between declines and increases, correlations with climatic, air quality, land cover/use, land condition, and other potential drivers should be considered. Strong correlations between a response and driver may be sufficient to understand reasons for the observed variation over time (e.g., strong correlation between shrub cover and annual precipitation).

Another form of correlational assessment is path analysis (Lindquist 2000). This method accounts for the inter-correlated structure among factors by decomposing correlations to direct and indirect effects. For instance, changes in grass cover in a shrub-steppe system may be influenced by shrub cover alone, or by climate alone, or by the influence of climate on shrub cover. A path analysis would decompose the effects of climate and of shrubs on grass cover, while considering the combined influence of climate and shrubs. The result of a path analysis is the indication of the strength of direct and indirect factors on a response, thus providing insight into reasons for the observed changes in a response. Path analysis is based on correlation values, and the simultaneous solution of structural equations. Simple examples of the construction and use of path analysis are provided in

Lindquist (2000) and Van Bruggen and Arneson (1986); details of path analysis are provided in Pugese et al. (2003).

Correlation and path analysis are recommended, but exact guidelines are not provided. As monitoring data accumulates, correlational procedures should be developed. With experience, specific guidelines for simple correlation and for path analysis should be developed and documented in this section of the SOP.

6.4 Comprehensive Assessment Report

The exact structure of a comprehensive assessment report will evolve with experience. In general, the report should be structured as a ‘typical’ scientific document with standard sections – including an Introduction, Study Area, Methods, Results, Discussion, and Literature Cited. Also, an executive summary is required which should be general enough for a wide audience, but of sufficient detail to be informative. Appendices should be used for information that would be too detailed for the average reader if included in the main body of the text.

At a minimum, report content should include the following:

- Explanation of all methods and data sources (e.g., those from other vital signs monitoring)
- Results of each status and trend assessment using the survey-design approach (e.g., Table 22)
- Status estimates for all monitored populations combined
- Results of each model-selection procedure
- Results of Bayesian procedures, if used
- Results of correlational procedures, if used
- A detailed synthesis of above results, in terms of which upland attribute exhibits a trend, and plausible reasons for the trend
- A detailed assessment of other available information for comparison with NCPN results, and to aid in explaining trends (or lack of trends) in NCPN monitoring results. ‘Other data’ would include results from other I&M networks, from monitoring by other federal and state agencies across the Colorado Plateau, etc.
- The highlighting of trends which require more careful scrutiny by the NCPN and park management. Specifically, an evaluation of the status of a declining attribute relative to a management trigger or ecological threshold is critical. The results of this evaluation need to be in the fore-front of the report, to ensure early-warning of possible resource degradation.
- Results of the evaluation of sampling design variance and power-for-trend. This includes the tabulation of results (Table 19) and discussion regarding the need to modify the sampling design. If modification is required, the alternative designs evaluated and the recommended new design needs to be discussed and documented.

7.0 Literature Cited:

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Attachment A Power-for-Trend Procedures

The Power-for-Trend R code written by T. Kincaid (EPA, Corvallis, OR) is used to evaluate power for trend. This code resides as two files on the NCPN server, and are called trendse.R and power.R. The original power.R code was modified to facilitate ease of code modification to evaluate multiple sets of variance estimators. The portion of the code that must be modified occurs at the very top, and is shown in Table A-1. User-provided values are inserted in place of < >. Variance components are derived following procedures described in section III. Sampling-design Variance Assessment. The % trend value and alpha level correspond to the sampling objective being evaluated. The ind.mean (indicator mean) is set to 1 when working with variance measures from log-transformed data. Otherwise, this parameter is set to the mean of the indicator.

The nsites attribute specifies the number of panels and plots per panel, and re-visit design. In the example below, there are 5 panels (hence, nrow=5) with the number of plots specified for each year out to 10 yrs (hence, ncol = 10). In the first panel, 1 plot is visited in yr 1, then revisited every 4 years. The same re-visit scheme occurs for each panel, but the first year of monitoring increases by a year. The nrow and ncol parameters control how the list of numbers are interpreted. The nrow essentially indicates the number of panels, and ncol indicates the number of years of the panel design. Power-for-trend is derived from year 2 up to year = ncol. Thus, if the sampling objective being examined specifies a minimum detectable change over a 15-yr period, the panel-revisit design in nsites must extend out to 15 yrs. Values shown in bold in the nsites command are replaced with values specific to the design being examined.

After modifying the necessary parameter values in power.R, cut and paste trend.R into an R window, then cut and paste the modified power.R code into the same window for immediate execution. The modified power.R code also can be saved for later execution. For instructions on running R or to access the R program, see **The Comprehensive R Archive Network (CRAN)** web site (<http://cran.r-project.org/>).

Table A-1. Portion of Power-for-Trend R code that is modified for a specific assessment.

indicator=	"<name of indicator>"
ind.mean=	1
trend=	<% trend>
site.var=	< site variance >
year.var=	< year variance >
siteyear.var=	0
index.var=	< residual variance >
site.rho=	1
year.rho=	0
alfa=	<alpha value; e.g., 0.05, 0.1 >
plot.ind=	TRUE

```
nsites <- matrix(c(1,0,0,0,1,0,0,0,1,0,
0,1,0,0,0,1,0,0,0,1,
0,0,1,0,0,0,1,0,0,0,
0,0,0,1,0,0,0,1,0,0,
1,0,0,0,1,0,0,0,1,0), nrow= 5, ncol= 10 ,byrow=TRUE)
```

Successful execution of the power-for-trend code will result in a listing at the bottom of the screen indicating the year, power-for-trend, and the standard error of status (e.g., see below). The last entry in the list contains the power-for-trend value used for comparison with the sampling objective.

```
.....
Year      Power      Standard Error of Status
1  2      0.10171      0.29905
2  3      0.10583      0.27777
3  4      0.11288      0.26163
4  5      0.12349      0.24823
5  6      0.13836      0.23656
6  7      0.18196      0.20541
7  8      0.24693      0.18830
8  9      0.32448      0.17866
9 10      0.40652      0.17277
```

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 20

Revising the Protocol Narrative and SOPs

Version 1.01 (March 2007)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3-1-2007	S. Garman, NCPN Ecologist	Updated MVT	To reflect changes based on 2006 field work	1.01

This Standard Operating Procedure (SOP) explains how to make and track changes to the Narrative and Standard Operating Procedures for the Northern Colorado Plateau Network (NCPN) Upland Monitoring Protocol. Individuals editing the Protocol Narrative or any one of the SOPs need to follow these procedures in order to eliminate confusion on how data are collected and analyzed. All observers conducting the monitoring should be familiar with this SOP in order to identify and use the most current methods.

Procedures:

1. Modifications must be reviewed for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by NCPN Inventory and Monitoring staff. An outside review is required for substantive changes in methods. Regional and national staff of the National Park Service and experts outside of the Park Service with familiarity in vegetation and soil monitoring and data analysis will be used to review major changes.
2. All changes must be documented, and updated protocol versions must be recorded in the Revision History Log that accompanies the Protocol Narrative and each SOP. Changes are recorded only in the Protocol Narrative or the SOP being modified. 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 the changes along with the new version number.
3. Narrative and SOP updates may occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs; a narrative update may not require

SOP modifications. The NCPN tracks the narrative and SOP version numbers in a Master Version Table (MVT), which is maintained in this document (SOP #20). Any time a narrative or an SOP version change occurs, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The VK number increments by whole integers (e.g., 1, 2, 3, 4, 5). Updates to the MVT also must be provided to the NCPN Data Manager for inclusion in the master version table database. *The protocol narrative, SOPs, and data should not be distributed independently of this table.*

4. New versions of the protocol narrative and SOPs must be posted on the NCPN web page. Older versions of the Protocol Narrative and SOPs must be archived in the NCPN Upland Protocol Library (R:\Monitoring_Archive\Upland\Protocol).

Upland Monitoring, Northern Colorado Plateau Network Master Version Table

A dash (“-“) in a cell indicates that the narrative or SOP is not applicable during the corresponding time period.

Effective Date	Narrative	1-Preparations for the Field Season	2-Training Field Technicians	3-Using GPS Units	4-Crust-Friendly Field Procedures	5-Site Characterization	6-Establishing Plots	7-Repeat Photographs	8-Measuring Vegetation & Surface Cover	9-Measuring Canopy & Basal Gaps	10-Density, Frequency, & Richness	11-Soil Aggregate Stability	12-Site Impact Assessment	13-Measuring Overstory Trees	14-Measuring Fuels	15-Sampling Oak Plots	16-Unknown Plant Species	17-After the Field Season	18-Data Management	19-Data Analysis & Reporting	20-Revising the Protocol	21-Quadrat-Based Sampling
1/1/2006	-	1.00	1.00	1.00	-	1.00	1.00	1.00	-	1.00	-	1.00	1.00	-	-	-	-	1.00	-	-	1.00	1.00
1/1/2007	1.00	1.10	1.10	1.00	1.00	1.10	1.10	1.10	-	1.10	-	1.10	1.10	-	-	-	-	1.00	1.00	1.00	1.01	1.10

Upland Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 21

Measuring Occurrence and Cover of Vegetation and Soil Surface Features, and Shrub Density Using 10-m² Quadrat-Based Sampling

Version 1.1 (March 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3/1/07	SGarman	Added Preface section	To better explain how to integrate multiple SOPs while conducting this SOP	1.1

This SOP provides instructions for estimating nested frequency and cover of live vegetation, and soil-surface features, and for recording shrub density in 10-m² quadrats. Also, instructions are included for filling out the corresponding data form and the “Unknown Plant Species Data Sheet” (Appendix A). This SOP is used every plot visit. This SOP was adopted with modifications from the Vegetation Community Monitoring Protocol For the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program SOP #5 “Measuring Frequency and Cover of Herbaceous and Shrub Species”, Version 1.0 (Debacker et al. 2004).

Preface

Multiple SOPs are conducted while conducting quadrat sampling. Each SOP is a complete, stand-alone set of instructions with a specific purpose. For efficiency reasons and to minimize soil trampling, multiple SOPs are conducted more-or-less simultaneously or in an order that minimizes the number of times each transect has to be traversed. The following SOPs should be carefully reviewed before beginning quadrat sampling.

- **SOP#4** (Crust-Friendly Field Procedures) provides guidance to minimize soil trampling. Procedures must be followed while recording measures on a plot.
- Photos of transects and of selected quadrats (**SOP#7** – Repeat Photographs) are collected while conducting quadrat sampling. SOP#7 should be reviewed to ensure that the appropriate photos are acquired.
- While traversing each transect during quadrat sampling, soil samples are collected for soil-aggregate stability measures (**SOP#11** – Soil Aggregate Stability). This procedure

requires collecting 18 random samples. The Principle Investigator will provide a list of locations along each transect for samples.

- Shrub-canopy gaps are measured along the transect tape simultaneously with reading the five sets of quadrats on a transect (**SOP#9** -Measuring Basal and Canopy Gaps Using Line-Intercept Sampling). Basal gaps are measured immediately after completing the canopy gap/quadrat reading.
- Site Impact Assessment (**SOP#12**) records disturbances within and around the macroplot. While traversing the transects to record other measures, within plot impacts are recorded. Off-plot impacts within the vicinity of the macroplot also are recorded opportunistically while traveling between transects. Where visibility of the surrounding landscape is obscured, however, additional effort may be required for a thorough impact assessment. SOP#12 provides specific instructions for determining the spatial extent for assessing off-site impacts.

Sampling Teams

Quadrat sampling requires a two-person team: one “observer” to call out frequency, cover, and density and one “recorder” to write down these data. The sampling team should keep their same roles for frequency, cover, and density on a given transect.

Procedures

If field measures are recorded during a different visit from site establishment, start with procedure #1; otherwise skip to procedure 2.

1. Set up the tape.

Use a GPS (SOP #3) and the coordinates of the centroid to navigate to the macroplot. Look around for rebar posts marking the ends and middle of each transect using a metal detector if necessary. Read the metal tag on the rebar to check the plot ID and to determine the transect number and the position along the transect. See the section on plot ID below for information on the naming convention. Use a compass, the transect azimuth/aspect, and a metal detector if necessary to locate the other ends of the 50-m transects. Each monitoring site includes three 50-m transects spaced 25 meters apart (Fig. 1). Mark the middle and ends of each transect with pin flags and/or flagging tape. Avoid trampling the sampling area on the uphill side of transects.

Navigate to the “origin” end of transect 1. It is absolutely crucial to begin at the “origin” end and to know which transect you are sampling. Check metal tags on the rebar to confirm plot and transect identification. Anchor the “0” end of the tape to the “origin” end of transect 1. Walk towards the other end of the transect while pulling out the tape. Walk slightly downslope of the line to avoid trampling the sampling area. Fasten the tape with a steel pin so that 50 m is aligned with the rebar at the end of the transect. The line should be taut and as close to the ground as possible to avoid curvature in the line. It is okay to run the tape over low shrubs, but the tape should be threaded through any shrubs taller than ~0.7 m. If this is a repeat visit, check for proper transect alignment using the nails marking the two

corners of the 10-m² quadrat. A metal detector may be required for successful discovery of existing nail monuments. If it is windy, use additional steel pins to hold the tape in place at other points along the transect.

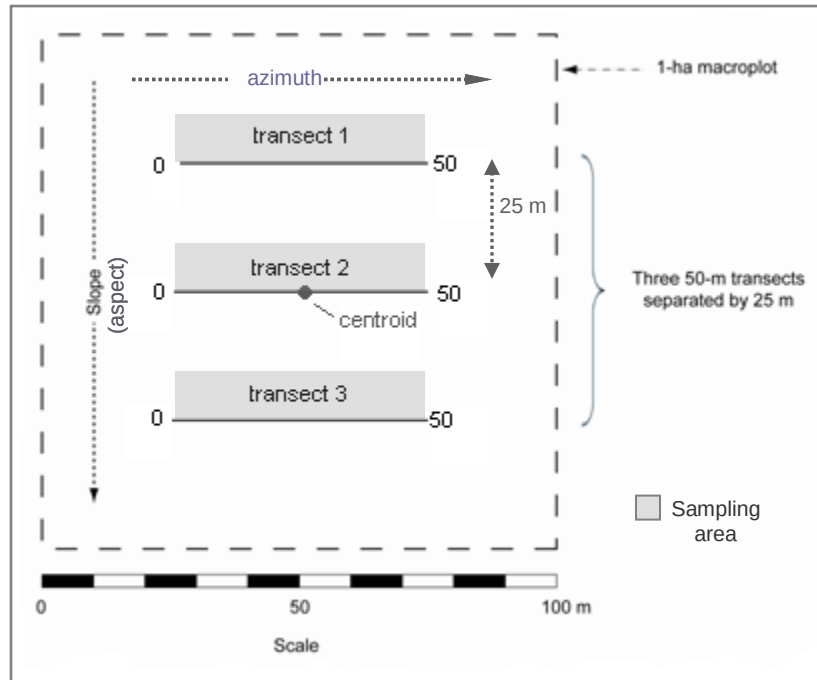


Figure 1. Standard macroplot and transect layout for terrestrial monitoring.

2. Take a photograph of the transect.

Use SOP #7 “Repeat Photos” to record a photo of each transect before you begin sampling. Complete only one photo point per transect per sampling date. SOP#7 also indicates the location of the three quadrat photos, which should be taken in conjunction with quadrat measurements.

3. Assemble the 1-m² sampling frame.

Make sure the sides are correctly aligned so that the tape marks form the 0.01-m² and 0.1-m² nested quadrats on one corner of the sampling frame (Fig. 2).

4. Lay out the nested 10-m² quadrats.

Frequency, cover, and shrub density data are collected in five 10-m² rectangular quadrats located along each transect, spaced 10 meters apart (Fig. 3). Along all transects, plots begin at 0 m, 10 m, 20 m, 30 m, and 40 m on the uphill side of the tape. For the first quadrat, align one unfolded 2m folding rule with one end of the rule at the anchor point of the quadrat (ie., 0, 10, 20, 30, or 40-m) and the other end of the rule resting against the nail that lies 2m perpendicular to the tape. Lay out the other unfolded rule at the 5m, (or 15m, 25m, 35m, or 45m) anchor point, with the far end resting against the other nail that is 2m perpendicular to the tape. Slide rules under or through shrubs if necessary. Care should be taken not to damage vegetation simply to lay frames flat on the ground. Also, the area within the nested

quadrats should not be disturbed during the frame lay-out process. Minimize the amount of walking around the 10-m² frame during the lay-out process unless you can do so without walking on soil – e.g., if rock or dead vegetation affords stepping stones. If this is the first time quadrats are being established, monument the two corners of the 10-m² quadrat that lie on the transect with 8-12” spikes. Pound the nails so that they are flush with the ground. If nails can not be inserted into the ground due to rock or other obstruction, indicate this in the comments box on the data sheet by noting the transect, quad number, and corner (i.e., transect distance from the origin; e.g., 15-m) and the reason for failure of an exact monument. If a repeat visit, make sure the two ends of the folding rules are properly aligned with the permanent nails marking the 10-m² quadrat corners. It is important to be diligent about the placement of the plots to ensure consistent sampling from year to year.

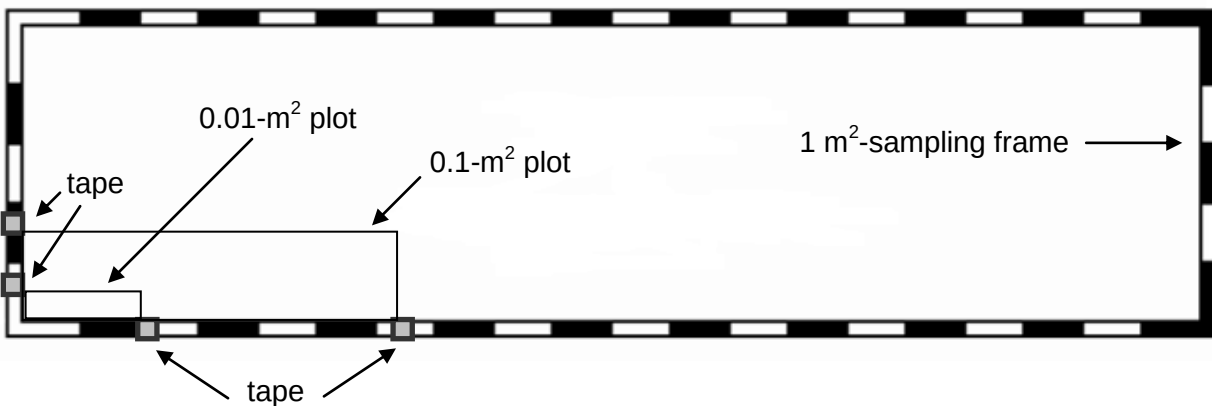


Figure 2. Alignment of nested frequency quadrats on the 1-m² sampling frame. Notice that the 0.01-m² and 0.1-m² quadrats are defined by the inside edge of the tape on the 1-m² sampling frame.

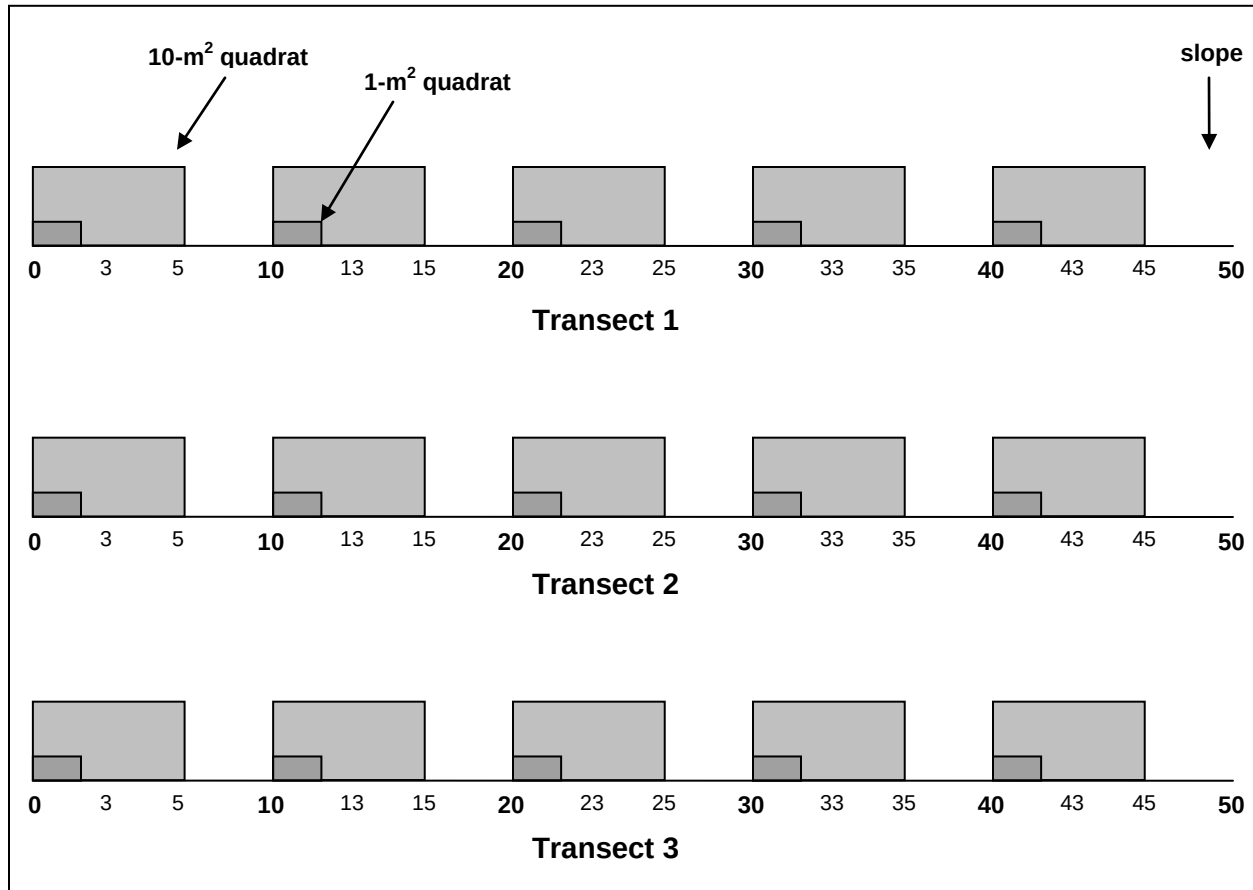


Figure 3. Quadrat placement along transects. Transects are not drawn to scale.

5. Fill out relevant information at the top of the “Frequency, Cover, and Shrub Density Data Sheet” including:

- **Park** – Use the standard 4-letter code to indicate the park unit.
- **PlotID** – A pre-assigned, unique number is provided for each plot.
- **Transect#** - 1-3 based (see Fig. 1).
- **Quadrat #** – Number the quadrats according to where they start along a transect (e.g. 0 m, 10 m, 20 m, ect.).
- **Date** – mm/dd/yyyy.
- **Observer** – Record the initials of the person calling out quadrat data. If initials of two or more persons are the same, include a middle initial or some other distinguishing initial.
- **Recorder** – Record the initials of the person recording data.
- **Page #** – Record the page # and the total number of data pages for each transect.

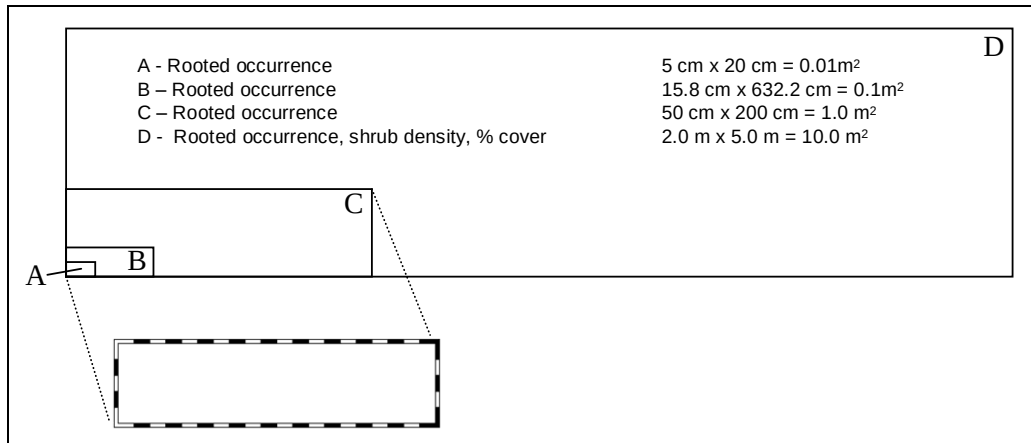


Figure 4. Nested frequency quadrat size and alignment on transect.

6. Sample nested frequency.

Nested frequency data are collected using 0.01-m², 0.1-m², 1-m², and 10-m² rectangular quadrats, one positioned inside the other, and noting the occurrence of rooted species, soil-surface disturbances, and scat within each quadrat. The frequency of undifferentiated crust and biological soil crust components are recorded in $\leq 1\text{-m}^2$ quadrats. This ensures proper distinction between lichen and moss of well-developed crust. Overall, the small quadrats intentionally favor capturing mostly dominant species so that even small shifts in their abundance may be observed.

Data collection begins in the smallest quadrat. The corners of the 0.01-m² quadrat are marked with tape on the sides of the 1-m² sampling frame. The sides of the tape closest to the corner of the 1-m² sampling frame mark the 10-cm long sides of the 0.01-m² quadrat (Fig. 1). If necessary, use a retractable measuring tape or other straight surface to project the corners and determine whether species or other features of interest are in or out of the quadrat. If a species is rooted underneath the quadrat frame, count it. Generally, the quadrats sit on or close to the ground when sampling. However, tall or dense vegetation, rocks, or an otherwise uneven surface may prevent this. In such cases, simply estimate as well as you can whether a borderline species appears to be rooted inside or outside the quadrat. The observer identifies to species (if possible) all plants rooted within the 0.01-m² quadrat. All species with live and dead plant material rooted within the quadrat are recorded in the “Species” column of the data sheet (under live or under dead) using the full latin name or the NCPN master plant-names species code. Mark a check in the 0.01-m² column next to each of the species found. Senesced plants that were alive earlier in the current growing season are counted as live plants for frequency. Also include the frequency of all BSC’s, disturbances, and scat listed on the data sheet. BSC and disturbance categories are defined in Tables 1 and 2. The observer must take care not to trample the quadrats. This is integral to the success of any long-term monitoring project.

Once all plant species, BSC's, soil-surface disturbances, and scat have been identified within the 0.01-m² quadrat, the observer moves to the next largest quadrat (0.1-m²) and so on until the 10-m² quadrat is reached. Within each consecutively larger quadrat, only new occurrences within the larger 10-m² quadrat are recorded. When recording occurrence, a plant species, surface feature or disturbance type should always be recorded in the first (smallest) quadrat in which they occur. Notice that you do NOT need to record frequency for all surface features. Frequency is not collected for bare soil, litter, woody debris, and all rock classes.

It is important not to trample the soil around the larger quadrat. Unless rocks and dead vegetation provides a suitable set of stepping-stones, observers should not leave the transect. Even if biological crust is not present, trampling can still lead to soil-instability, and this is to be avoided at all costs. This may require stretching over the 2-m width of the larger quadrat. Frequency estimates should be as precise as possible, but not at the risk of impacting soil and biological crust on a macroplot.

Once the observer has completed the search of the 10 m² quadrat, the species list is consulted to look for possible mistakes in species identifications and missed species. This list provides the names, but not associated cover values, of species previously collected in a quadrat for comparison to those currently collected. If a species was previously collected but is now missing, double check the quadrat to ensure the species has not been overlooked. The species may be absent, may surface in a later sampling period, or its record in previous years reflects a change in species identification or sampling error. At this point, any lingering questions on species identification should be communicated to the crew leader of Principle Investigator.

Table 1. Abbreviations and definitions of soil surface feature classes for quadrat sampling.

Soil surface type	Definition
Bare soil	Loose soil particles (0-2 mm diameter) not protected from wind erosion by any type of crust or any other soil surface feature
Crust, undifferentiated	Anything from physical crust to weak biological crust (weak cyanobacteria) but NOT including dark cyanobacteria, lichen, or moss
Cyanobacteria	Darkened cyanobacterial soil crust, typically black in color
Lichen	Lichen crust on soil (lichen on rock is recorded as the appropriate rock type)
Moss	Moss on soil (moss on rock is recorded as the appropriate rock type)
Litter	Embedded litter that is less than 2.5 cm in diameter, where removal of the litter would leave an indentation in the soil surface or would disturb the soil surface
Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and in direct contact with soil
Small rock	Rock fragments 2-20 mm in diameter
Large rock	Rock fragments >20 mm in diameter
Bedrock	Exposed bedrock
Scat, livestock	Any type of livestock scat
Scat, wildlife	Any type of wildlife scat

Table 2. Abbreviations and definitions of soil-surface disturbance classes for quadrat sampling.

Disturbance type	Definition
Ant mound	Holes and mounds created by ants
Bicycle	Disturbances caused by non-motorized bicycles
Human track/trail	Tracks or trails created by humans
Livestock track/trail	Tracks, marks, or trails created by livestock
Motor vehicle	Disturbances caused by any motorized vehicle
Wildlife excavation	Holes and mounds created by wildlife
Wildlife track	Tracks, marks, or trails created by wildlife
Other anthropogenic	Any human disturbance other than tracks and trails
Undifferentiated	Any disturbance of indeterminate origin or not classified as one of the other categories

The project leader will decide if it is necessary to fill out an “unknown” record and give the species of question an unknown number and name. See the section below entitled “Unknown Plant Species” for detailed instructions on how to deal with unknown plant species.

After finishing frequency, you will complete cover and shrub density at 0 m (Step #7) before moving to the next 10-m² quadrat.

Unknown Plant Species

Sometimes it may be difficult or impossible to determine the specific identify of individual plants encountered during sampling. When this situation occurs, search the immediate area surrounding the plot, looking for specimens of the unknown plant that are more readily identifiable (e.g., due to the presence of flowers or fruits from current or previous seasons). These may assist in correctly identifying the species in the plot. Most of these plants are not entirely “unknown.” Rather, they represent species that are known but sometimes difficult to distinguish from other similar species at the time of sampling. For example, vegetative individuals of *Sporobolus contractus* and *S. cryptandrus* generally cannot be differentiated, but both of these species can be identified with confidence when flowering.

When an unknown species is encountered, create a unique name using the following code: “unk” + 4 letter park code + number + space + genus or description (e.g. unkARCH3 cordylanthus). Record this in the appropriate column on the data sheet instead of the species code. Because there are different species lists for each park, start numbering unknowns at “1” for each park. If you know the genus of the unknown plant, use this as its description. Otherwise, create a short description (1-3 words) that will help you remember the unknown species. Before sampling, review previously collected unknown species from the ecological site and use existing unknown names whenever possible.

For each unknown species, fill out a corresponding “Unknown Plant Species Data Sheet” (Appendix A). This data sheet was adopted with modifications from Debacker et al. (2004). The more detailed description of each characteristic, the greater the possibility of future identification. Complete the following information on the data sheet:

- **Park:** A four letter code unique to a particular park (e.g. ARCH – Arches National Park)
- **Plot ID:** The pre-assigned, unique number.
- **Transect:** 1-3 (see Fig. 1).
- **Quadrat #/Position on Transect:** Number quadrats according to where they start along a transect (e.g. 0 m, 10 m, 20 m, ect.).
- **Unknown Code:** A unique code using “unk” + 4 letter park code + number + space + genus or description (e.g. unkARCH3 cordylanthus).
- **Date:** Use the format mm/dd/yyyy.
- **Plant type and General Description:** Circle the appropriate category and provide a detailed description of the overall appearance
- **Most Salient Feature:** A unique characteristic that identifies the plant from others.
- **Leaf Characteristics:** Describe the leaf type, leaf margin, leaf surface, petiole, etc.

- **Stem Characteristics:** Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.
- **Flower Characteristics:** Describe the floral formula, location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.
- **General and Microhabitat Characteristics:** List other species located in the general vicinity, selecting the more conservative species in the area. Describe the microhabitat in which it was found.
- **Collected:** Circle yes or no, whether a specimen was collected.
- **Best Guess:** Preliminary guess about species in field.
- **Confirmed to be:** The species determined after consultation of reference books and/or herbarium.

A sample of the unknown species is then collected and preserved in the plant press for later identification. Because of the long-term nature of monitoring, collecting outside the plot is preferred. If a specimen does not occur outside the plot, a portion of the plant from inside the plot can be collected, but at no time should the roots be dug up or the entire plant be collected from inside the plot. Collecting the roots and/or the entire above-ground portion of the plant may affect future sampling events. If a camera is available, a photograph could be taken.

7. Sample biological crust cover in 1-m².

For biological crust, an ocular estimate of cover is made within the 1-m² quadrat. This should be completed immediately after frequency is collected for each individual quadrat. The recorder begins calling out the crust categories (undifferentiated, cyanobacteria, lichen, moss) with a recorded frequency in $\leq 1\text{-m}^2$ quadrats. The cover of each category is estimated to the 1% level. If cover is $<1\%$, record as trace cover (i.e., T). Percent cover is recorded on the data sheet in the column titled **% cover 1-m²**.

8. Sample 10-m² cover by species.

For each plant species, surface features other than biological crust, and disturbance types, an ocular estimate of cover is made within the 10-m² quadrat.

Plant Species. The recorder begins calling out the species recorded for frequency one at a time. The estimate is a vertical projection of live cover, both photosynthetic and non-photosynthetic, onto the ground surface. The cover of each species is estimated to the 1% level. If cover is $<1\%$, record as trace cover (i.e., T). Percent cover for plant species are recorded in the column titled **Percent cover in 10-m² Quadrat**. All species with plant parts within a 2-m vertical projection above a quadrat are included in cover estimates, whether they are fully rooted in the quadrat or not. For live plants, record the species code in the “Species name (live)” column and the cover-class code in the % cover column, but do NOT check any of the “Nested quadrats” columns. Also indicate if the plant is rooted outside the quadrat. Cover of individual species cannot exceed 100 percent, but total live cover can exceed 100 percent due to canopy layering. The same procedures are used to record dead plants, but measures are recorded on the data sheet under the “Species name (dead)” columns. Refer to Fig. 5 for assistance in estimating percent cover.

Surface and Disturbance Features. Percent cover for these features are recorded similarly to procedures for plants. For livestock and wildlife scat and disturbance features, the recorder begins calling out surface or disturbance types recorded in the frequency assessment. The cover of each species is estimated to the 1% level. If cover is <1%, record as trace cover (i.e., T). Cover estimates are recorded in the **% cover 10-m²** column on the data sheet. For surface features not recorded in frequency counts (bare ground, litter, woody debris, small and large rock, bedrock), the recorder prompts the observer to provide cover estimates (1% resolution and T for <1%) for each of the six categories, and records estimates in the **% Cover in 10 m² quadrat** column.

9. Sample 10-m² cover by functional groups.

After completing cover for all species in the quadrat, the recorder prompts the observer for an estimate of **Total Live Vegetation** cover by functional groups (shrub & dwarf-shrub, annual grass, perennial grass, forbs/herbs). This is intended to provide a general measure of percent cover that is more easily comparable among plots and among ecological sites. This estimate is a vertical projection of total live cover (dead-plant cover is not included), both photosynthetic and non-photosynthetic, onto the ground surface. This accounts for overlapping species' canopies that cannot be estimated from individual species data.

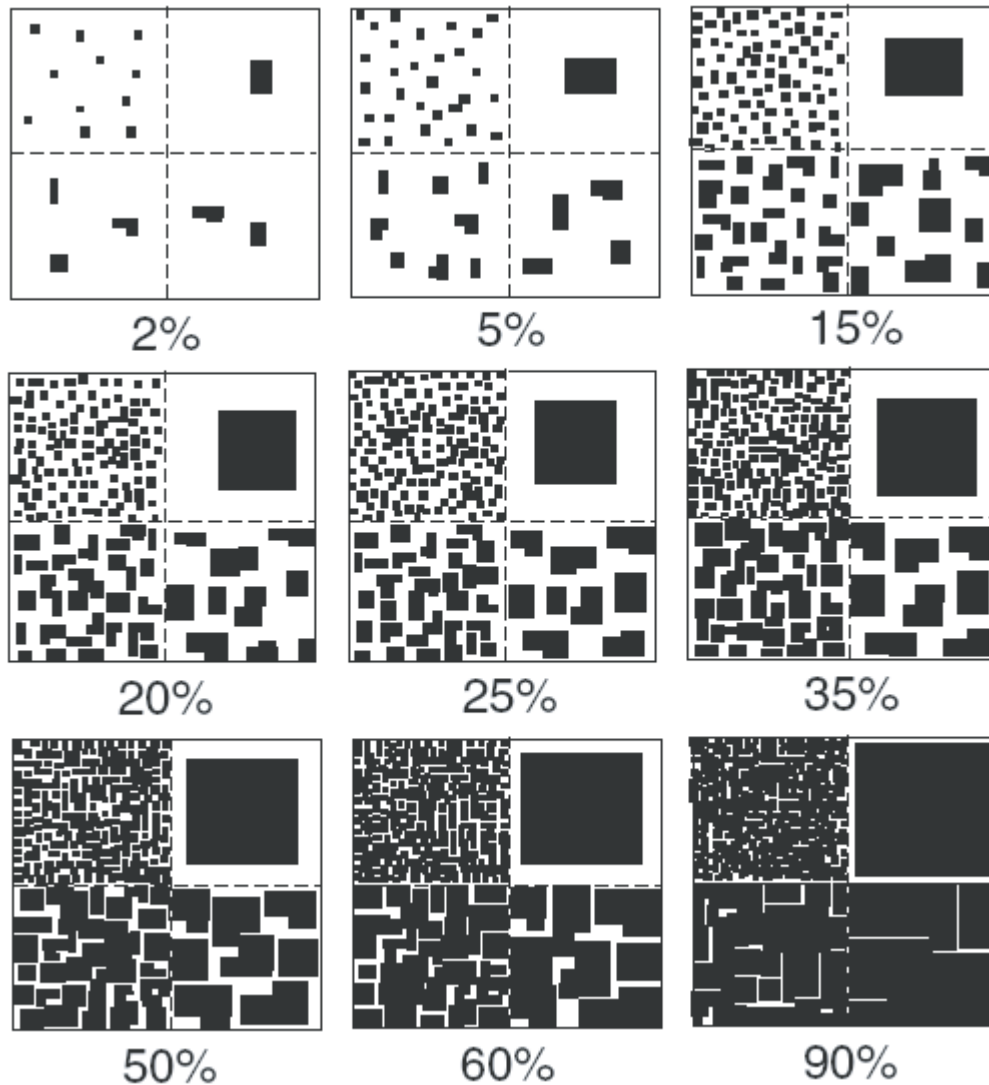


Figure 5. Guide for estimating percent of area covered (from Schoeneberger et al. 2002).

10. Sample shrub density.

After you complete cover estimates at 0 m, you will count the density of live shrubs in that 10-m² quadrat. Shrubs are divided into six height classes (0-10 cm, 10-25 cm, 25-50 cm, 50-100 cm, 1-2 m, and >2 m). The recorder should transfer the names of any shrub species from frequency into the “Shrub species” column for density. Dwarf shrubs, however, are not included in density counts.

Use a 5-m retractable measuring tape (or a measuring stick with the size classes demarcated) to count the number of each shrub for each size class. Shrubs must have at least 50 percent of their base in a quadrat to be counted. The recorder is responsible for making sure that the observer collects data for all shrub species present. Here are some additional rules for shrub density:

- In cases where “individuals” are difficult to distinguish (e.g. *Coleogyne ramosissima*), the counting rule is that stems separated by 25 cm are separate counting units. For *Artemisia* species, it should be possible to trace branches down to single stem in most cases.
- At sites with high levels of shrub density, estimate density using the following categories: 100-250, 250-500, 500-1000, and >1000 individuals.

11. Complete sampling at all quadrats along the transect.

After you finish sampling the first quadrat, repeat steps 4 through 10 to set up the quadrats and sample the remaining quadrats along the transect. Sample quadrats in order as you move down the transect, making sure to sample all locations indicated in Figure 3.

Remember to collect soil samples for soil-aggregate stability measures (SOP#11) as you traverse this and other transects. The locations for samples will be provided by the Principle Investigator. Also, while traversing this and other transects, note within-plot disturbances, and where possible, off-site disturbances according to the instructions in SOP#12.

12. Complete SOP#9 on the transect.

After you finish sampling frequency and cover on all quadrats on a transect, Basal area and Canopy Gap Measurements (SOP#9) should be performed on the transect.

13. Collect equipment and move to the next transect.

After completing SOP#9, repeat steps 1 through 12 of this SOP on transects 2 and 3.

14. Pack equipment and complete the site assessment.

After this SOP and SOPs #9 and #11 are completed on all three transects, determine if the Site Impact Assessment (SOP #12) is completed. If it is, pack equipment and leave the plot following general procedures for minimizing trail development and trampling disturbance provided in SOP #4 (Crust-Friendly Field Methods). If visual obstructions prevented a thorough off-site assessment while recording measures within the plot, complete the Site Impact Assessment. Remember to always walk 20+m away from the edges of the macroplot and to use rock, washes, and dead vegetation as stepping stones when walking.

References

- DeBacker, M.D., A.N. Sasseen, C. Becker, G.A. Rowell, L.P. Thomas, J.R. Boetsch, and G.D. Willson. 2004. Vegetation Community Monitoring Protocol for the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program. National Park Service, Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield, Republic, Missouri.
- Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., and Broderson, W.D. (editors), 2002. *Field Book for Describing and Sampling Soils, Version 2.0*. Natural Resource Conservation Service, National Soil Survey Center Lincoln, NE.

Appendix A.

Data Sheets

Presence, Cover, and Shrub Density Data Sheet (p. 1)

Park: _____ Plot ID: _____ Observer: _____ Page ____ of ____
Transect#: _____ Quadrat #: _____ Recorder: _____ Date: _____

Check if overflow table used ☐

[illegible]

Presence:	Nested quadrats (m ²)				% cover 1-m ²
Surface features	0.01	0.1	1	10	
crust, undifferentiated				-----	
cyanobacteria				-----	
lichen				-----	
moss				-----	
-----	-----	-----	-----	-----	% cover 10-m ²
scat, livestock					
scat, wildlife					
Disturbance	-----	-----	-----	-----	-----
ant mound					
bicycle					
human track/trail					
livestock track/trail					
motor vehicle					
wildlife excavation					
wildlife track					
other anthropogenic					
undifferentiated					

% Cover in 10 m ² quadrat	
Total live vegetation	-----
shrub & dwarf-shrub	
annual grass	
perennial grass	
forbs/herbs	
Surface features	-----
bare soil (loose)	
litter	
woody debris (>2.5cm)	
small rock (2-20mm)	
large rock (>2cm)	
bedrock	

Number of Live Shrubs Rooted in 10 m² Quadrat

Comments:

Presence

Presence						Percent cover in 10-m ² Quadrat	
Species name (live)	Species Code	Nested quadrats (m ²)				%	Check if rooted outside
		0.01	0.1	1	10		
Species name (dead)	Species Code						

Unknown Plant Species Data Sheet

Park: _____

Plot ID: _____

Transect# _____

Unknown Code: _____

Date: _____

Quadrat #/Position on Transect: _____

Plant Type & General Description: *herb shrub tree grass sedge other*_____

Most salient feature:

Leaf Characteristics:

Leaf Type: (compound/simple, arrangement, etc.)

Margin:

Other: (pubescence, sap, stipules, etc)

Stem Characteristics: (shape, pubescence, bud)

Flower Characteristics: (color, location, floral formula)

General and Microhabitat Characteristics:

Collected: *Yes* *No*

Best Guess:

Confirmed to be: