

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

Standard Operating Procedure (SOP) # 1

Preparations for the Field Season and Equipment Needed

Version 1.22 (December 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/1/2007	SGarman	Updated equipment list	Provide more logical organization of equipment needs	1.10
1.10	11/2008	R.Weissinger	Updated equipment list	Added forest equipment	1.20
1.20	3/2009	DWitwicki	Updated Field Data Sheet section and equipment list	Updated for forest, woodland, & oak methods	1.21
1.21	12/2010	Dwitwicki, STopp	Revised formatting, added detail, and updated equipment list	Methods changes; to increase usability	1.22

This SOP describes how to prepare for the field season, including a list of field equipment, and tasks that are performed before each field trip.

Before the Field Season

The following tasks should be completed by the project manager or field crew leader well before the arrival of seasonal field crew members.

1. Post positions for seasonal employees or student interns 3-4 months prior to scheduled field work. Upland monitoring requires six field crew members that work in pairs. Hiring must be completed at least six weeks prior to the beginning of the field season to allow time for federal background check procedures.
2. Review the entire protocol. Understand the goals and procedures of the monitoring program before beginning other preparations. Discuss any proposed or recent changes to the sampling design or protocol with appropriate I&M personnel. If a change has been implemented since the last field season, make sure that all field forms, databases, and relevant SOPs have been updated.
3. Compile a list of plots that will be monitored. Discuss the season's objectives with appropriate I&M personnel to develop a field schedule.
4. Schedule field work. Use the guidelines below to develop a field schedule that meets the objectives for the field season and maintains some flexibility for unforeseen events.

Seasonality of sampling

Vegetation is sampled during the growing season, typically between mid-May and mid-October. Sampling visits should be scheduled to optimize phenology for the group of NCPN park units included in upland monitoring. Park units should be visited at approximately the same time each year to maximize repeatability.

Field crew schedule

Crew members typically work 8 consecutive 10-hour days, followed by 6 days off, especially when working at distant park units or in the backcountry. Field work that does not require travel and camping will have more flexibility. Office work at the beginning and end of the field season is scheduled for 8 hours days Monday through Friday, and additional office days throughout the field season may be scheduled for trainings, field preparation, or data management.

5. Request research permits. Begin the process at least 10 weeks before the start of the field season to allow ample time for processing.
6. Coordinate with the appropriate park staff to make sure that the proper compliance is followed before installing rebar. It could take several months from the time paper work is submitted until our proposed installations are cleared.
7. Plan travel logistics. Notify appropriate park personnel of the dates the upland field crew will be in their park unit. Discuss housing availability and needs with appropriate parks, and acquire backcountry camping permits.
8. Organize and check all equipment. Equipment is usually tested and inventoried at the end of the field season. Review this list to make sure that you have adequate supplies and that all replacement equipment is ordered and will be available before the field season begins. Table 1 lists equipment needed for each SOP.
9. Review plant species lists for each park unit, and update them with new species detected in the previous field season. Print additional copies, if necessary, so that each 2-person team has a copy for the field. Review the species most likely to be encountered in each park and assemble relevant flora, keys, and field herbaria.

A few weeks before each field visit

The following tasks should be completed by the field crew leader in the weeks before a scheduled field visit.

1. Review existing maps for each park, and request additional maps from the GIS technician if necessary.
2. Pack and review relevant information for each plot including:

Revisit data sheets – provides directions to the plot, coordinates of monuments, and any other specific information from the previous visit.

Plot species list- list of species detected during the previous monitoring visit.

Trip reports - from the previous field season. At the end of each field trip, the crew leader writes a brief report describing general field conditions, access issues, logistical challenges, safety concerns, equipment problems, and suggestions for improving efficiency.

Access information – contains useful information for navigating to remotes areas of park units.

3. Coordinate with the data manager to reserve field laptops and load the database and other relevant information for the plots to be sampled. Transect photos are especially useful for relocating rebar in forest and oak plots and should be loaded onto the laptops.
4. Print and copy backup field data sheets. Pack the appropriate amount data sheets printed on Rite-in-the-Rain® paper for the predicted weather. Copies of each form are found at the end of the appropriate SOP. Data sheets for field measures are listed in Table 2 with the minimum number needed to sample a plot.
5. Coordinate with the GIS technician to reserve GPS units and load UTM coordinates for the plots to be sampled.
6. Contact parks and provide detailed trip information. Contact the resource staff and chief ranger and provide dates the crew will be working in the park, names of field crew members, vehicle descriptions, and approximate locations of monitoring activity.

Immediately before each field visit

The following tasks should be completed by the field crew leader immediately before each field visit.

1. File a backcountry safety plan. The day the crew leaves for a multi-day field trip, the crew leader should fax a backcountry safety plan to Glen Canyon dispatch. Crew leaders should review the NCPN Backcountry Safety Plan for specific procedures.
2. Check for satellite phone availability using the Globalstar Call Times Tool at <http://calltimes.globalstarusa.com/>.
3. Perform a vehicle safety inspection and replace any necessary fluids.
4. Check out cameras, lasers, GPS units, and satellite phones to crew members. **Make sure that the batteries are fully charged for all rechargeable equipment.**

Table 1. Equipment needed to sample an upland monitoring plot by a two-person team.

Item	Number needed	Description	Notes
General Equipment - necessary for all SOPs			
GPS with extra batteries	2	Trimble GeoXM or more accurate	main unit and backup
GPS car charger	1		
Digital camera	1		transect and biocrust photos, scenics
Extra battery for digital camera	1		
Inverter	1	plugs into vehicle	charge satellite phone
Permit	2 per vehicle		one on dashboard, one with crew

Item	Number needed	Description	Notes
Maps	1		
Data sheets	One complete set		Rite in the rain compliment for point intercept and gaps
SOPs	1		
Clipboard	1	lightweight with interior storage	
Field notebook	1 per person	small, Rite-in-the-Rain©	field notes
Pencils	2-3		
Toughbook	1		data entry
Extra battery for Toughbook	1		make sure batteries are fully charged before leaving
USB	1	rugged, waterproof	data backup after each transect
Car charger for Toughbook	1		
Chair with backrest	1		for data recorder
Safety Equipment - necessary for all SOPs			
First aid kit	1		content list in NCPN Backcountry Safety Plan
Satellite phone	1		
Satellite phone charger	1		
NCPN Backcountry Safety Plan	1		
NCPN Accident Report Logs	1		found in NCPN Backcountry Safety Plan
NCPN Medical Information Forms	2	each person carries their filled out form	found in NCPN Backcountry Safety Plan
2-way radios	1		crew communication
Extra radio batteries	min. 3	AA alkaline	radios require 3 per unit
Personal Equipment - necessary for all SOPs, provided by observers			
Sunscreen			
Sunhat or baseball hat			
Water bottles			
Raingear (jacket and pants)			
Site Characterization – SOP # 5, Necessary for site recon.			
Ecosite keys/tables	1		
Compass	1	with declination setting	photo direction
Acid bottle filled with 1M HCL	1		test soil effervescence
Soil sieve	1	2 mm	separates rock fragments from fine soil particles
Trowel	1	U-dig-it or other small metal trowel	scoops surface soil into sieve
Spray bottle with water	1	Small plastic	moistens soil sample
Clinometer	1		measures slope

Item	Number needed	Description	Notes
Plot Establishment and Revisits - SOP #6, Necessary for all visits unless noted with an E = establishment or R = re-visit.			
Compass	1	with declination setting	set declination, take transect bearings
Pin flags	min. 3	narrow steel pins with flag top	mark locations
50-m transect tapes	2	Plastic reel tapes	set up transects
Chaining pins	min. 6	striped metal pins	secure tapes
Rebar	E – 6 per plot R – 2 per plot	3/8" diameter cut into 18" lengths	permanent markers
Aluminum tags	E – 6 per plot R – 2 per plot	Oval	plot reference information
Sledgehammer	1		drive in rebar
Stamp kit	1	¼" steel	stamp transect information on tags
Wire		18-20 gauge	attach tags to rebar
Wire cutters	1	small	
Tree tags	12	round, numbered	for optional witness trees in forest plots
Nails	12	galvanized steel	for optional witness trees in forest plots
Plot Revisit Form	R	For each plot	provides directions to plot
Photographs - SOP #7, Necessary for all visits.			
Chalkboard	1	5 x 7"	label photos
Chalk	several pieces		
Monopod	1		delineate photo height
2-m folding ruler	1		delineate transect photo location
Point-Intercept Sampling - SOP #8, Necessary for all visits.			
Laser	1		sample cover of understory vegetation
Laser monopod	1		mount lasers
Extra laser batteries	min. 3	1.5V silver oxide watch batteries	lasers take 3 per unit
Densitometer	1		sample cover of overstory canopy in all vegetation types except forest
Screwdriver or multitool	1	small Phillips head	change laser batteries
Biocrust darkness guide	1		
Plot species list	1	species previously recorded at plot	
Park species list	1	Annotated species list	assist with plant ID
Basal and Canopy Gap – SOP #9, Necessary for grassland/shrubland plots.			
2-m folding engineers ruler	1	Marked with shrub height classes	

Item	Number needed	Description	Notes
Annual species list	1		
Exotic Frequency, Species Richness, Canopy Closure, Shrub and Tree Seedling Density - SOP #10, Necessary for all plots (unless otherwise noted).			
Folding ruler	2	2-m folding engineer's ruler, marked with shrub height classes	delineate exotic frequency quadrats; delineate 1-m belt for species richness and shrub/seedling count; measure shrub height
Modified concave spherical densitometer	1		overstory canopy (forest plots only)
Exotics species list	1	perennial and annual	
Soil Stability - SOP #11, Necessary for grassland/shrubland and woodland plots.			
Slake kit	1		holds soil samples
Soil spoon	1		collect soil samples
Deionized or distilled water			dip samples during test
Stopwatch	1		time stability test
Random numbers sheet	1		soil collection locations
Site Impact Assessment - SOP #12, Necessary for all visits.			
Stopwatch	1		time exotic species search
Saplings and Overstory Trees - SOP #13, Necessary for forest, woodland, and oak plots.			
DBH tape	1	cloth diameter in cm	measure trees
15-cm plastic DBH calipers	1	in cm	measure sapling diameter
Round aluminum tree tags	Many	numbered	permanently mark overstory trees
3" nails	Many	galvanized steel	attach tags to trees
2-m folding engineers ruler	1		delineate 5-m belt for sapling count (woodland and forest only)
Fuels - SOP #14, Necessary for forest and woodland plots.			
Go-no-go gauge	1		determine size class of woody materials
Transparent plastic ruler	1	Marked in cm and inches	measure litter and duff depth
U-dig it or trowel	1	Small metal	sample litter and duff
20- or 50-m transect tape	1	fiberglass reel tapes	
Modifications for oak plots - SOP #15			
See equipment lists for all relevant SOPs.			
Unknown Plants - SOP #16, Necessary for all visits.			
Hand lens	2		
2-gallon resealable plastic bags	several	2- gallon or larger	collect plants
Masking tape	1		label plant collections

Item	Number needed	Description	Notes
Permanent marker	1		label plant collections
Trowel or U-dig it	1	small garden tool	extract specimen roots
Plant press	1	press with card, blotter, and paper	kept in vehicle; store plant collections for identification
Relevant floras and park species lists		various by park	

Table 2. Number of data sheets needed to sample an upland monitoring plot by vegetation type.

Data Sheet	Vegetation type			
	Grassland/ shrubland	Woodland	Forest	Oak
Site characterization (initial plot visit only)	1	1	1	1
Site establishment or Re-visit	1	1	1	1
Photos	1	1	1	1
Point intercept	3	3	3	
Point-intercept (oak)				3
Canopy closure and shrub density	3	3	3	
Seedlings, species richness, and exotic frequency	3	3	3	
Species richness and exotic frequency (oak)				3
Canopy and basal gaps	3			
Soil aggregate stability	1	1		
Overstory trees		1	1	1
Fuels		1	1	
Unknown plants	10	10	10	10
Site impact	1	1	1	1

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

Standard Operating Procedure (SOP) # 2

Hiring and Training Observers

Version 1.30 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/1/07	SGarman	Addition of reference to SOP #4	To emphasize procedures that minimize crust busting	1.10
1.10	11/2008	R.Weissinger	Addition of safety training	Improve safety of crew	1.20
1.20	3/2009	DWitwicki	Minor formatting edits	Consistency with other protocols	1.21
1.21	1/2011	RWeissinger, STopp	Added detail	To be more useful and comprehensive	1.30

Hiring Field Technicians

Staffing requirements

Integrated upland monitoring requires ecological and vegetation expertise. A permanent or term subject-to-furlough biological science technician (minimum GS-6) leads a crew responsible for vegetation sampling. Five seasonal crew members (NPS, volunteer, intern, or cooperator) comprise the upland vegetation crew. Two of these seasonal technicians (GS-5 or GS-6), along with the crew leader, will each lead a two-person crew while performing field work.

Qualifications and attributes

In addition to the technical skills, experience, and knowledge listed below, certain qualities are necessary for all NCPN field personnel. To maintain data quality, all staff should have the ability to successfully engage in repetitive, detail-oriented work. Technicians must be in excellent physical condition and able to thrive in difficult field conditions. Certification as a Wilderness First Responder (or Wilderness First Aid) and CPR is also an asset. Employees must expect to work away at parks for periods up to 8 consecutive days and, in many instances, to camp in backcountry situations.

Technical Skills, Experience, and Knowledge

The Upland Crew Leader will be a Biological Science Technician, specializing in botany. The technical skills, experience, and knowledge required for all integrated upland field positions is detailed below.

Lead Biological Science Technician (Crew Leader)

- Ability to identify common upland genera and species on sight.
- Ability to key plants to species using floras and technical keys.
- Experience leading a field crew to collect biological data in remote field settings.

Assistant Biological Science Technicians (Field Crew Leads)

- Ability to identify common upland genera and species on sight.
- Ability to key plants to species using floras and technical keys.
- Ability to make logistical decisions on a daily basis and lead a two-person team.
- Ability to communicate effectively with the crew leader regarding planning and completion of daily assignments.

Seasonal Biological Science Technicians (seasonals, interns or volunteers)

The most essential element for the collection of quality data is well-trained, experienced field crews. Given the variability of plant community types across NCPN parks, it is necessary to hire highly skilled personnel with botanical skills and experience working throughout the region. The importance of hiring and training well-qualified observers cannot be overemphasized. In order to accurately detect trend across sampling periods, it is imperative that observers record vegetation data using the same methods and level of precision year after year. While not imperative, experience conducting quantitative vegetation sampling is a valuable skill in any employee. During the applicant review process, it will be important to give priority to those candidates with considerable experience conducting vegetation surveys and, secondly, to candidates with (1) experience conducting any type of field work that involves data collection, (2) extensive experience backpacking and hiking, and/or (3) an academic degree related to vegetation or ecology. Particular attention should be paid to the experience of the observer, his/her ability to learn new plants, physical abilities to withstand difficult field conditions, ability to be productive in a team environment and overall attitude. NCPN will train biological science technicians in methods particular to our goals.

Training Seasonal Vegetation Observers

To promote accuracy and consistency in data collection among data collectors, training should be designed to calibrate data collectors so that they have comparable skills in identifying species and are recording data in a consistent format. For data collectors who are already competent at identifying plants by sight and taxonomic keying, the need for training in plant identification may be minimal. If the program is fortunate enough to hire all experienced personnel for a season, then the proposed training program will improve their skills. No data collector is exempt from the training program.

1. Prepare for the training program. The project manager or crew leader acts as the primary instructor; however, experts in various aspects of the protocol (such as First Aid/CPR) should be scheduled to assist in training as necessary. The instructor must prepare training materials, itineraries, and field gear before the training program begins.

2. Issue field gear before training begins. See SOP #1 for a list of field equipment. Provide a copy of this protocol to all trainees, along with a list of recommended personal field and camping equipment, before training begins. Ensure that observers examine the list of necessary personal gear (see SOP #1) and that they have all the appropriate equipment by the time field work starts. Make sure that trainees are informed and prepared for the training and survey events. Have the field technicians read the relevant riparian SOPs prior to field training.

3. Have all vegetation crew members participate in Upland Monitoring Vegetation sampling training. The project manager and field crew leaders will provide several days of instruction covering all field-based procedures, including navigation, site characterization, toughbook use, and plot establishment, revisit and measurement procedures. Field training will be practiced prior to operational monitoring efforts. In order to prevent excessive trampling at monitoring sites, these exercises will be conducted at highly-impacted sites outside of potential areas for upland monitoring. Crew members from previous seasons normally do not need as much training as new crew members; however, all data collectors must attend the entire training course each year. In these cases, it will be important to specifically point out any changes to the protocol, in addition to reviewing the past year's QAQC results. Experienced crew members can assist with training less-experienced data collectors. Experienced crew members will also continue practicing plant identification skills, navigational abilities, and data collection methods.

Navigation: Each crew member will be tasked with finding plot centers using a GPS. Training should be given in both general navigation techniques using traditional maps and compass, as well as handheld GPS units. Knowledge of GPS is essential. GPS units are used to navigate to plots and to record key site information. SOP #3 should be thoroughly reviewed, and any questions should be directed to the NCPN GIS expert. Training sessions described below require field crew members to use GPS units.

Site Characterization: At one or more plot centers, site characterization procedures will be explained and demonstrated, including evaluation of ecological site conditions. Identifying ecological site types is critical during site reconnaissance and plot establishment. Both site recon and new plot establishment require determining if the pre-selected plot corresponds to the targeted ecological site. Ecological site is an underlying stratum in NCPN upland monitoring, and it is important that the plots selected for monitoring actually represent the intended ecological-site stratum. Tables and dichotomous keys summarizing descriptions of target ecological sites at each park unit will be provided to crew members. The project manager will provide instructions for using tables and keys and will demonstrate their use in the field by visiting examples of target ecological sites.

Toughbook use: All field data will be collected on rugged laptops called toughbooks unless more than 3 field crews are collecting data concurrently. The Toughbook Quick Reference Guide should be thoroughly reviewed and user protocols presented by the data manager prior to field exercises.

Plot establishment, revisit and measurements: Plot establishment, site measurement methods, and site-impact procedures will be explained and demonstrated. All technicians should practice recording spatial data using a GPS unit. For each of these activities, new field crew members

will be paired and required to exercise all procedures under the critical eye of the project manager or a field crew leader. All procedures will be exercised to the full extent, including actual recording of observations on data sheets or in the field laptop. SOPs 8-12 & 16 should be thoroughly reviewed prior to field exercises and questions discussed in the field and afterward. Specialized training for protocols specific to particular vegetation types which will be visited later in the season will occur as needed during the field season and prior to monitoring those vegetation types.

Training shall be an on-going practice throughout the field season. Crew members will periodically check each other's accuracy with various instruments, especially accuracy in compass, clinometer and spherical densitometer use. Additionally, field teams should consistently check that all data fields in the toughbook have been filled out prior to leaving a plot.

4. Conduct the majority of the training program at plots in parks that are easily accessible.

Training shall continue throughout the 1st field hitch at actual plots. The 1st week of sampling following formal training should occur in a park that is easily accessible to account for reduced production. It may be advisable to conduct a test plot first rather than sample a real plot, especially with first-time employees. The initial objective of the training program is to expose the trainees to the equipment used and data-collection methods. Discuss specific techniques for navigation and identifying plant species. It is important to recognize that training sessions early in the season will fail to detect all of the species that will be encountered later in the season.

5. Exercising crust-friendly procedures. A critical component of Upland monitoring is the enforcement of crust-friendly procedures, detailed in SOP #4. Concern for trampling of sensitive biological soil crusts requires that crew members practice minimum-impact procedures while walking to and from plots, during plot set-up, and while recording measures.

6. Emphasize field safety procedures and issues. Discuss important safety issues for the NCPN region, notably, thunderstorms, heat/cold exposure, hiking safety, fatigue, and highway and 4WD driving. Review past scenarios. Present emergency and accident protocols. Training includes a one-day CPR/First Aid course and a review of the NCPN Backcountry Safety Plan. The crew leader or project manager will also review low impact camping procedures.

7. Plant identification. Training will consist of field and office-based identification of plants likely to be observed during the field season, with emphasis on difficult-to-identify species. Additionally, field crews will be introduced to and instructed on the use of available taxonomic keys and reference materials. Since NCPN parks are ecologically diverse, brief training in the form of reviewing field herbaria prior to and conducting guided plant walks upon arrival at each park will be provided by the crew leader.

Suggested topics for training:

Program overview – introduction to NCPN goals and projects, overview of Upland Monitoring sampling design and objectives

Administrative responsibilities and policies – timesheets, travel, work hours, leave policies, and equipment care

Safety – NCPN Backcountry Safety Plan, Job Hazard Analysis, first aid kits, satellite phone use, project-specific safety concerns

Government vehicles – proper use and care, vehicle inspection, tire changing, defensive driving, 4WD review

Park etiquette – biological soil crust (SOP 4), visitor interactions, low impact practices

GPS – navigation, logging points, data dictionaries (SOP 3)

Upland recon and site characterization – overview of ecosite identification and why it is important

Plot establishment – hiking to and from plots, determining plot layout, taking bearings using a compass, transect set up (SOP 6)

Vegetation measures – Includes methods in following SOP's (8-12, 16)

Photos – taking good transect and crust photos, appropriate camera orientations for monitoring photos, checking time and date settings (SOP 7)

Plant identification – procedures on making plant collections, vouchering new species, using available plant references, review of common species with particular attention to grasses, plant walks in the field

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 (May 2009)

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 navigating to and/or collecting geospatial data at upland monitoring 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 is divided into two main sections: 1) Upland Site Characterization and Upland Plot Establishment, and 2) Upland Site Revisit. Each main section contains minimum GPS receiver requirements, followed by brand-specific instructions. The intent is to maintain a high quality of GPS spatial accuracy and collection capabilities

This SOP does not require the use of a specific brand of GPS unit; however, the unit is required to meet the minimum standards listed below.

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 – A computerized system used to input, manage, manipulate, analyze and display geographic data in digital form.
<i>GPS</i>	Global Positioning System (unit/receiver/datalogger) – A three part system of 1) 25+ Department of Defense satellites 2) Control segment 3) Users with receivers

<i>Coordinate system</i>	Any three-dimensional reference frame that locates objects in space.
<i>FGDC</i>	Federal Geographic Data Committee, the interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.
<i>Feature</i>	A physical object or location of an event. A feature can be a point, line or polygon (area).
<i>Data Dictionary</i>	Information (data) that describes features that will be located in the field.
<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 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>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.

2 Site Characterization and Plot Establishment

The project manager predetermined possible upland monitoring locations (specific XY coordinates in UTM NAD83). Each potential monitoring location must be visited to determine if it meets the criteria prior to becoming a permanent monitoring location. The NCPN requires the use of a mapping grade GPS unit to record these Site Characterization and Plot Establishment data locations.

2.1 Minimum GPS Receiver Requirements

- Capable of uploading pre-determined (potential) upland monitoring locations
- Capable of utilizing data dictionary utilities (NCPN Upland Data Dictionary, see section 2.3)
- Capable of utilizing park-specific background GIS data layers
- Capable of navigation
- Capable of maintaining 4 or more satellites

- Capable of maintaining horizontal errors of less than 5 meters (PDOP (or equivalent error reading) of less than 6)
- Capable of post data collection correction (differential correction)
- Capable of storing date, time, elevation and coordinates of features collected (in addition to data dictionary items)
- Capable of exporting features collected to a GIS data format

2.2 GPS Unit Setup

The NCPN currently uses the Trimble line of mapping grade GPS units and TerraSync software to capture the spatial data for the upland monitoring plot locations (site characterization and plot establishment). The requirements should be transferable to other mapping grade GPS receivers (such as Leica etc.).

Positional accuracy can be affected by several factors which mapping-grade GPS units can track and to some extent, compensate for. Table 1 lists these functions, their definitions, and the standard settings.

Table 1 Minimum GPS Receiver Settings Standards

Name	Definition	Standard
Almanac	GPS unit collects data containing estimated position of satellites, time corrections, and atmospheric delay parameters.	The unit will automatically collect the almanac. Acquire within 10 days prior to data collection or navigating, download to computer.
Altitude reference	Ellipsoid model	Height Above Ellipsoid (HAE)
Antenna heights	GPS unit height above the ground (average).	1.0 – 1.5 meters
Coordinate System	A reference system consisting of a set of points, lines, and/or surfaces, and a set of rules, used to define the positions of points in space in either two or three dimensions.	Universal Transverse Mercator (UTM)
Datum	Geodetic model designed to fit a point on the earth's surface to the ellipsoid.	NAD 1983 (Conus)
Elevation mask	The minimum angle at which a GPS receiver will track satellite vehicles.	15 degrees
Logging intervals	Time interval between positions gathered.	Point: 1 second Line and Polygon: 5 seconds
Minimum number of positions for a point feature	Number of positions received then averaged to create a point feature.	10 - 20
Mode	2-Dimensional or 3-Dimensional	3-Dimensional (4 satellites)
PDOP Mask	Positional Dilution of Precision is a measurement of the geometry of the satellites.	6.0 or less
Satellite vehicles	Number of satellites, currently a constellation of 28 DOD satellites.	4

Name	Definition	Standard
SNR Mask	Signal-to-Noise Ratio is a measure of the strength of the satellite signal relative to background noise.	4.0
Unit of Measure	Units of measure.	Meters
Zone	In UTM coordinate system, the globe is divided into 60 north-south zones.	Zone 12 North (N)* *Black Canyon & Curecanti are Zone 13 N

2.3 Data Dictionary

A data dictionary should be created to facilitate field data collection as well as assuring necessary data items are (correctly) collected. The minimum elements necessary for the upland data dictionary are shown below. Once the project lead has given the GIS technician the potential upland points for a given park in a given year, those points are then imported with the Upland data dictionary (using Pathfinder Office), creating a data file for both Site Characterization (park_crc.imp) and Plot Establishment (park_est.imp). Points may also be combined in Pathfinder into one .ssf file. All point features in the Upland Data Dictionary should have the default feature settings of:

Logging Interval	Time = 1 second
Minimum Positions	3
Accuracy	Code
Label 1	PlotID

The following data dictionary digital file (.ddf) can be obtained by contacting the NCPN Data Management staff.

Site Characterization Point Feature

This feature point is used primarily when scouting possible upland plot locations. If the location is accepted as a monitoring plot and the establishment of the plot is commencing *immediately* following decision that the location is appropriate, this data dictionary point may be skipped.

Site_Crc Attributes	Attribute Explanation	Entry	Type
PlotID	Numeric unique ID from Project Lead	Entry not permitted in the field	Numeric
S_Action	- Accept – decision to accept the site as an acceptable upland monitoring location - Reject – decision to reject the site as an acceptable upland monitoring location	Entry required in the field	Menu
Comments	Any comments regarding the site	Entry permitted in the field	Text – Optional
Visited	Used to indicate to monitoring crew those sites visited in prior field excursions vs those unvisited sites.	Entry not permitted in the field	Text – Optional

Plot Establishment Center Point Feature

The plot establishment point is taken at the center point of a location deemed acceptable as an upland monitoring plot. A point should be collected to establish the exact center point of the plot, with as little trampling of future transects as possible. The GPS unit should collect 10-20 “hits” to establish the plot centroid location. The Plot ID will already be included in the data dictionary, and will not need to be re-entered in the field. Other than collecting (updating) the locational information, there is no further data necessary to collect for this point using the GPS unit.

EstPlotCenter Attributes	Attribute Explanation	Entry	Type
PlotID	Numeric unique ID from NCPN ecologist	Entry not permitted in the field	Numeric
Comments	Any comments regarding the site	Entry permitted in the field	Text – Optional

Transect Start and End Points Feature

For upland monitoring, there are three 50 meter transects per monitoring plot. Each transect beginning (0 meter) and end (50 meter) point needs to be GPSed.

Trans_Pts Attributes	Attribute Explanation	Entry	Type
PlotID	Numeric unique ID from NCPN ecologist	Entry permitted in the field	Numeric
Transect	• T1_origin – Transect 1, 0m • T1_end – Transect 1, 50m • T2_origin – Transect 2, 0m • T2_end – Transect 2, 50m • T3_origin – Transect 3, 0m • T3_end – Transect 3, 50m	Entry required in the field	Menu
Comments	Any comments regarding the site	Entry permitted in the field	Text – Optional

Other Optional Point Locations (incidental observations worth recording) Feature:

This point feature is for incidental observations the monitoring crews may encounter. For example, if you found lithic scatter or invasive exotic plant community or wanted to mark a particularly good way to get to the plot, you may want to mark that location with this point feature, briefly commenting why you marked the location.

OtherPt Attributes	Attribute Explanation	Entry	Type
Comment	Incidental observation comment	Entry permitted in the field	Text – Optional
Comment2	Incidental observation comment	Entry permitted in the field	Text – Optional

Routes to Plots

This line feature is for mapping routes to upland monitoring plots that seem somewhat difficult to locate. Once all data collection is complete, on the hike out of the plot, this feature can create a route or trail for future field crews to easily locate the monitoring plot.

OtherPt Attributes	Attribute Explanation	Entry	Type
PlotID	unique PlotID	Entry permitted in the field	Text – Optional
Comments	Incidental observation comment	Entry permitted in the field	Text – Optional

All other data required from the GPS unit can be automatically downloaded from the GPS unit (see section 2.6).

2.4 Uploading possible monitoring locations

Mapping grade GPS units have the ability to upload data points to be used in concert with the data dictionary. The potential upland monitoring points are imported with the Upland Data Dictionary by the NCPN GIS technician. Importing points (uploading) to the GPS unit eliminates possible plot mis-identification in the field, as well as allowing the user to navigate more easily to an upland plot.

Also, background data layers can be used to assist with navigation. The two GIS data layers found most useful as background layers have been 1) roads and trails and 2) hydrography, both combined with the park boundary.

2.5 Collecting data

Once you've navigated to the plot (or potential plot), it's time to collect the GPS locations necessary. Appendix A contains detailed instructions for use with the Upland data dictionary and various files. Open the file necessary, and begin logging the point and any required data. Each point collected should be allowed to receive 10-20 positions before ending data collection and moving onto collecting another type of point.

2.6 Downloading

When data collection is finished, the GPS data needs to be downloaded. The NCPN GIS technician downloads the data from the GPS unit(s) after each field excursion, and then differentially corrects the data, using the appropriate (closest) base station. The corrected GPS files are then exported to a GIS data format. Table 2 indicates the attributes to capture while exporting the corrected GPS data into a GIS data format ("turn on" in Pathfinder Office).

Table 2 GPS Auto-generated Attributes to Capture

PDOP	Update Status	Height
Correction Status	Data File Name	Vertical Precision
Receiver Type	Total Positions	Horizontal Precision
Date Recorded	Filtered Positions	Standard Deviation
Time Recorded	Data Dictionary Name	Position

Data should be exported using the same coordinate system used in the field (UTM, NAD83 Conus, Zone 12 or 13, meters).

2.7 Uploading to the master Upland Database

Once the GPS field data is validated & verified (GPS points given a visual review, compared to GRTS coordinates, transect plot ID attributes verified) in ArcMap, the data is ready to be uploaded into the working Upland Database. The GPS data is exported from ArcMap into an Excel spreadsheet for importing into the Upland Database (see SOP #13, section 3.1).

3 Upland Plot Revisit

Once plots are established, no new data will be collected with a GPS unit when the site(s) are revisited. GPS units will be used primarily for relocation of and navigation to and from the upland plots. This allows for the use of recreational grade GPS units (Garmins, Magellans, etc.) rather than the sometimes heavier and larger mapping grade GPS units. Mapping grade units certainly can be used to navigate to plots ready to be revisited; however, the following steps demonstrate how one could utilize a recreational GPS unit.

If it becomes necessary to physically move the plot, the field crew should GPS the new plot centroid with the Garmin (or other recreational) GPS unit. In addition, a distance (in meters) and bearing should be taken from the old centroid to the new centroid. Both data sets should be given to the GIS technician, who will determine the new coordinates for the plot, and pass those updated coordinates to the Data Manager for incorporation into the Upland database.

3.1 Minimum GPS Receiver Requirements

- Capable of uploading previously visited upland monitoring plot locations (XY points)
- Capable of storing date 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)

3.2 GPS Unit Setup

The upland monitoring plots which are to be revisited in a given year will be given to the NCPN GIS technician. These locations (XYs of the plot centroid as well as all six transect beginning and end points) will then be uploaded into any recreational grade GPS unit for relocation purposes. If using a Garmin GPS, data transfer is enhanced by utilizing the freeware DNRGarmin (<http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions.html>). Background maps of the area(s) to be visited should be uploaded from Map Source as well. Once the data is transferred to the GPS unit, the GPS unit is ready for field use.

The GPS unit should be configured with the settings in Table 3.

Table 3 Minimum GPS Receiver Settings

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

Attachment A

File Explanations:

Existing Data Files on GPSes:

- *Park_crc* – (Park/Place Site Characterization) The points contained in this file are the point centers for the potential plots. Use this file primarily to recon potential monitoring points. Log the center point of the plot, and then choose either Accept or Reject from the data dictionary. If you are immediately setting up the plot, log the plot center with the feature point “Park_est” instead.
- *Park_est* – (Park/Place Plot Establishment) This file also contains potential center points of upland monitoring plots. IF a plot has been found acceptable, log the center point UTM's at the time of plot establishment.
- *Park_Upland* – (Park/Place established plots and transects) This file contains already established upland monitoring plots and transect end points. This file is useful for navigation purposes when re-reading upland monitoring plots.

Background Layers (Files):

- *PARK_RdsTrls* – This file contains the roads and trails for PARK, and the park boundary.
- *PARK_Strms* – This file contains the “streams” (hydrography) for PARK, and the park boundary.

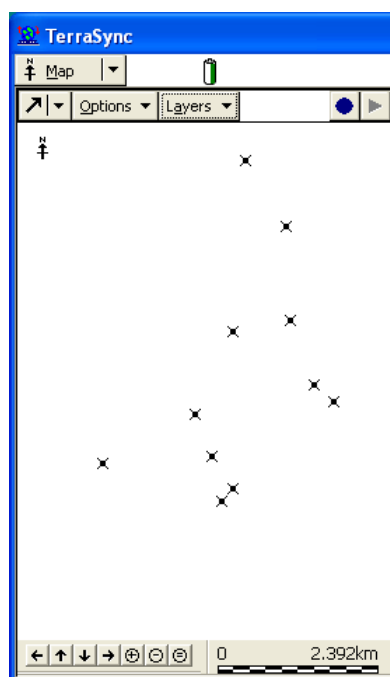
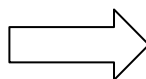
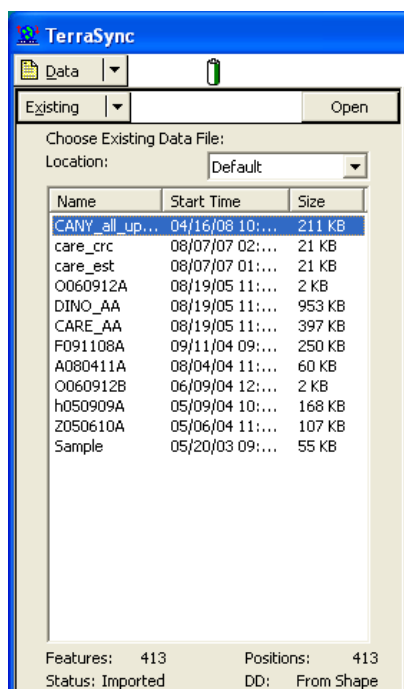
Basic instructions:

The following instructions are based on using a Trimble GPS unit with TerraSync Professional GPS software loaded.

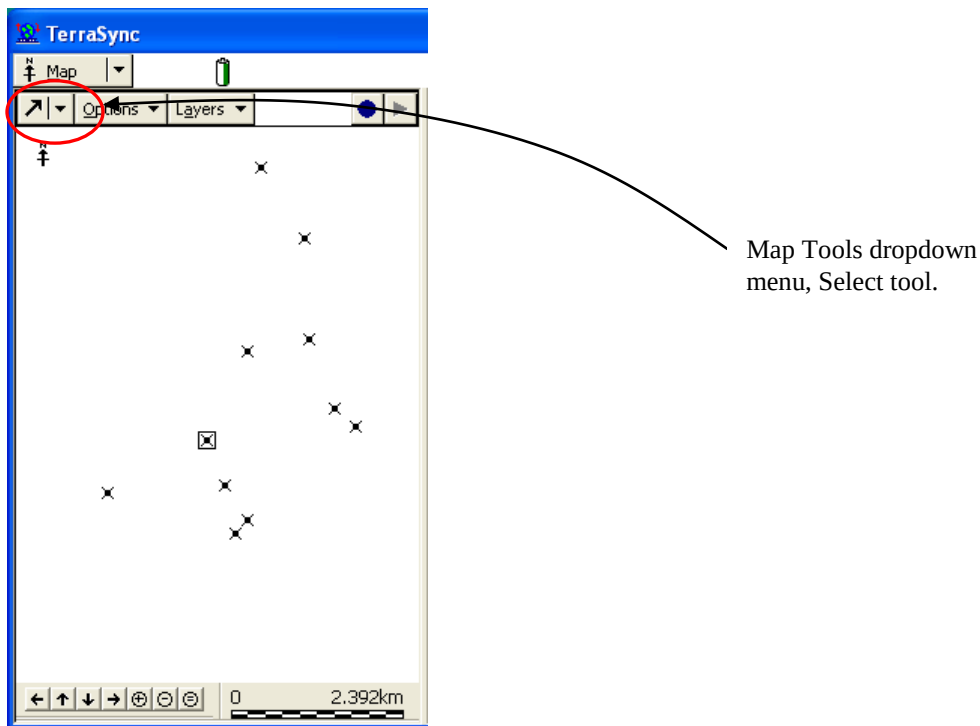


Navigation:

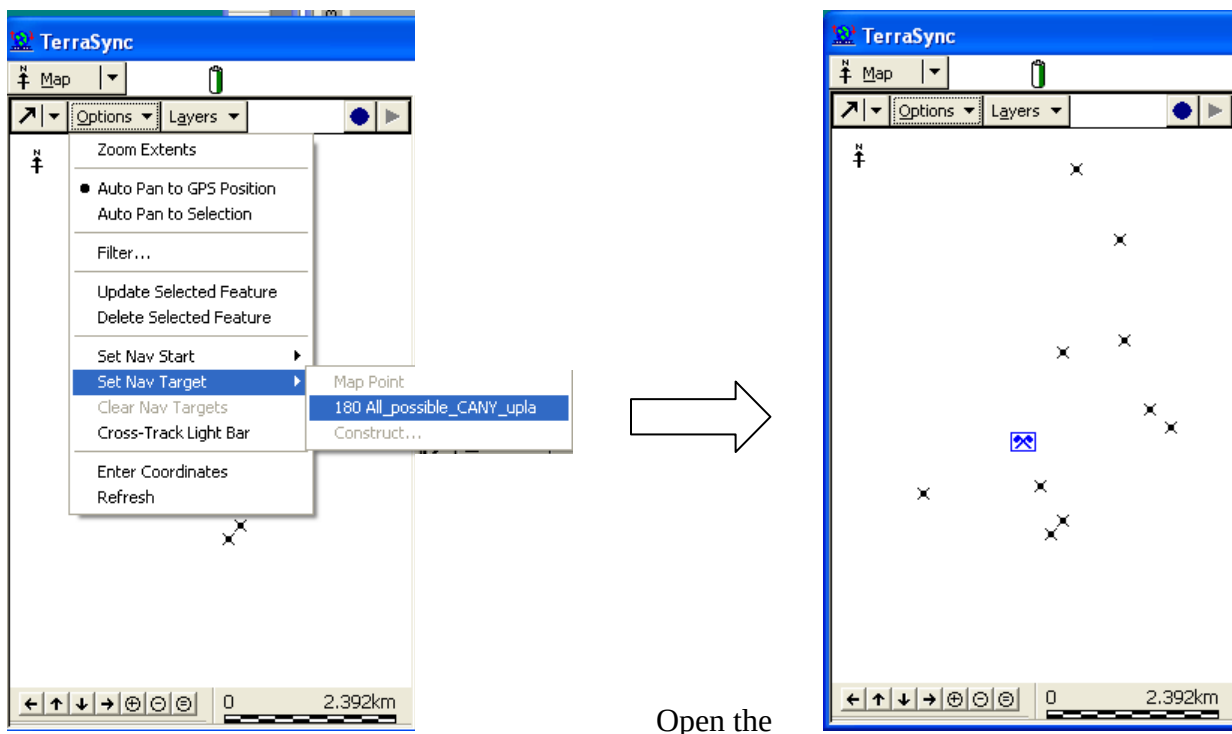
To navigate to a point, open the file which contains the point you want to update. Change the screen to the Map View (click on the Data drop down, and choose Map).



Using the Map Tools (the drop down menu directly underneath Map), use the Select tool to select the point to which you wish to navigate. A box will display around the point.

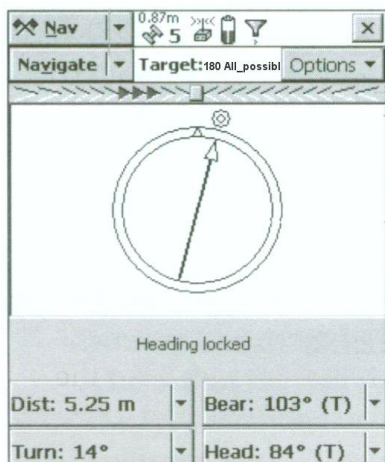


Click on the Options button, then Set Nav Target, then the point file name. The selected point will then be displayed with the target icon. When revisiting established plots, setting the Nav Target can be done in the same manner.

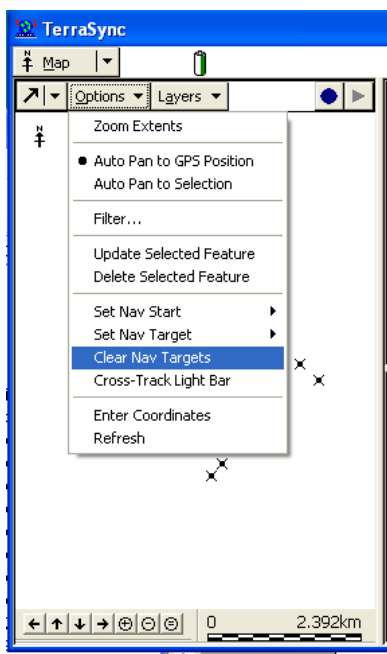


Open the

Navigation section (click on Map and chose Navigation). This will open the navigation screen. As you move, this screen will display the information needed to navigate to the point. When you are within 5 meters of the point, the unit will beep, and the screen will change to the map display.



When you've reached your point and/or no longer need to navigate, select the Map screen, then go to Options and select Clear Nav Targets.

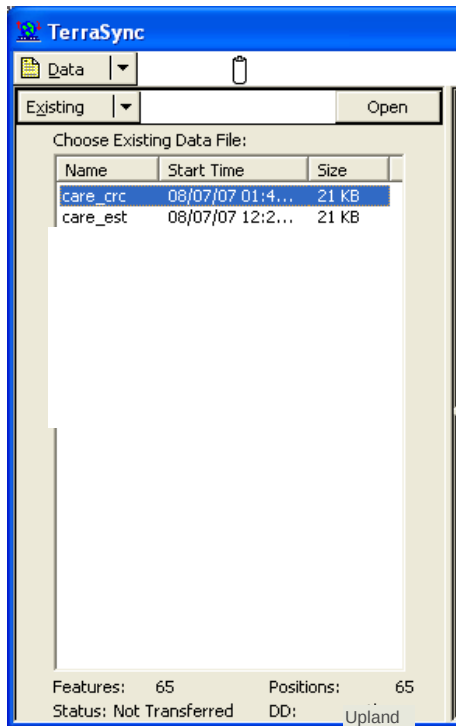


Data Collection:

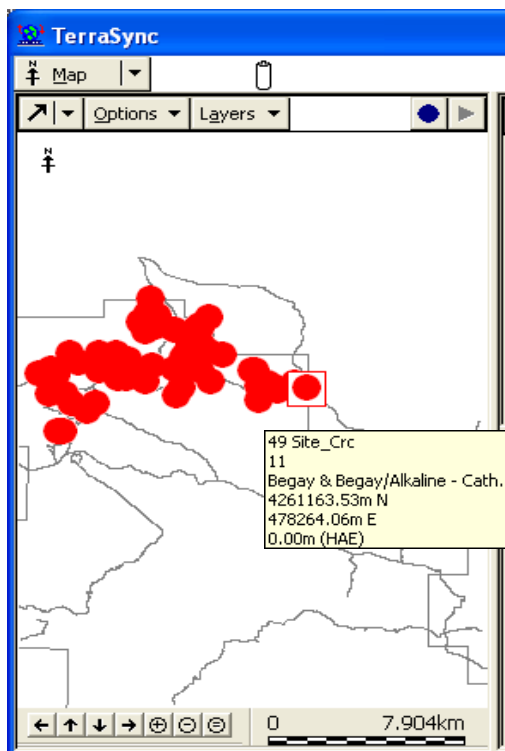
Site Characterization (recon)

The following instructions are written describing doing site recon work, but the navigation instructions are applicable to either characterization or establishment of a plot.

Open up *park_crc*:



Change the view from the Data view to the Map view (upper left dropdown menu). In this example, the background file is “CARE_RdTrls”, so all the roads and trails are displayed in addition to the potential upland monitoring plots.



Note that the PlotID (11) and ecosite/allotment (Begay & Begay/Alkaline – Cath) are displayed. The second label (ecosite/allotment) does not always have data displayed.

Once you've navigated to the point to be reconned, double tap the point from the Map screen to bring up the data dictionary. You'll notice the only field required to fill in is the S_Action field (either Accept or Reject).

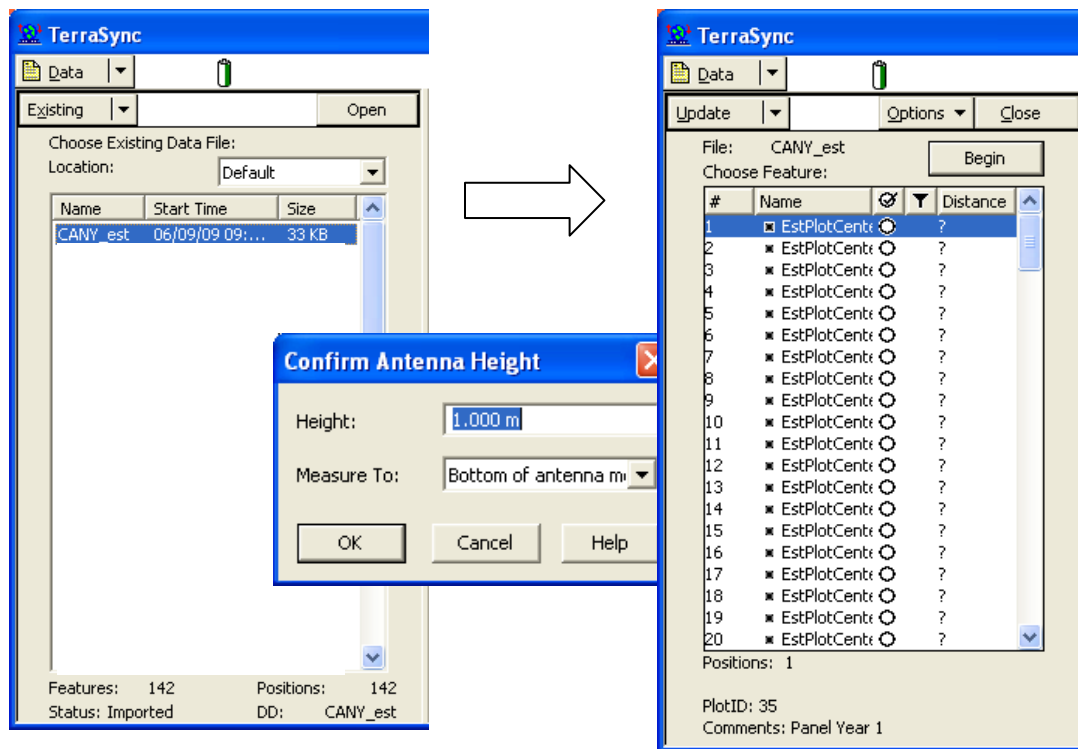
The screenshot shows the TerraSync application interface. At the top is a blue header bar with the 'TerraSync' logo. Below the header is a navigation bar with a 'Data' dropdown menu and a mobile phone icon. The main content area has a title bar with '49 Site_Crc', an 'OK' button with a red square icon, and a 'Cancel' button. Below the title bar are several fields: 'Mark as updated:' with a checkbox, 'PlotID:' with the value '11', '* S_Action:' with a dropdown menu, 'Allotment:' with the text 'Begay_Begay/Alkaline - Cath.', 'Comments:' with a text input field, and 'Visited:' with a checkbox. The 'S_Action' field is marked with a red asterisk, indicating it is a required field.

Note: At times, other fields will be added to aide field crews, (such as ecotype and soilmu), but those fields will not require data to be entered in the field. Those data will be displayed as the best guess we could generate in the office. Items not editable in the field will not have a white box around the text.

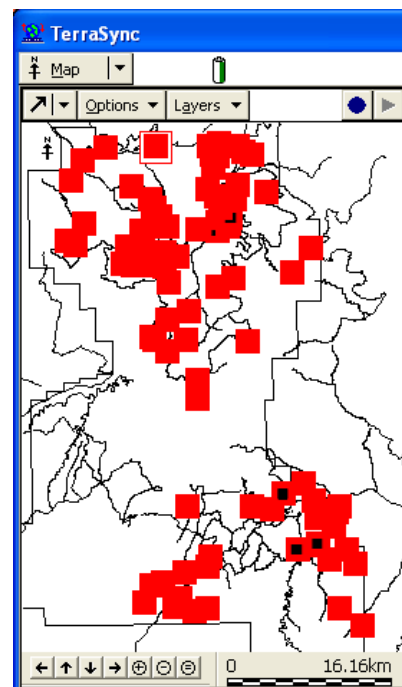
Plot Establishment

For the purposes of these instructions, it is assumed that possible plot locations will have been reconned prior to the visitation of the plot establishment crew.

Open *park_est*. Tap OK to Confirm Antenna Height. The file will open, displaying the points contained in list form.

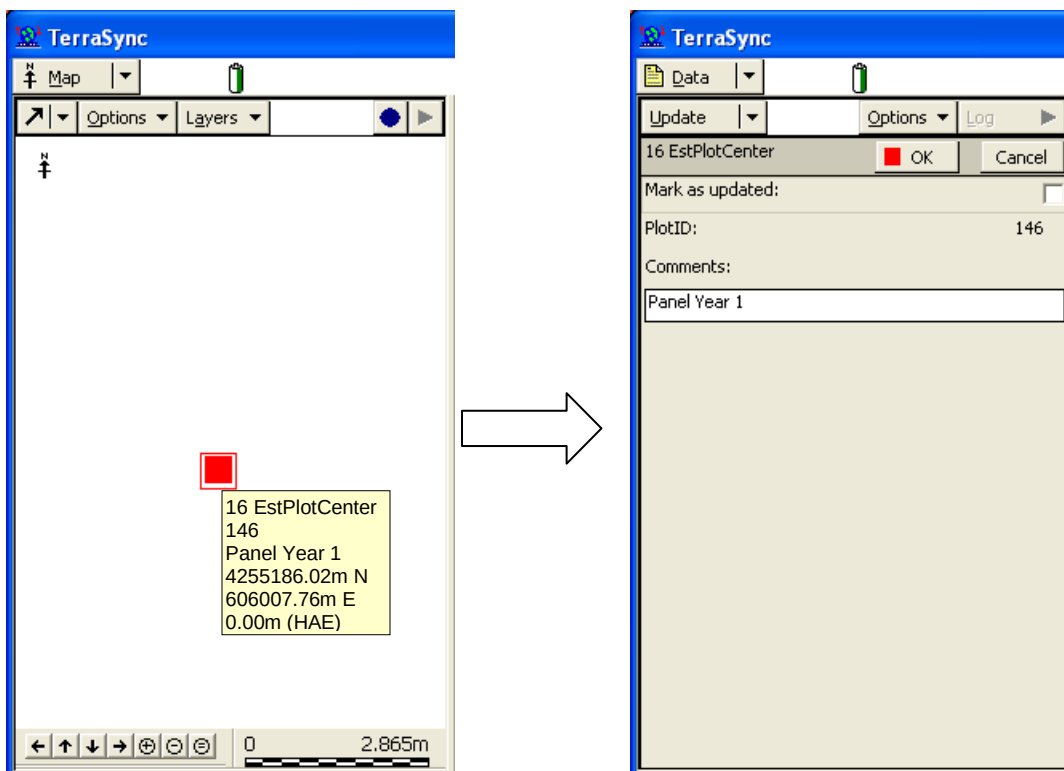


To view the points in the Map display, tap Data and choose Map. The points, with any background data layers will be displayed.

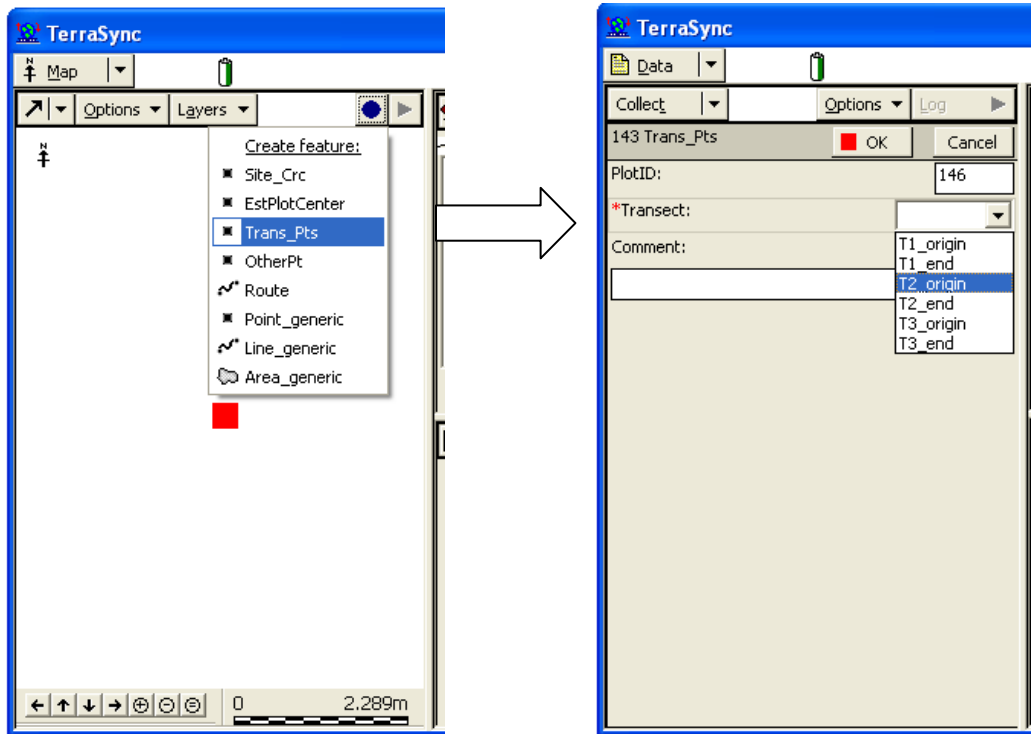


Navigate to the plot (see instructions above for navigation help). When you are nearing the plot, travel carefully so as not to trample the plot you are establishing! Navigate to the point to collect (log) the location.

Double tap the point, and the data dictionary will open. Log the point for 10-20 “hits” (seconds), and tap OK. Carefully navigate away from the center of the plot to begin setting up the transects.



Once you are ready, GPS the beginning and end points of each transect. When you are at a beginning or end point, from the Map screen, tap on the blue dot in the upper right corner. This will display the other features contained in the Upland Data Dictionary, including a transect point feature (Trans_Pts). Log each transect point, and fill in the plot ID as well as which transect origin/end point. Tap OK to save the point.

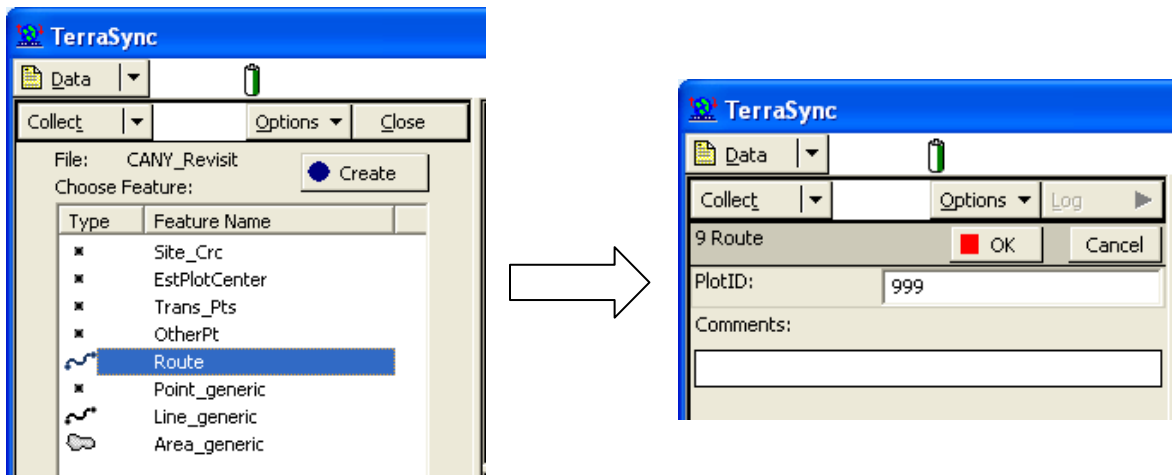


Remember, the locations you record will be used in years to come to relocate plots and transects, so log as accurately as you can.

Creating Trails/Routes:

If you feel that the plot you've visited is difficult to navigate to and/or hard to find, you may want to GPS the route you take out. This route can then be shown to future field crews to enable them to get to the plot efficiently.

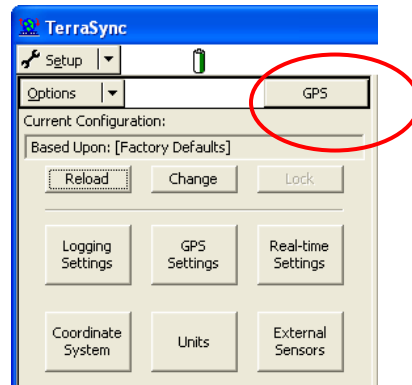
To map the route (trail) from the plot, click on Data/Collect and click on Route, which will bring up a field to fill in the PlotID and any brief comments you'd like to add:



As you walk along, the GPS unit will collect a point every 3 seconds. You don't need to do anything until you get to the end (as in, back to the paved road or trail or whatever). At that point, just click OK to end, close and save the feature.

Hints for Trimble units:

- Log a point for a minimum of 10 (to 20) “hits” (about 10 seconds).
- Holding the power button down for 30 seconds will soft re-boot the XM GPS. Holding the power button down for 60 seconds will hard re-boot the XM GPS. Neither of these re-boots will loose any data, but you should recheck the coordinate system.
- To re-boot the Junos, there is a little hole on the top left side (next to the expansion card). Push that with the tip of the stylus to re-boot the Juno.
- To conserve on battery life (generally 8 hours on XMs and 4+ hours on Junos), turn the unit off if you aren’t using it to navigate. It is recommended that TerraSync be closed *prior* to turning off the unit.
- On the Juno GPS units, there is a sliding button near the power button, if it is slid down, this will “lock” the Juno off so it won’t accidentally turn on while bouncing around in a backpack. Using this to turn the unit off (and on) seems to help conserve battery life (and seems to behave if TerraSync is left open).
- If the GPS gets disconnected, go to the Setup screen and tap the GPS button on the upper right side. A little connecting icon will appear as the unit reconnects to the GPS. A satellite icon will replace the connecting icon when TerraSync is reconnected to the GPS.



- The NCPN has a copy of the TerraSync Guide, which goes into more detail about the many functions of TerraSync. Please contact the GIS technician if you would like to take a look at it.
- Report any idiosyncrasies with the Trimble GPSes to the NCPN data management staff.

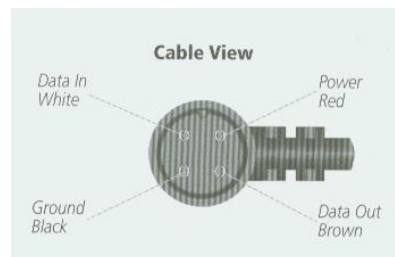
Attachment B



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

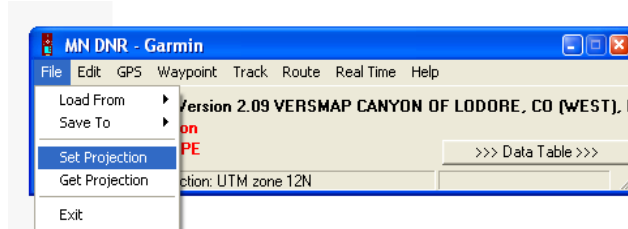
4. In the Field - optional

- 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.
 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

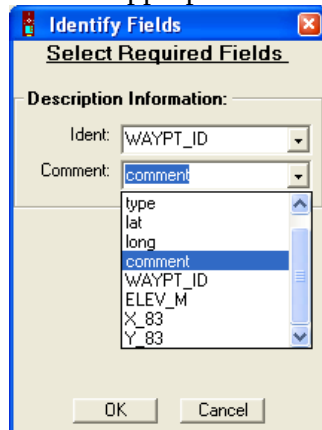
5. Highlight the 'GoTo' button, press ENTER
6. As you start walking, the Pointer will point to your destination

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.

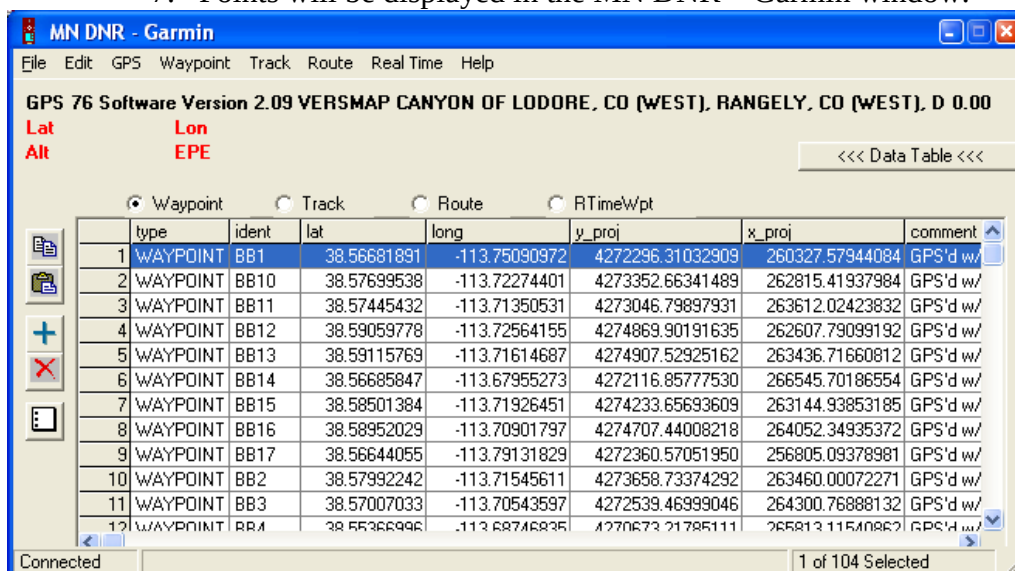


4. Click on File, then Load From. You can upload a .txt file, .dbf file or a shapefile. Navigate to the file you wish to upload and click Open.
5. A window will open prompting you select description information. Choose appropriate fields for Ident (ID) and Comment and click OK.



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

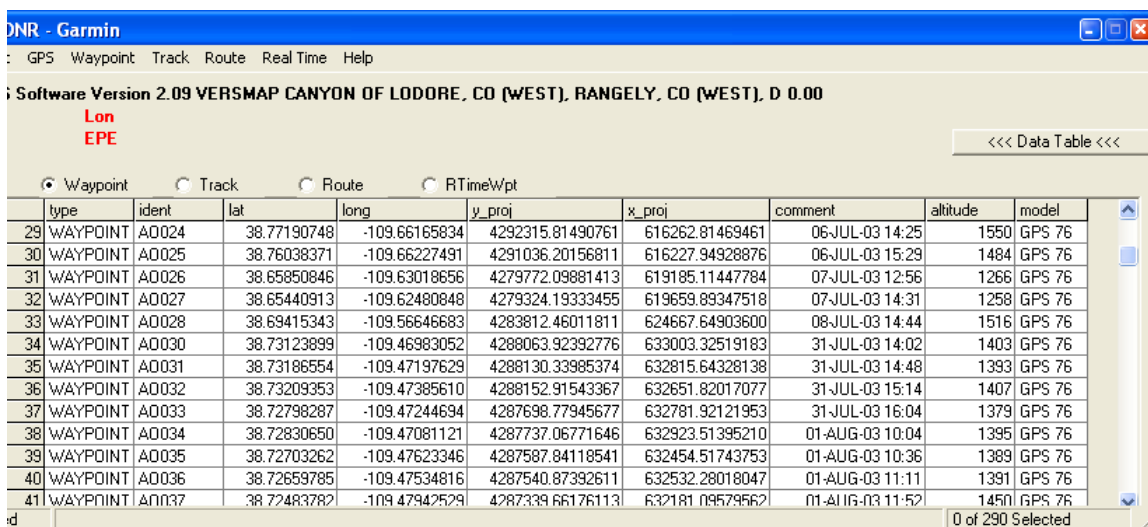
7. Points will be displayed in the MN DNR – Garmin window.



8. If the points are correct, click on WAYPOINT on the top menu, 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 where GPS files are stored.
4. There are several file types which you can save the file as. The NCPN recommends saving the data as a projected shapefile (*.shp) file.
5. Name the file with the date of download in the file name (example: Upland_June10_09.shp) and click the Save button. A window will display “File successfully written to ...”

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

Standard Operating Procedure (SOP) # 4

Crust-Friendly Field Procedures

Version 1.02 (March 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	4/2008	R.Weissinger	Formatting only	Improve useability	1.00
1.00	3/2009	DWitwicki	Formatting only	Standardize among SOP's	1.01
1.01	3/2010	DWitwicki	Updated within plot methods & definition of extreme disturbance	Improve clarity	1.02

Biological soil crust (BSC) is an important ecosystem component on 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 (as long as a century) is problematic. NCPN monitoring efforts must exercise considerable effort to minimize 'crust busting' for several reasons. First, park values must not be compromised by monitoring efforts. Second, destruction of crust on plots can impact the validity of the monitoring data, providing a false representation of 'natural' system dynamics. The following procedures were adapted from those used by USGS researchers working in the Colorado Plateau. All crew members must learn and follow these procedures.

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.

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 hiking to and from a monitoring plot, select a route that maximizes the use of bedrock, washes, and other large rocks than can be used as stepping stones. Tracks in washes will be erased during the next rain storm. At all times, avoid stepping on crust, no matter how developed it is.

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.

B) If you must step in areas with crust, leave only one set of footprints by walking in existing footprints.

C) Trails may eventually form below each transect in plots with well-developed crust. Be extra cautious to walk only in these trails and to avoid trampling any additional crust.

D) Place packs and recorder's chair on litter, on bedrock, or in a wash. If these options do not exist, minimize disturbance as much as possible and use previously disturbed area on return visits.

E) Have recorder sit by packs and use radio to communicate with observer in plots with well-developed crusts.

F) Carry your water bottle and other necessities with you so that a trip across the plot to reach your backpack is not necessary.

G) In areas with well-developed crusts and very shallow soils, attempt to monument transect ends with shorter pieces of rebar (no less than 9 inches) before using rocks to hold standard lengths of rebar in place.

III. When re-measuring a monitoring plot, if soil disturbance due to previous visits is extreme, note this on the site impact data sheet (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 project manager. The plot will be either rested before consideration for re-measurement or abandoned to avoid further degradation. Detailed descriptions and pictures will be useful to determine the proper course of action. One example of an extreme disturbance is soil erosion originating from previous trampling that causes deep furrows. Imprints from footprints or trails next to a transect are not considered an extreme disturbance.

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

Standard Operating Procedure (SOP) # 5

Site Characterization

Version 1.23 (March 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/2007	SGarman	Added additional instructions for site rejection	To expedite site assessments	1.10
1.10	4/2008	DWitwicki	Simplified incomplete “geologic setting” section to “parent material”, added parent material definitions, deleted NRCS list of landforms, and updated hypertext link for soils glossary	Instructions for geologic setting were not written and too complicated for field crews, landform list included too much unnecessary information	1.20
1.20	3/2009	DWitwicki	Updated locating plot center; formatting	To be consistent with previous year’s SOP updates	1.21
1.21	7/2009	DWitwicki	Added photo, vegetation type, grazed; deleted unused soil collection methods	To document rejected plots & sort plots; methods not used	1.22
1.22	3/2010	DWitwicki	Added instructions for rejecting plot due to cultural resources	To comply with SEUG cultural resources standards	1.23

This SOP provides instructions for characterizing potential field sites and 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 master plot ID, the NRCS soil map unit number of the plot, and the target ecological site of the plot. Visit the locations in the plot ID 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 about 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 additional trampling of the plot.

- 1) If it is obvious that the 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 road, reject the plot. Depending on the park and monitoring design, transects can cross old roads and trails.
- 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 transects of the macroplot, the plot is rejected. Inclusions include bedrock or pockets of non-target ecological site discernable as obviously different vegetation from the target ecological site.
- 6) If any of the 3 transects spans areas presenting safety hazards (e.g. cliff, deep ravine), reject the plot.
- 7) If there are cultural resources within the plot. For SUEG park units (ARCH, CANY, HOVE, and NABR), a ½ day training is required for any field crew member assessing plots for the presence of cultural resources.

If a plot is immediately rejected for reasons noted above, record the information listed below under Site Selection Comments, record reasons for site rejection, leave the site, and visit the next plot on the list.

Remember that plots are different sizes based on vegetation type, so use the appropriate size when rejecting plots for the above reasons. Forest and woodland plots require the greatest amount of space, extending approximately 45 m upslope, downslope, and across slope from the centroid due to the orientation of fuels transects. Grassland/shrubland plots extend approximately 25 m and oak plots extend approximately 10 m up/downslope and across slope from the centroid.

During initial and subsequent assessments never move the 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, which is acceptable. Purposely moving the plot center, however, introduces 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 inappropriate sites – they were selected in a manner that accommodates rejection without 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.
- **Vegetation type** – record whether the plot is grassland, shrubland, forest, woodland, or oak.
- **Grazed** – circle yes or no.
- **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).
- **Photo # & direction** – Take a photo from the centroid, aligning the camera so that you take a picture of the area in the potential monitoring plot (i.e. do not include sky and scenery in the background). Record the direction (N, NE, E, SE, S, SW, W, NW) of the photo.

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 B).

- A. *Parent Material* – Note the parent material and any information about geology that you can ascertain. The most common parent materials on the Colorado Plateau are alluvium, colluvium, eolian, residuum, and various glacial deposits. See Table 1 for definitions of common parent materials. Use surface rock fragments or other clues to determine what type of rock the soil is derived from (sandstone, shale, limestone, basalt, ect.). For example, parents materials are mixed eolian deposits derived from sandstone.

Table 1. Definitions for common parent materials of the Colorado Plateau (derived from the NRCS at <https://www.soils.org/sssagloss/>)

alluvium	Sediments deposited by running water of streams and rivers. It may occur on terraces well above present streams, on the present flood plains or deltas, or as a fan at the base of a slope.
colluvium	Unconsolidated, unsorted earth material being transported or deposited on sideslopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.
eolian	Pertaining to earth material transported and deposited by the wind including dune sands, sand sheets, and loess.
residuum	Unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place.

- 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 are listed and defined in Table 2. 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 <https://www.soils.org/sssagloss/>. Write in the appropriate landform on the data sheet.

Table 2. Definitions for common landforms of the Colorado Plateau (derived from the NRCS at <https://www.soils.org/sssagloss/>)

alluvial fan	A fan-shaped deposit of loose soil and/or rock material, commonly with gentle slopes, and deposited by a stream at the place where widens after a narrow upland valley.
alluvial flat	A nearly level, graded, alluvial surface which commonly does not manifest traceable channels or terraces.
alluvial terrace	One of a series of platforms, representing the dissected remnants of an abandoned floodplain, stream bed, or valley floor that is thickly mantled with alluvium.
cuesta	An asymmetric, homoclinal ridge capped by resistant rock layers. 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.
hill	A generic term for an elevated area of the land surface above surrounding lowlands, usually with nominal summit area relative to bounding slopes, a well-defined rounded outline, and slopes that generally exceed 15 percent.
hillslope	A generic term for the steeper part of a hill between its summit and the valley bottom or depression at the base of the hill.
mesa	A broad, nearly flat-topped, and usually isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal, rocky summit with the width greater than the height of bounding escarpments.
plateau	A relatively flat area of great extent and elevation; specifically an extensive flat land region considerably elevated above adjacent lower-lying terrain that is commonly limited on at least one side by an abrupt descent.
sand dune	A low mound, ridge, bank, or hill of loose, windblown sand, either barren and capable of movement from place to place, or covered and stabilized with vegetation, but retaining its characteristic shape.
sand sheet	A large, thin sheet of eolian sand, lacking discernible slip faces that are common on dunes.
strath terrace	Erosional surfaces cut into bedrock and thinly mantled with alluvium.
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 orientation.
valley	An elongate, relatively large, externally drained depression of the Earth's surface that is primarily developed by stream erosion or glacial activity.
valley floor	A general term for the nearly level to gently sloping, lowest surface of a valley.

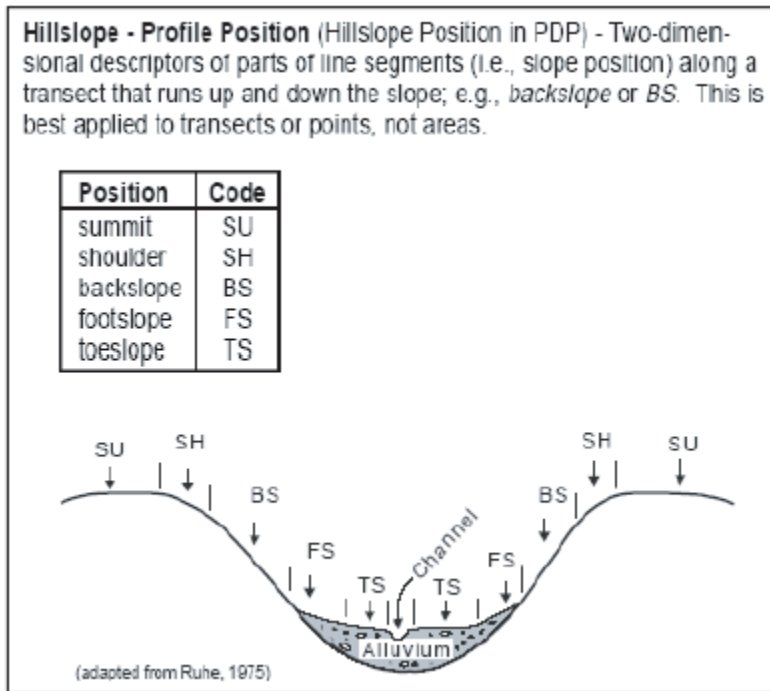


Figure 1. NRCS figure for determining hillslope position (Schoeneberger et al. 2002)

- 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.

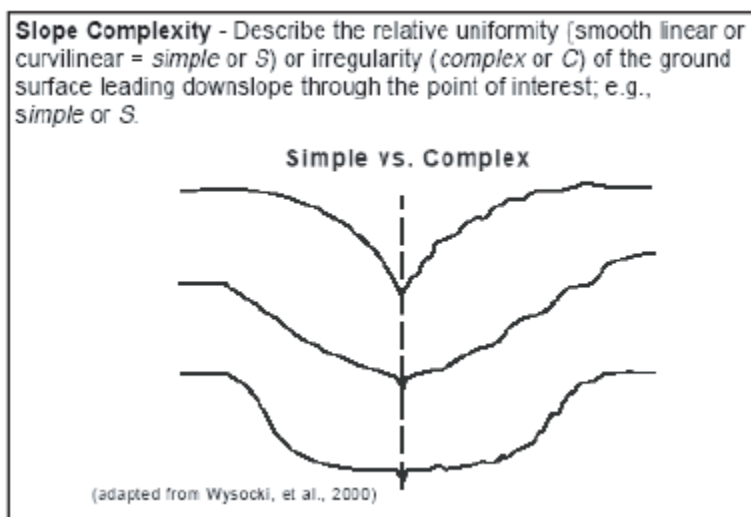


Figure 2. NRCS figure for determining hillslope complexity (Schoeneberger et al. 2002)

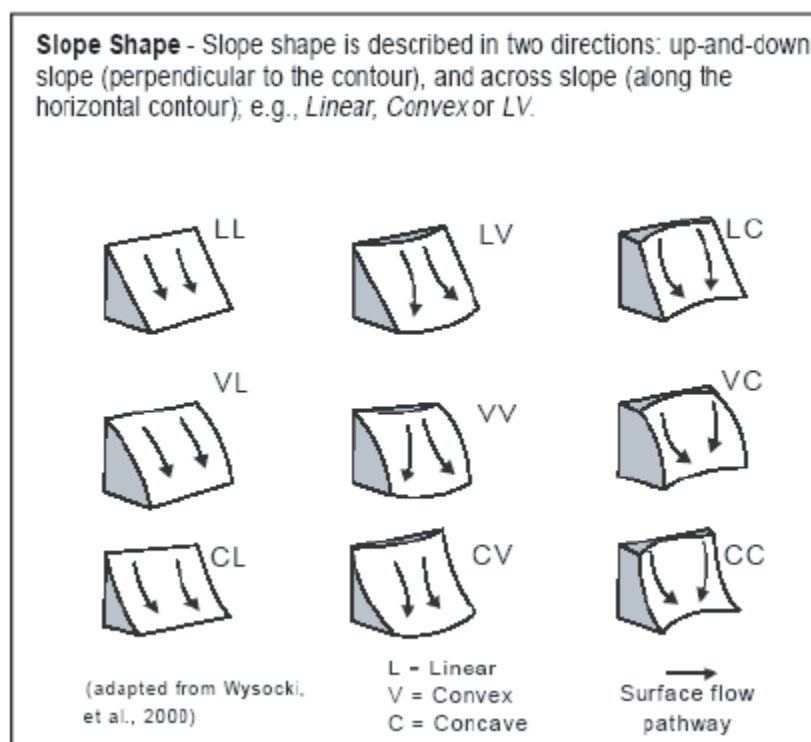
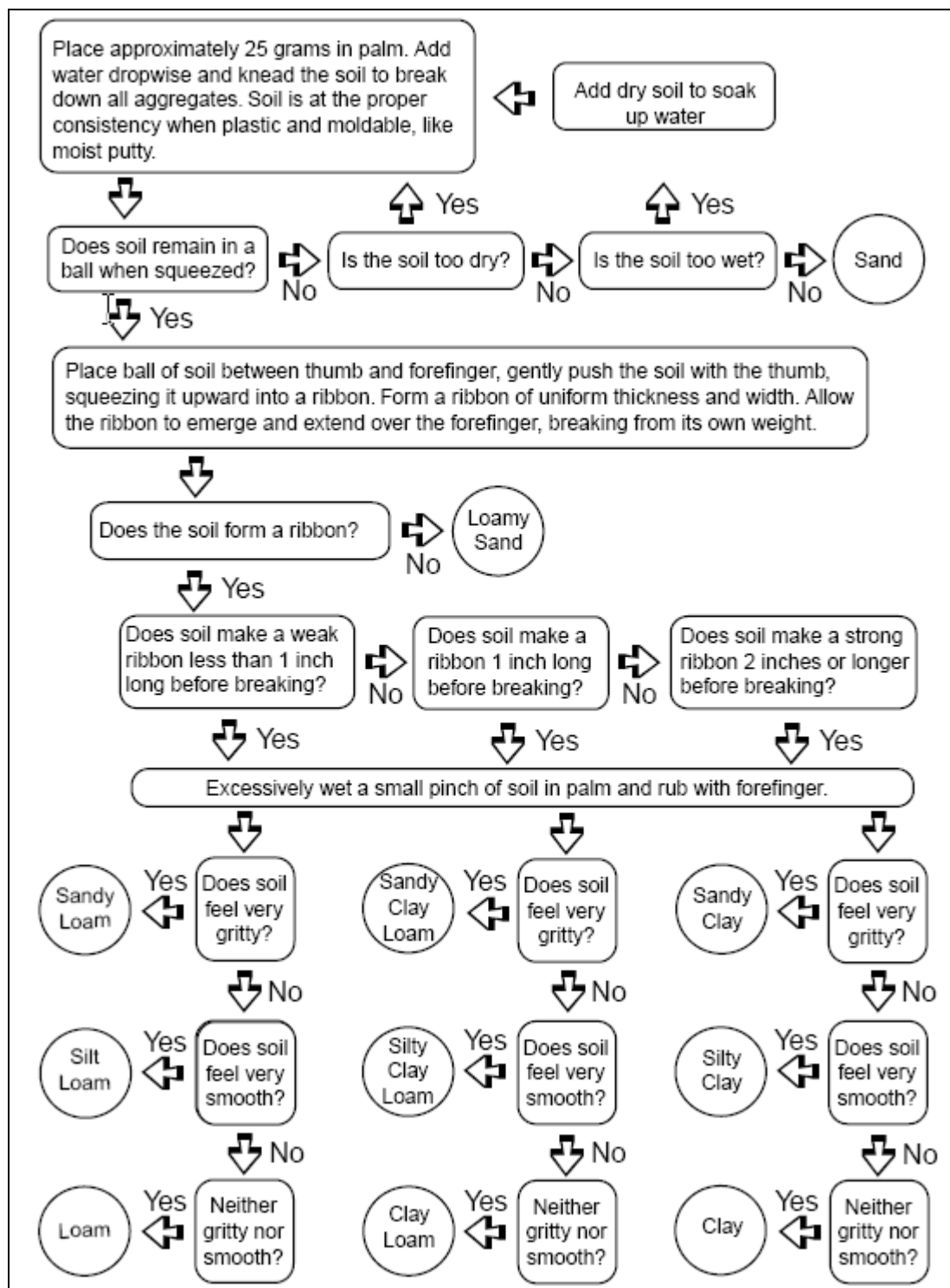


Figure 3. NRCS figure for determining slope shape (Schoeneberger et al. 2002)

Table 3. 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 3 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.

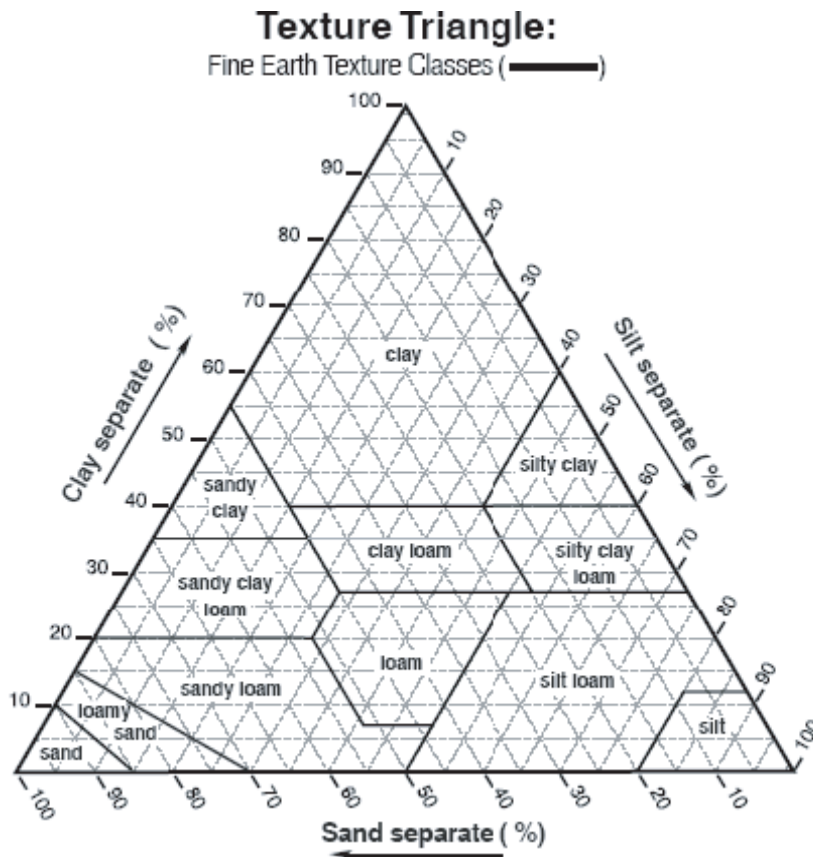


Figure 5. Soil texture triangle (Schoeneberger et al. 2002)

- 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				
										channers		150	380	600 mm
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 under “Size” below. (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 4 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. Definitions for some potentially unfamiliar rock fragment types are listed below.

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

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

Table 5 provides examples of rock fragment texture modifiers for rock fragments of different quantity and size.

Table 4. 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 5. 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 6 to determine the effervescence class. More bubbles indicate higher amounts of carbonate compounds in the soil. Circle your choice on the data sheet.

Table 6. 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. *Depth class* – Estimate the soil depth class based on your observations of bedrock exposures or naturally occurring soil profile exposures in the area. Use Table 7 to determine the approximate depth class or classes, and circle your choice(s) on the data sheet. **Do not dig to determine the actual depth.** NPS requires that an archeologist be present during any digging to make sure the area is free of sensitive archeological artifacts.

Table 7. 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

- L. *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. 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 grassland/shrubland, woodland, and forest plot has three 50-m transects separated by 25 m (Fig. 7) for a total of 150 meters of transect. Oak plots have three 20-m transects separated by 10 m for a total of 60 meters of transect. Enter the ecological site number and name recorded on the dichotomous key for the respective park unit (e.g. 212-Semidesert Sand (Four-wing Saltbush)). When in doubt, enter **other**.

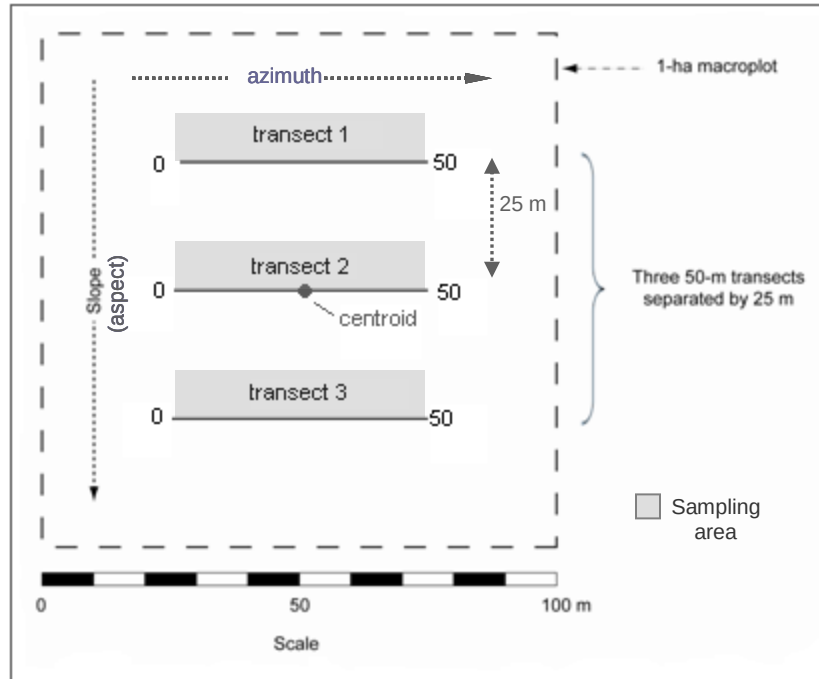


Figure 7. Standard macroplot and transect layout for upland monitoring.

6) Site Selection

Plots will be rejected if they do not match the target ecological site (wrong slope, landform, soil texture, 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).

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

References

- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005. *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.
- 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.
- 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

Data entered by:

Data verified by:

p.1

NCPN Upland Monitoring

1. GENERAL PLOT INFO.

Park code: _____ Plot ID: _____ Date: _____ Recorder: _____

Vegetation type: _____ Grazed: yes no

Soil survey area: _____

Soil map unit: _____ GPS file name: _____

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

Photo #: _____ Direction: _____ Datum: _____ UTM Zone: _____

2. SOIL AND VEGETATION CHARACTERIZATION

A. Parent Material: _____

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

L. Dominant vegetation: _____

p.2

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: _____

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	Alluvium 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.

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

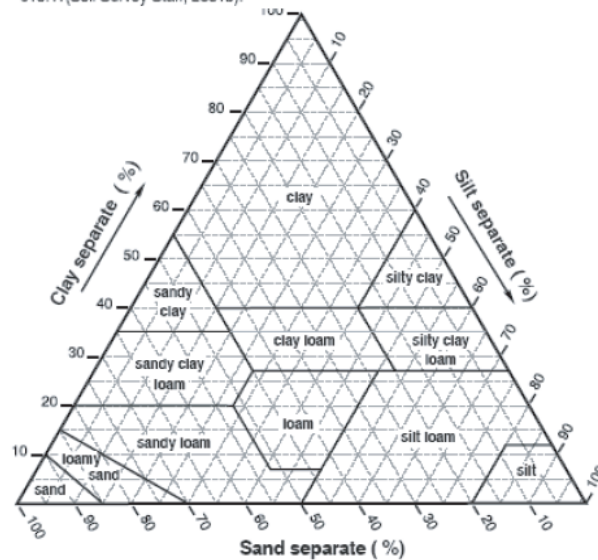
- Add excess water to small amount of soil; soil feels at least slightly gritty.....**Sandy Clay Loam (SaCL)** or **Clay Loam (CL)**
- Soil feels smooth.....**Silt (Si)** or **Silty Clay Loam (SiCL)**

- 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).



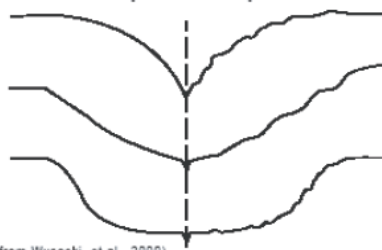
FINE EARTH										ROCK FRAGMENTS					150	380	600 mm
										channers			flagst.	stones	boulders		
Clay ²		Silt		Sand					Gravel			Cob- bles	Stones	Boulders			
fine	co.	fine	co.	v. fi.	fi.	med.	co.	v. co.	fine	medium	coarse						
0.0002	.002 mm		.02	.05	.1	.25	.5	1	2 mm	5	20	76	250	600 mm			

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*.

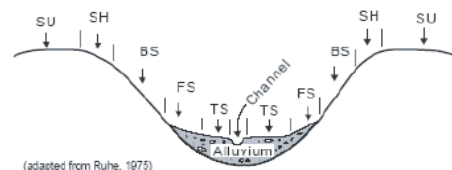
Simple vs. Complex



(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.

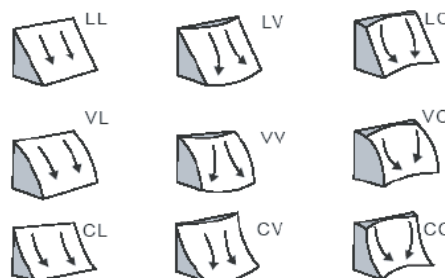
Position	Code
summit	SU
shoulder	SH
backslope	BS
footslope	FS
toeslope	TS



(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

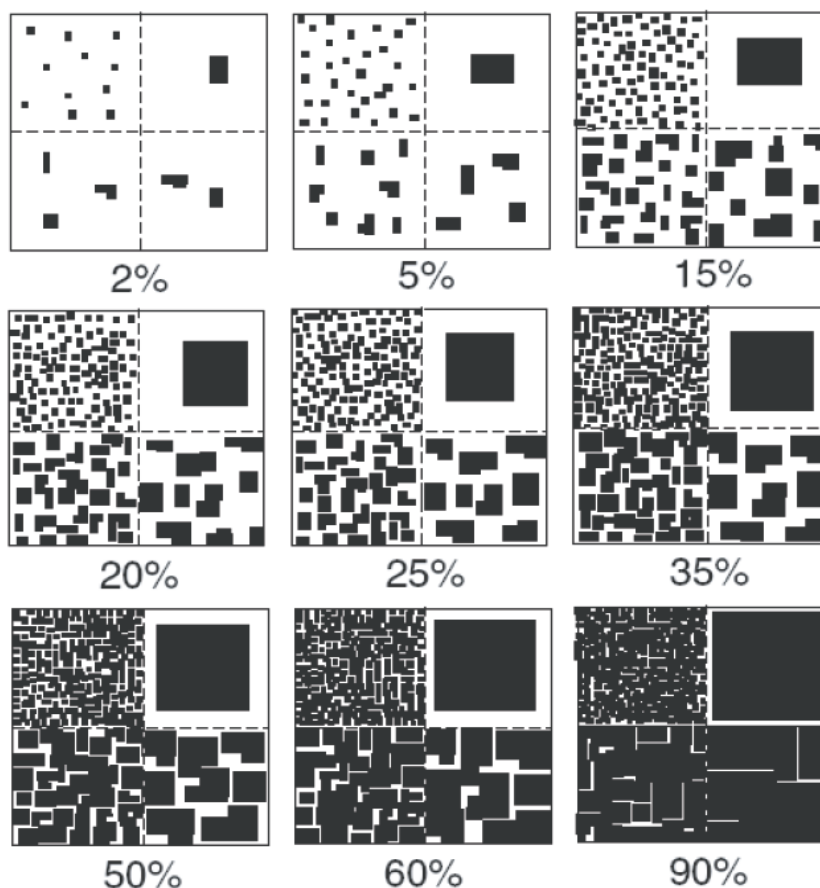
Slope Shape - Slope shape is described in two directions: up-and-down slope (perpendicular to the contour), and across slope (along the horizontal contour); e.g., *Linear*, *Convex* or *LV*.



(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 Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 6

Plot Establishment and Revisit Set-Up

Version 1.22 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	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	1.10
1.10	4/08	RWeissinger	Formatting only	To improve useability	1.10
1.10	7/08	RWeissinger	Added procedures and equipment for woodland sampling	Expanded sampling frame to include forest ecosites	1.20
1.20	7/09	DWitwicki	Added procedures for forest and woodland; revise establishment procedures for transects 1 & 3; remove DRC from data sheets; pre-numbered tree tags; orange stakes	Need to record slope of plot sides; clean up	1.21
1.21	1/11	DWitwicki	Change size of rebar for monuments	Compliance	1.22

This SOP provides instructions for establishing a permanent monitoring site in grassland, shrubland, woodland, and forest vegetation types. For oak scrub, see SOP #15. This SOP includes instructions for setting up macroplots, recording changes in permanent markers, and recording general comments while revisiting an existing monitoring site. A list of necessary equipment for these procedures can be found in SOP #1. SOP #4 (Crust-Friendly Field Procedures) should be reviewed before plot establishment.

I. Plot Establishment Procedures

1. Navigate to the plot centroid using a GPS unit, topographic map, and pre-determined UTM coordinates.

- Approach from downslope to avoid trampling the sampling area.
- Place a pinflag at the plot centroid.

2. General Plot Information

Park Code– Use the four letter NPS code, e.g. ARCH, CANY, ZION, etc.
Plot ID – Use the ID number provided

Date – Use the format mm/dd/yyyy, e.g. 05/14/2009

Observer – Record the first initial and last name of the observer

A. Record directions to the plot.

Write directions assuming that they will be used to relocate the site by someone who has never been to the plot before. Begin with road travel from a designated location (such as the park's visitor's center), where to park, and the route used. Describe (and photograph) landmarks used in navigating to the origin of the center transect. Note particular obstacles or hazards to be avoided at and en route to this particular site. Use specific language such as "southwest" and "downslope" rather than ambiguous terms such as "left" or "below."

B. Record the position of the pin flag using the GPS (**SOP#3**). Check to make sure the Datum is NAD83.

3. Slope and Aspect Measurements

A. Stand at the centroid and face downhill.

- If it is difficult to determine which direction is downhill, aim towards the nearest drainage.

B. Aim the clinometer at a point at eye level roughly 25 m downslope. Record the percent slope.

C. Set the compass to true north using the correct declination. Aim the compass downslope, level the compass, and record the aspect of the slope in degrees.

D. Face uphill and aim the clinometer at a point at eye level roughly 25 m upslope. Record the percent slope.

E. Average the two percent slope measures.

4. Azimuth of the Center Transect

A. Subtract 90° from the slope aspect. Record this number as the centroid transect azimuth.

- If the plot is truly level, arbitrarily choose a transect azimuth.

5. Establish the center transect.

The upland macroplot consists of three 50-m long transects running parallel across the slope at intervals of 25 m (Fig. 1).

A. Have one crewmember stand over the centroid pin flag holding the reel of the transect tape and a compass.

B. The second crew member takes the end of the tape and walks toward the transect origin (left when facing upslope). Walk until the tape is at 25 m over the centroid pin flag.

- Walk downslope of the transect to avoid trampling the sampling area.

- Have the crew member with the compass guide the person with the tape to ensure the correct transect azimuth.

- The line should be taut and as close to the ground as possible to avoid curvature in the line.
- Thread the tape through shrubs whenever possible using a chaining pin as a needle.

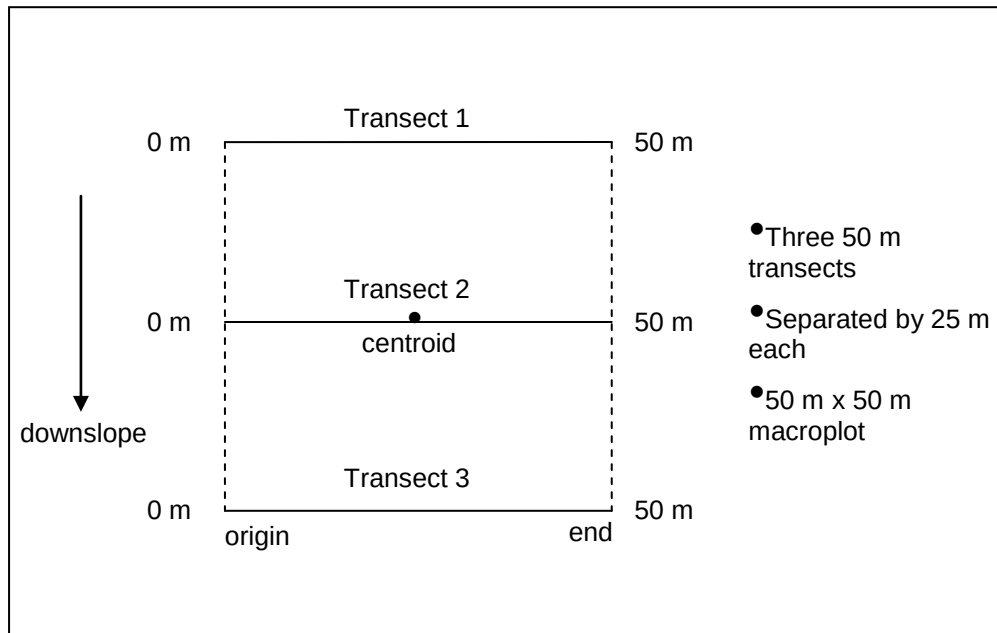


Figure 1. Standard macroplot and transect layout for upland monitoring.

- C. Drive a 3/8" diameter rebar stake into the ground at the origin of the transect, leaving less than 30 cm exposed. Note the distance along the transect where the rebar is placed (i.e. at the origin, the distance is 0).
- If bedrock exposure prevents sinking the rebar in at the origin or at the end, locate the closest possible point along the transect and drive the rebar stake in there. Note the displacement on the data sheet.
 - If a piece of rebar is easily visible from a road or trail, only leave about 10 cm of rebar above ground or sink it to ground level. Note this in the comments on the data sheet.
 - 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.
 - In some cases, such as plots that are accessed by very long hikes or in areas with dense undergrowth, orange plastic stakes may be substituted for rebar. This requires prior permission from each park and may require painting the stakes a more subtle color. Rebar should always be used in rocky soils, near roads, and in places where stakes may be easily broken (washes, avalanche paths, cattle trailing routes, etc.).
- D. Stamp the plot information on a metal tag (Fig.2). Tags can be prepared beforehand in the office or in camp.
- Side One: "NCPN" and date (e.g. Aug 2006)
- Side Two: PlotID number, transect number (i.e., 1 = upper, 2 = center or 3 = lower), and transect location (i.e., O = origin, E = end).

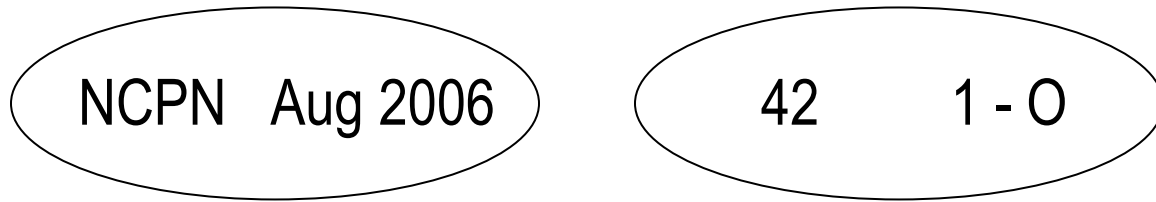


Figure 2. Format of metal tags used to mark rebar.

- E. Attach the metal tag to the rebar by threading the tag with a piece of wire and wrapping the wire at the base of the exposed rebar.
- F. Using the GPS (SOP #3), record the UTM coordinates and elevation of the rebar marking the transect origin on the Plot Establishment Data Sheet.
- G. Place a chaining pin in line with the transect past the origin rebar. Attach the transect tape to the chaining pin using a loop of cord such that the 0-m mark falls over the rebar. Secure the transect tape using chaining pins placed at 10 m and 20 m as you walk back to the centroid. While one crew member is completing this, the crew member at the centroid should fill out the directions to the plot.
- H. From the centroid, walk with the tape reel along the appropriate azimuth to the 50 m mark, placing chaining pins at 30 m and 40 m. Follow the guidelines noted in 5B.
- I. Place rebar with a marked tag at the end of the transect. Use a GPS unit to collect UTM coordinates and elevation for the rebar at the end of the transect.
- J. Place a chaining pin in line with the transect past the rebar and wrap the transect tape around the chaining pin such that it crosses the end rebar at 50 m.
- K. Move all packs and loose gear to the area near the transect origin.

6. Photograph the transect (SOP #7)

7. Collect all data along the transect (SOPs #7-14)

8. Establish and collect data on the remaining transects

- A. Have one crew member stand over the pin flag at the origin of the center transect holding the reel of the transect tape and a compass.
- B. The second crew member takes the end of the tape and walks upslope along the slope aspect bearing determined in Step 3. Walk until the tape is at 25 m over the pin flag at the origin of the center transect.
- C. Place a pin flag at the new location. This point becomes the origin of Transect 1.

- D. Have one crewmember stand over the pin flag at the origin of Transect 1 holding the 0-m end of the transect tape and a compass.
- E. The second crew member takes the reel of the transect tape and walks toward the transect end (right when facing upslope). Walk until the tape is at 50 m, following guidelines in 5B.
- F. Monument, tag, GPS, and secure Transect 1 in the same manner as described for the center transect in Step 5. Photograph and collect data along Transect 1 (Steps 6 & 7).
- G. Repeat the procedure in Step 8 A-E, going downslope from the origin of the center transect instead of upslope to establish Transect 3.
- H. Monument, tag, GPS, and secure Transect 3 in the same manner as described for the center transect in Step 5. Photograph and collect data along Transect 3 (Steps 6 & 7).

9. Record slope of plot sides (forest and woodland plots only)

In order to scale up canopy measurements, the slope of all plot sides is recorded in forests and woodlands.

- A. Figure 3 illustrates the naming convention for slope sides and the direction of slope side measurements.
- B. For sides A and C, stand at the origin of the transect and aim the clinometer at the point roughly eye level above the transect end.
- C. For side B, stand at the origin of transect 1 and aim the clinometer at the point roughly eye level above the origin of transect 3.
- D. For side D, stand at the end of transect 1 and aim the clinometer at the point roughly eye level above the end of transect 3.
- E. Record the percent slope of each plot side. Record whether the slope is going uphill or downhill by circling “up” or “down” on the data sheet.

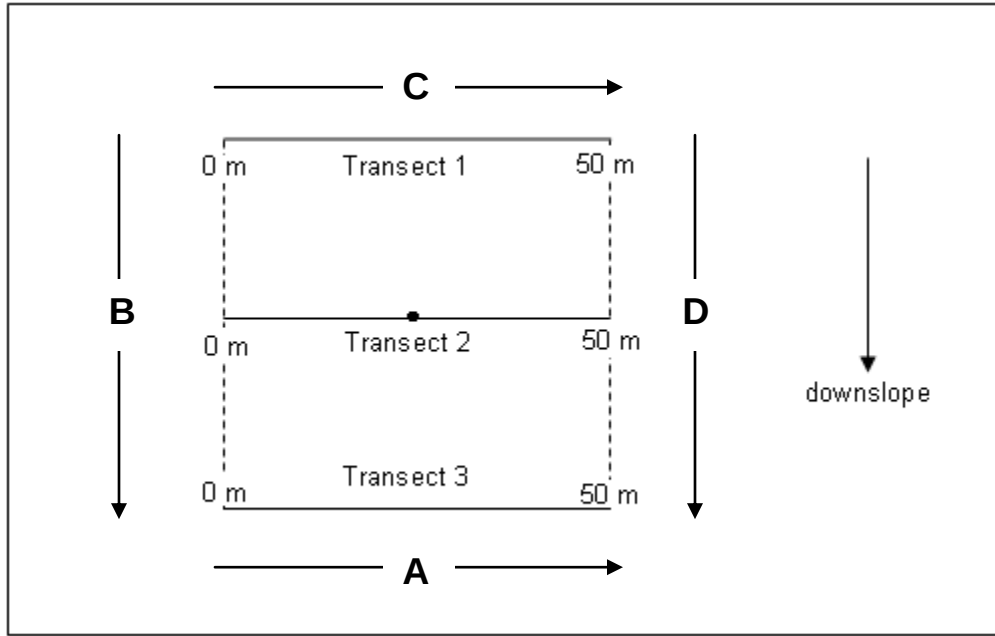


Figure 3. Naming convention (A, B, C, D) and direction of slope measurements for forest and woodland plots.

10. Plot Marking – Monument Tree Establishment (Optional for forest & woodland plots)

In some wooded areas, plots may be difficult to relocate due to thick vegetation cover and poor satellite reception. In such areas, monument trees should be established at each plot corner.

- A. Up to three monument trees are established for each corner rebar (Figure 4). Each monument tree should be located within 5 meters of the plot corner. Each tree should be of a long-lived species that is healthy and free of major defects that could reduce longevity. If possible, select monument trees from a variety of species so that they will not all be susceptible to the same diseases or insects.
- B. Fill in the appropriate row on the data sheet. Monument tree codes are the transect number and location, followed by a, b, or c (e.g. T1-Oa, T3-Ec, etc.).
- C. Record the tree's species and diameter at breast height (DBH). See SOP #13 for details on how to measure tree diameter.
- D. Determine the bearing **from** the monument tree to the plot corner, and the distance from the **center point** of the monument tree to the plot corner on the data sheet. Be sure your compass is set to the correct declination before recording this bearing.
- E. Tag the tree using a pre-numbered round aluminum tree tag. Insert the nail just below breast height, angled downward, with the head pointing toward the transect rebar. Leave approximately 1" of the nail exposed so that the tree can continue to expand.

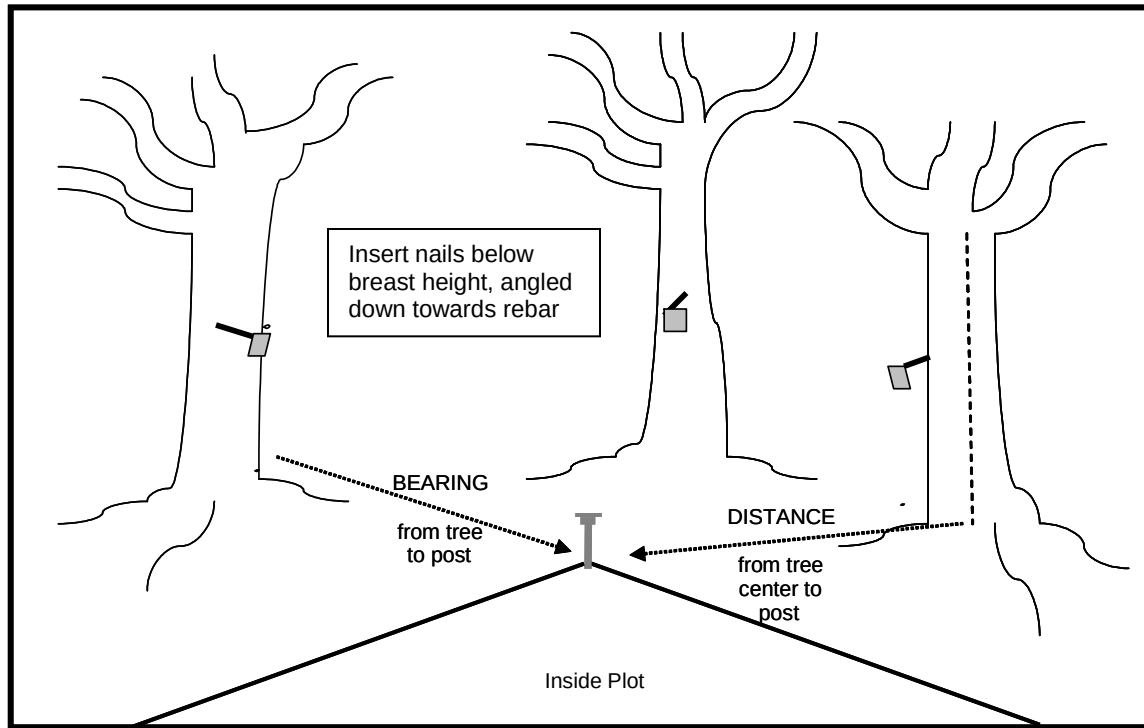


Figure 4. A plot corner with three monument trees.

II. Revisiting An Existing Monitoring Site

1. Navigate to a plot corner using a GPS unit, topographic map, and UTM coordinates marked on the Plot Revisit data sheet (Appendix B).

- Approach from the downhill side to avoid trampling the plot.

2. Set up Transect 3.

- A. Use UTM coordinates and witness trees to find the rebar marking the origin end of Transect 3.

- B. Check the metal tag to make sure it is marked “3-O.”

- If the monuments of the transect ends have been altered or removed due to disturbances and can not simply be replaced at the same locations, they should be relocated.
 - a. After determining a suitable location along the transect for a transect-end monument, use the GPS to record the new UTM coordinates.
 - b. Cross off the old coordinates on the Plot Revisit data sheet, and record the new coordinates below.
 - c. Note the displacement of the new rebar location in the comments section of the data sheet.

- C. Anchor the “0” end of the tape to a chaining pin in line with the transect using a cord loop so that the 0 m mark falls over the rebar at the origin end of the transect.
- D. Walk towards the other end of the transect while pulling out the tape.
 - Walk downslope of the transect to avoid trampling the sampling area.
- E. Secure the tape in place as you walk by using chaining pins at least at 10 m, 20 m, 30 m, and 40 m. This is important for repeatability, especially during windy visits.
- F. Wrap the tape around a chaining pin past the end rebar such that the 50 m mark falls over the rebar.

3. Photograph the transect and collect all data (SOPs #7-14).

4. Proceed upslope to set up and read the center transect.

5. Set up and read the upper transect.

6. Complete the Plot Revisit data sheet.

References

- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005. *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.
- USDI National Park Service. 2003. *Fire Monitoring Handbook*. Boise (ID): Fire Management Program Center, National Interagency Fire Center, 274p.

Plot Establishment Data Sheet

Data entered by: _____

Data verified by: _____

NCPN Upland Monitoring

Park Code: _____	Plot ID: _____	Date: _____	Plot side A _____ up down B _____ up down C _____ up down D _____ up down
Observers: _____			
Centroid UTM's: Zone _____	_____ E	_____ N	
Ave. Slope (%) _____	Aspect (°) _____	Centroid Transect Azimuth (°) _____	

Transect Location

Transect	Rebar at origin		Location (m)	Rebar at end		Location (m)
	UTM Easting	UTM Northing		UTM Easting	UTM Northing	
1 (upper) - upslope						
2 (center)						
3 (lower) - downslope						

Monument Trees

Monument	Tag #	Species	DBH (cm)	Bearing (°)	Distance to rebar (m)
T1 - Oa					
T1 - Ob					
T1 - Oc					
T1 - Ea					
T1 - Eb					
T1 - Ec					
T3 - Oa					
T3 - Ob					
T3 - Oc					
T3 - Ea					
T3 - Eb					
T3 - Ec					

Directions to plot: _____

* Most information in this data sheet is pre-filled by the upland database.

Plot Revisit Data Sheet

Data entered by: _____

Data verified by: _____

NCPN Upland Monitoring

Park Code: _____	Plot ID: _____	Date: _____	Plot side A _____ up down B _____ up down C _____ up down D _____ up down
Observers: _____			
Centroid UTM's: Zone _____	_____ E	_____ N	
Ave. Slope (%) _____	Aspect (°) _____	Centroid Transect Azimuth (°) _____	

Transect Location

Transect	Rebar at origin		Location (m)	Rebar at end		Location (m)
	UTM Easting	UTM Northing		UTM Easting	UTM Northing	
1 (upper) - upslope						
2 (center)						
3 (lower) - downslope						

Monument Trees

Monument	Tag #	Species	DBH (cm)	Bearing (°)	Distance to rebar (m)
T1 - Oa					
T1 - Ob					
T1 - Oc					
T1 - Ea					
T1 - Eb					
T1 - Ec					
T3 - Oa					
T3 - Ob					
T3 - Oc					
T3 - Ea					
T3 - Eb					
T3 - Ec					

Directions to plot: _____

Comments: _____

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

Standard Operating Procedure (SOP) # 7

Repeat Photographs

Version 1.31 (March 2009)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/1/2007	SGarman	Added additional photo points	To provide a more comprehensive photo record of plot conditions	1.10
1.10	2/5/2008	DWitwicki	1) Clarified orientation of camera in transect photos 2) Added specific instructions for avoiding body parts in photos.	1) Not specified in previous version 2) Field crew in transect photos from previous years	1.20
1.20	4/2008	RWeissinger	Formatting only	To improve useability	1.20
1.20	7/2008	RWeissinger	Added woodland procedures	New ecosites	1.30
1.30	3/2009	DWitwicki	Clarify photos taken for each vegetation type; photo labeling; other photo instructions	Made consistent with database	1.31

This SOP provides instructions for taking photographs of each upland monitoring site. For grassland/shrubland plots, one photo of each transect and one photo of biological soil crust along each transect are required. For forest and oak plots, two photos of each transect are required. For woodland sites, all three types of photos are required for each transect.

I. Fill out the data sheet

1. **Park Code** – The four letter park code
2. **Plot ID** – The plot ID number
3. **Date** – Use the format mm/dd/yyyy
4. **Folder ID** – Record the name of the folder into which photos are downloaded.

II. Photo Points

Photos are taken using a digital camera. In the Frame or photo # column, number the photos in the order that they are taken. If a film camera must be used, procedures are the same, but the film-roll information is recorded in the roll # column on the data sheet. When using a digital camera, the roll # field can be left blank.

1. Transect Origin Photos – All Plots

Take transect photos from the origin end of each transect while the meter tape is stretched out along the transect.

A. Label photo point ID board and lean it next to the rebar marking the origin of a transect.

Site – Park code and Plot ID number (e.g., CANY 143)

Date – mm/dd/yyyy, e.g., 08/22/2010

Transect photo ID - T1-O, T2-O, or T3-O

- If you are having difficulty propping up the ID board, use additional objects behind or underneath it rather than including field crew members or their body parts in the photos.

B. Stand 3 meters back from the end of a transect, set the camera body on top of a folding engineer ruler extended to 1.5-m in height, and point the camera down the transect.

C. Orient the camera so that it is rotated 90° and takes a vertical (portrait) format photo.

D. Check to ensure that the sign board is visible at the bottom of the field of view and the 50-m tape is visible on the right side.

E. Take a photo and record the photo information under Transect# on the Photo Data Sheet. Record the location of the photo point as -3 m.

2. Transect End Photos – Forest, Woodland, and Oak Plots

In vegetation types where one photo may not be sufficient to show the characteristics of a transect, an additional photo is taken at the end of each transect.

A. Label the board with an “E” at the end of the transect number, e.g. T3 – E.

B. Follow the instructions above, standing at 53 m along the transect.

3. Biological Soil Crust Photos – Grassland, Shrubland, and Woodland Plots

BSC photos are taken at 0 m on Transect 1, 20 m on Transect 2, and 40 m on Transect 3.

A. Stand at the designated position along the transect.

B. Position the camera horizontally so the transect tape just shows on the bottom of the frame, and an area approximately 1-m² fills the screen.

C. Record the photo and the location information under Crust on the Photo Data Sheet. Take a crust picture even if biological soil crust is not present.

4. Other Photos

Record any additional photos on the data sheet. Additional transect photos may be recorded here if origin and end transect photos do not sufficiently illustrate the transect. Be sure to record the location the photo was taken along the transect.

Appendix A.
Photograph Data Sheet

Photo Data Sheet

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:

Plot ID:
Folder ID:

Date:

Transect Photos (portrait)

Location	Roll #	Frame or photo #	Photographer	Location along transect (meters)
T1 - origin				Default = -3 m
T2 - origin				Default = -3 m
T3 - origin				Default = -3 m
T1 - end				Default = 53 m
T2 - end				Default = 53 m
T3 - end				Default = 53 m

Biological Soil Crust Photos (landscape)

Location	Roll #	Frame or photo #	Photographer	Location along transect (meters)
T1 - 0 m				Default = 0 m
T2 - 20 m				Default = 20 m
T3 - 40 m				Default = 40 m

Other photos (plants, disturbance, etc.)

Photo type	Roll #	Frame or photo #s	Photographer	Description

Type = archeology, disturbance, fauna, fieldwork, flora, scenic, other

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

Standard Operating Procedure (SOP) # 8

Measuring Vegetation and Surface Cover Using a Point-Intercept Transect

Version 1.02 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	7/09	DWitwicki	Updated rules for recording live/dead species and litter/woody debris; added instructions for recording tall PJ or other species hits; formatting	To make it consistent with live/dead cover recorded in quadrats; improved PJ cover methods.	1.01
1.01	1/11	DWitwicki	Edited method for tall shrub hits	Upward laser too difficult to see	1.02

This SOP gives step-by-step instructions for estimating cover of vegetation and soil surface features using point-intercept sampling. All vegetation types are sampled using the point-intercept method. SOP #15 details modifications to the method for oak plots.

Sampling Procedure

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

Park Code: Use the standard 4-letter code to indicate the park unit.

Plot ID: A pre-assigned, unique number provided for each plot.

Transect #: 1, 2, or 3

Observer: Record the initials of the person calling out the line-point intercept data.

Recorder: Record in the initials of the person recording the data.

Date: mm/dd/yyyy

2. Record point intercept data for understory species (<2 m) or at any height for PJ and oak plots.

A. Stand on the downhill side of the transect and work from the origin to the end.

B. Start at 0.5 m on the tape and move forward 0.5 m for each consecutive point. You will sample 100 points on each transect ending at 50.0 m.

C. If there is a shrub canopy layer taller than 1.5 m from the ground surface, use a densitometer to record the top canopy layer at the correct point on the tape.

(add instructions for how to use this tool- where to hold, leveling, taking the point...)

- C. Position the fully-extended monopod at the correct point on the tape with the laser extending out perpendicular to the tape on the uphill side.
- D. Use the bubble on the monopod to level the laser. With the laser leveled, push the button to take a point.
- E. Once you have recorded a point, move the uppermost vegetation away so that you can take subsequent hits for lower canopy and surface layers. If it is difficult to keep the monopod level and record hits, have one person hold the monopod level while a second person reads and records hits. On a windy day, it is important to turn the laser on for just a second to record a hit.
- F. Once the laser is leveled, record every plant species it intercepts. Record each canopy species no more than twice, a maximum of one live hit and one dead hit, even if it is intercepted several times. Record the following information for each point:

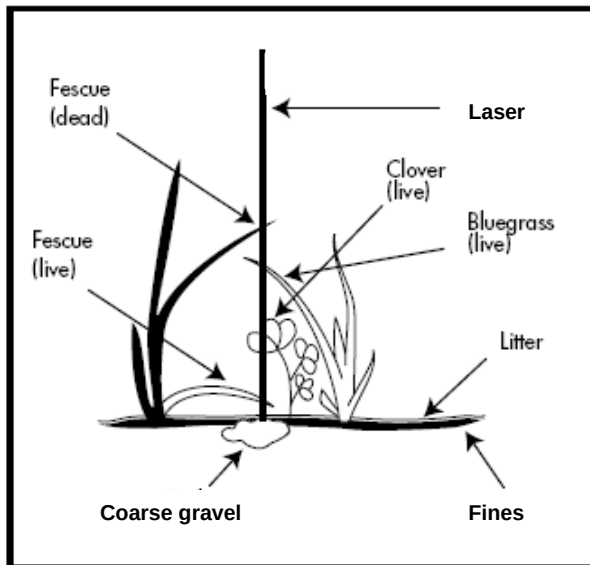
- I. Top Canopy** - Record the species of the top plant intercepted in the “Top canopy” column using a six letter code composed of the first three letters of the genus and specific epithet (Table 1 & Fig. 1). If a plant is not intercepted, leave this column blank. After the species code, write “-D” if the part of the plant intercepted by the laser is dead. Unknown plant species should be recorded according to the procedure in SOP #16. Follow the instructions in G. to record species that are taller than the height of the monopod.
- II. Lower canopy layers**- From the top canopy species, move down the laser and record species intercepted in the order that they occur. Use the “Lower canopy” columns (Table 1 & Fig. 1) to record all additional species intercepted by the laser. Record the plant as dead following the guidelines above. You may also intercept litter or woody debris, but it must be elevated above the soil surface to be considered a lower canopy layer (Table 2). If you hit more than two lower canopy layers, be sure to record them in the additional lower canopy layers section of the data sheet. If you do not encounter lower canopy layers leave these columns blank.

Table 2 Abbreviations and definitions of litter and woody debris as lower canopy layer classes for point intercept sampling.

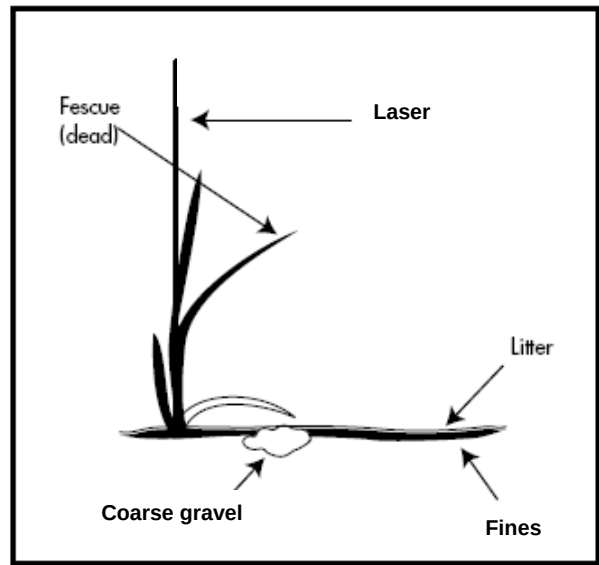
Code	Lower canopy cover type	Definition
L	Litter	Detached dead plant material less than 2.5 cm in diameter elevated above the soil surface
W	Woody debris	Detached woody plant material greater than 2.5 cm in diameter elevated above the soil surface

Table 1. Sample data sheet for examples illustrated below in Figure 1. Points 1 and 2 show the first two points on a transect. In Point 1, the laser is touching dead fescue (*Festuca octoflora*), bluegrass (*Poa secunda*), clover (*Trifolium gymnocarpon*), live fescue, and litter. Record fescue twice, once as dead and once as live. In Point 2, the laser touches dead fescue then the dead fescue plant base. The table below shows how to record these two points on the data sheet. Notice that all plants are recorded using six-character abbreviations.

Pt.	Top canopy	Lower canopy layers			Soil surface	Disturb.
		1	2	3		
1	FESOCT - D	POASEC	TRIGYM	FESOCT	L	
2	FESOCT - D				FESOCT-D	
3	ATRCAN	FESOCT			S	Ant
etc.						



Point 1



Point 2

Figure 1. Points along a transect associated with the example in Table 1 (from Herrick et al. 2005).

- III. Soil Surface** - In the “Soil surface” column record whether the laser intercepts a plant base (Fig. 2) or a soil surface feature. Use the appropriate six letter code to identify plant bases. Record the plant base as dead following the guidelines above. Use the abbreviations of soil surface features defined in Table 3 to record all other soil surface features. All points on a transect should have a code entered in the “Soil surface” column (Table 1 & Fig. 1). Use Figure 3 to help distinguish between undifferentiated crust and dark cyanobacteria.
- IV. Disturbance** - Record whether the laser intercepts a disturbance on the soil surface in the “Disturb.” column (Table 1 & Fig. 1). Use only abbreviations from Table 4 to label the type of disturbance. Leave this column blank if there is no disturbance.

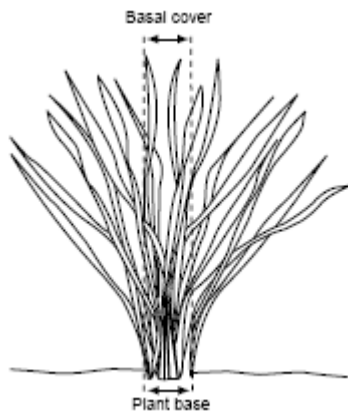


Figure 2. Area defined as plant base and included as basal cover (from Herrick et al. 2005).

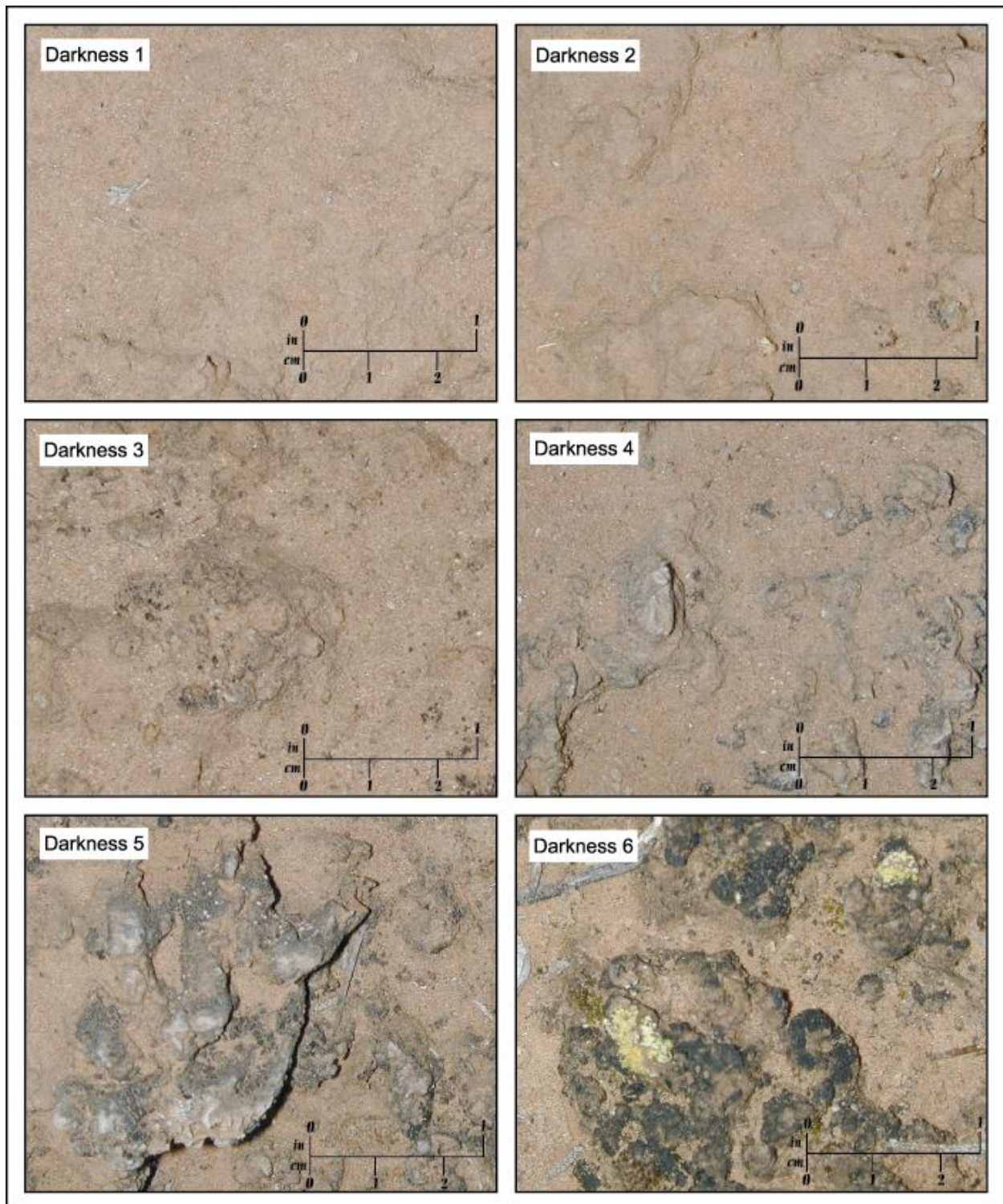


Figure 3. Photographic key to a six-class scheme for describing degrees of biological soil crust development (Belnap et al. 2008). Darkness 1-3 show mainly undifferentiated crust while Darkness 3-6 contain substantial areas of dark cyanobacteria. Darkness 6 also includes lichens.

Table 3 Abbreviations and definitions of soil surface feature classes for point intercept sampling.

Code	Soil surface type	Definition
S	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
U	Crust, undifferentiated	Anything from physical crust to weak biological crust (weak cyanobacteria) but NOT including dark cyanobacteria, lichen, or moss (Fig 3. #1-3)
CY	Cyanobacteria	Darkened cyanobacterial soil crust, typically black in color (Fig. 3. #4-6)
LC	Lichen	Lichen crust on soil (lichen on rock is recorded as the appropriate rock type)
M	Moss	Moss on soil (moss on rock is recorded as the appropriate rock type)
L	Litter	Detached dead plant material less than 2.5 cm in diameter
WA	Water	Flowing or pooled water
WD	Woody debris	Detached woody plant material greater than 2.5 cm in diameter
SR	Small rock	Rock fragments 2 mm-10 cm in diameter
LR	Large rock	Rock fragments >10 cm in diameter on any axis
BR	Bedrock	Exposed bedrock
SL	Scat, livestock	Any type of livestock scat
SW	Scat, wildlife	Any type of wildlife scat

Table 4. Abbreviations and definitions of soil-surface disturbance classes for point intercept sampling.

Code	Disturbance type	Definition
Ant	Ant mound	Holes and mounds created by ants
Auto	Motor vehicle	Disturbances caused by any motorized vehicle or old roads
Bike	Bicycle	Disturbances caused by non-motorized bicycles
Exc	Wildlife excavation	Holes and mounds created by wildlife
HT	Human track/trail	Tracks or trails created by humans
LT	Livestock track/trail	Tracks, marks, or trails created by livestock
Oth	Other anthropogenic	Any human disturbance other than tracks and trails
Und	Undifferentiated	Any disturbance of indeterminate origin or not classified as one of the other categories
Wash	Drainage area	Small to large eroded areas caused by temporarily flowing water
WT	Wildlife track	Tracks, marks, or trails created by wildlife

G. There may be instances where you need to point the laser upward to detect species hits. Two common instances are:

- 1) Pinyon pine, juniper, and Gambel oak above the height of the monopod but below the height of the densitometer.
- 2) In dense tall shrubs, where it may be easier to turn the laser upward on a shortened monopod to record canopy hits. This is used to avoid forcing the monopod down through dense woody branches.

Unscrew the laser level from the monopod. Turn the laser so that it faces upward and retighten the screw. Use the bubble to level the monopod. With the laser leveled, push the button to take a point. Record top canopy or lower canopy hits where the upward laser pointer is appropriate. Be careful not to point the laser at anyone's eyes.

References:

- Belnap, J., S. L. Phillips, D. L. Witwicki, and M. E. Miller. 2008. Visually assessing the level of development and soil surface stability of cyanobacterially dominated biological soil crusts. *Journal of Arid Environments* 72: 1257-1264.
- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005. *Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start*. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp.

Point Intercept Data Sheet

Data entered by:

Data verified by:

p.1

NCPN Upland Monitoring

Park Code:

PlotID:

Date:

Observer:

Recorder:

Transect:

1 2 3

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
0.5					
1					
1.5					
2					
2.5					
3					
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11					
11.5					
12					
12.5					

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
13					
13.5					
14					
14.5					
15					
15.5					
16					
16.5					
17					
17.5					
18					
18.5					
19					
19.5					
20					
20.5					
21					
21.5					
22					
22.5					
23					
23.5					
24					
24.5					
25					

Additional canopy layers can be added on the other side

Top canopy
Species code

Lower canopy layers
Species code
L = Litter
W = Woody debris

Soil Surface

S = Bare soil
U = Crust, undiff.
CY = Cyanobacteria
LC = Lichen
M = Moss
L = Litter
Species code (for basal hit)

SR = Small rock
LR = Large rock
BR = Bedrock
SL = Scat, livestock
SW = Scat, wildlife
W = Woody debris

Disturbance

Ant = Ant mound
Auto = Motor vehicle
Bike = Bicycle
Exc = Wildlife excavation
HT = Human track/trail
LT = Livestock track/trail
WT = Wildlife track
Wash = Wash
Oth = Other anthropogenic
Und. = Undifferentiated

Use “-D” for dead parts of species

p.2

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
31.5					
32					
32.5					
33					
33.5					
34					
34.5					
35					
35.5					
36					
36.5					
37					
37.5					

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
38					
38.5					
39					
39.5					
40					
40.5					
41					
41.5					
42					
42.5					
43					
43.5					
44					
44.5					
45					
45.5					
46					
46.5					
47					
47.5					
48					
48.5					
49					
49.5					
50					

Additional canopy layers

Point (m)	Lower Canopy		
	3	4	5

Point (m)	Lower Canopy		
	3	4	5

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

Standard Operating Procedure (SOP) # 9

Measuring Canopy and Basal Gaps

Version 1.12 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/1/2007	SGarman	Enhanced instructions for integrating this SOP with SOP#8	To ensure that procedures are conducted in concert with other SOPs	1.10
1.10	4/2008	RWeissinger	Formatting only	To improve useability	1.10
1.10	3/2009	DWitwicki	Clarify shrubs for canopy gaps; formatting	Consistency	1.11
1.11	1/2011	DWitwicki	Modify canopy gap methods to same method as basal gaps	Vegetation cover not used & more time consuming in dense shrublands	1.12

This SOP gives step-by-step instructions for obtaining gap-intercept estimates between plant canopies and between plant bases. This SOP is implemented in grassland and shrubland vegetation types.

Procedures

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

- **Park Code** - Use the 4-letter codes to indicate the park.
- **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.

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 beginning and ends of canopy gaps to the nearest centimeter.

- **Canopy gap (g)** – A space between canopy cover at least 20 cm in length.

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. 1 & 2, 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.
- 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 end of the tape, record the endpoint at 5000 if a gap (>20 cm) occurs. 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. Sample basal gaps.

Immediately after you finish recording canopy gaps, 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. 1 & 2, Tables 1 & 2). **Annual species are not considered in this measurement.**

Follow these rules:

- A plant base is any perennial 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.

4. Continue sampling.

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

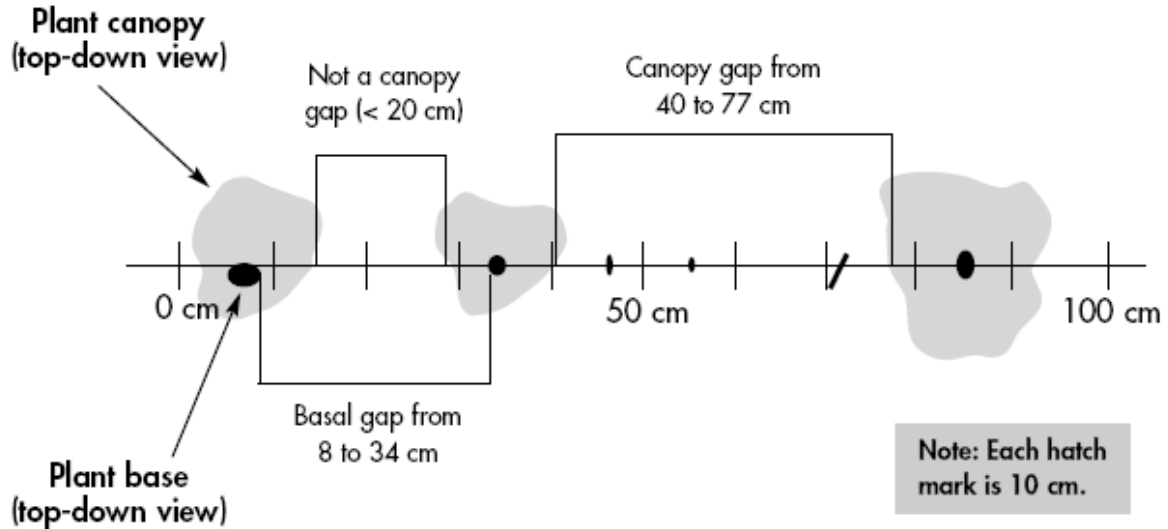


Figure 1. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 100 cm of a 50-m transect. Canopy gaps: Since the first two plants along the transect are both shrubs and the space in between is less than 20 cm, the entire segment from 0-40 cm is considered shrub 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. (Adapted from Herrick et al. 2005)

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

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

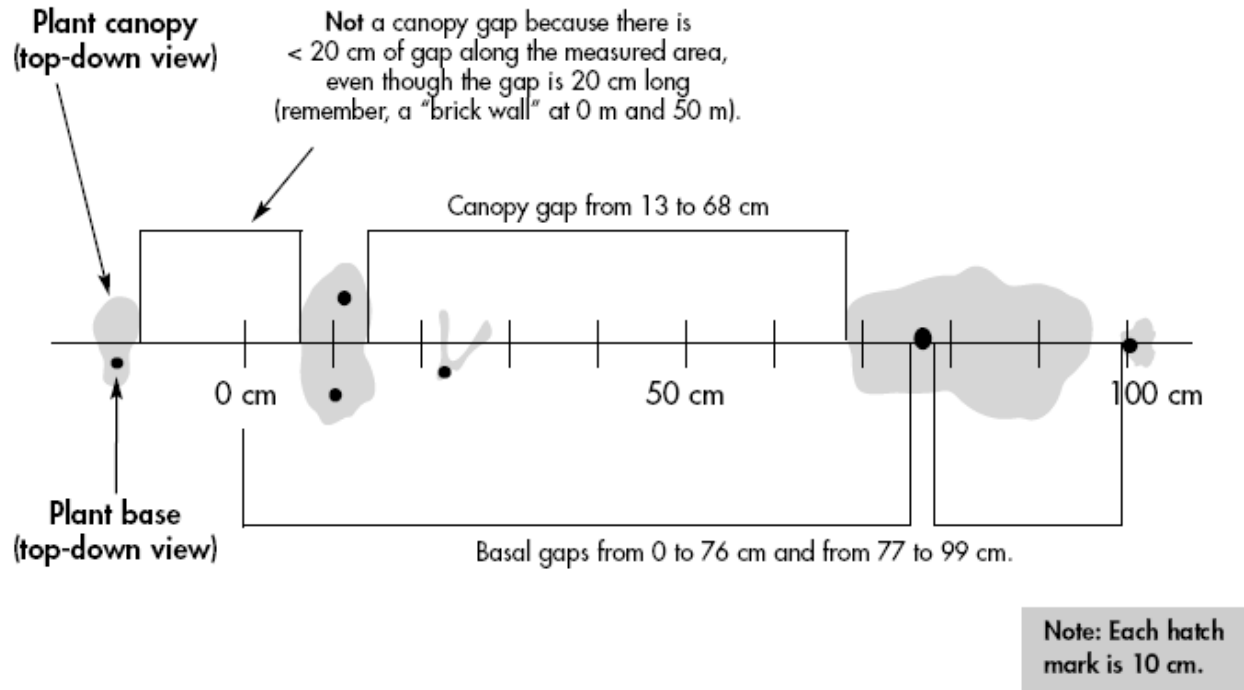


Figure 2. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 100 cm of a 50-m transect. Canopy gaps: Shrub canopy starts at 6 cm since the space from 0 to 6 cm is not large enough to be considered a canopy gap. Look at the plant canopy intercept between the 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. Adapted from Herrick et al. (2005).

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

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. 2005.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp.

Data verified by:

Shrub species on this transect:

S = shrub V = perennial veg G = gap

[illegible]

Date:

[illegible]

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

Standard Operating Procedure (SOP) # 10

Measuring Exotic Frequency, Species Richness, Canopy Closure, and Shrub and Tree Seedling Density

Version 1.14 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	07/08	RWeissinger	Added procedures for tree seedlings and saplings	New ecosite types	1.10
1.10	3/09	DWitwicki	Added introductory paragraph; edited instructions to record only live individuals; instructions for exotic perennials; increased box size on data sheet.	Clarified procedures.	1.11
1.11	7/09	DWitwicki	Added species richness	For subalpine plots	1.12
1.12	3/10	DWitwicki	Reworded spherical densiometer instructions and added details for trunk and branch obstructions.	Clarified procedures	1.13
1.13	1/11	DWitwicki	Deleted exotic perennial density and added exotic frequency; added species richness for all plot types	Improve exotic species data; more rare species data	1.14

This SOP provides instructions for recording species richness and the density of live shrubs and tree seedlings in a 1-m belt transect. Density is recorded in grassland/shrubland, woodland, and forest vegetation types. This SOP also provides instructions for recording frequency of exotic species in all plot types and canopy closure in forest plots using a spherical densiometer.

Sampling Procedure

1. Fill out relevant information at the top of the “1-m Belt Transect Data Sheet” including:

Park Code: Use the standard 4-letter code to indicate the park unit.

Plot ID: A pre-assigned, unique number provided for each plot.

Transect #: 1, 2, or 3.

Observer: Record the initials of the person calling out the belt transect data.

Recorder: Record in the initials of the person recording the data.

Date: mm/dd/yyyy

2. Sample overstory canopy cover using a modified concave spherical densiometer.

After you complete point-intercept sampling on a transect, you will record canopy cover measurements in forest plots only (e.g., aspen, mixed conifer, etc.). Take a modified concave spherical densiometer reading every 10 m, starting at the 5-m mark (i.e. 5 m, 15 m, 25 m, etc.). It is best to record overstory canopy cover early or late in the day so that the sun is not directly reflected in the densiometer.

- a. Hold the densiometer 12" in front of you at elbow height with your elbows steadied against your torso. Level the densiometer using the bubble level. Position your body so that your forehead is visible at the top of the mirror as you make the reading (Fig. 1).
- b. Count the number of point intersections covered by live or dead vegetation above the V (maximum is 17).
- c. Four measurements are made, (1) facing downhill; (2) facing the transect end; (3) facing uphill and, (4) facing the transect origin. Keep the densiometer in the same place as you rotate it and yourself for each reading.

Occasionally, you may not be able to take the measurement at one of the standard locations because a tree trunk is blocking that location. If this occurs, move down the transect 0.5 m (i.e. move to 5.5 m) until you can hold the densiometer in the correct location. Do not move the location of the densiometer along the transect for branch obstructions. You should be able to move the densiometer up or down a centimeter or so in order to take the measurement.

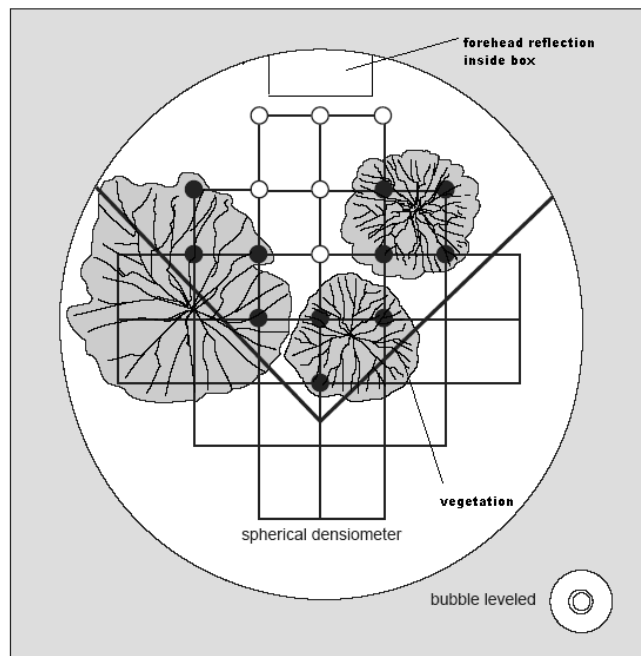


Figure 1. A modified concave spherical densiometer. Note the bubble level, tape marking right angle (above which points are counted), and 17 points of intersection. Closed circles represent line intersections where vegetation is present and consequently counted in measurement of canopy closure (example shows 11 out of 17 points) (from Fitzpatrick et al. 1998).

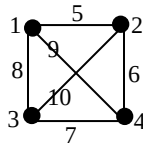
3. Sampling shrub and tree seedling density.

In all plot types, you will record density in a 1-m belt uphill of the point-intercept transect. In forest plots, take densiometer and density measurements concurrently as you proceed across the transect.

A. Unfold a ruler to 1 m in length and use the ruler and the transect tape to determine whether shrubs, tree seedlings and exotic perennials are rooted at least 50% within the belt transect.

B. Record the entire Latin name of each live shrub and tree seedling species encountered on the belt transect. Dead individuals are not recorded. The recorder is responsible for making sure that the observer collects data for all species present.

C. Use a dot tally to record the density of shrubs and tree seedlings. A dot tally is created by forming the following figure as you count stems:



Shrubs

Record shrubs in six height classes (0-10 cm, 10-25 cm, 25-50 cm, 50-100 cm, 1-2 m, and >2 m). Shrub height is determined by the tallest, live branch on the plant, regardless if the branch is in or outside the plot. In grassland/shrubland plots, count pinyon pine and juniper as shrubs. *Cactus*, *yucca*, *snakeweed*, and *Gambel oak* are NOT included in density counts.

In cases where “individuals” are difficult to distinguish (e.g. *Coleogyne ramosissima*, *Ribes montigenum*, *Symphoricarpos* sp.), the counting rule is that stems separated by >0.5 m are separate counting units. This should effectively turn the counting unit for some multi-stem shrubs into spatially-separated clumps.

Tree seedlings

Record all tree seedlings that are shorter than 1.37 m (breast height) or that are <2.5 cm in diameter at breast height (DBH). Follow the rules for measuring diameter provided in SOP #13 Measuring Trees on Forest and Woodland Sites. For juniper and other species with

multi-stem growth forms, only count young trees as seedlings and not branches that fall into this size class.

D. At sites with high levels of density, estimate density of the transect using the following categories: 100-250, 250-500, 500-1000, and >1000 individuals.

E. After completing a belt, add up the dot tally marks for each species and write in the numeric total in the “Total” row.

F. Complete a belt transect for all three transects in the macroplot.

4. Record all species encountered in the 1-m belt.

Record the presence of all live species or species that were alive earlier in the growing season that are rooted within the 1-m belt. Record the full Latin name for each species encountered on page 3 of the data sheet.

Exotic Frequency

Record the presence of all exotic plant species rooted in 1-m x 1-m quadrats placed every 5 meters along each transect beginning at 0 m.

- A. Use engineering rulers to delineate the quadrat starting at the 0-m mark on the transect tape and ending on the 1-m mark.
- B. Record the six-letter code of each exotic species rooted in the quadrat (see section X for instructions on six-letter codes). All live annual and perennial exotic species, or species that were alive earlier in the growing season, are recorded. For any plant rooted underneath the sampling frame, count ones that are rooted at least 50% within the quadrat.
- C. Sample exotic frequency in quadrats beginning at 0 m, 5 m, 10 m, 15 m, and every 5 m thereafter for the entire length of the transect.

References

- Fitzpatrick, F.A., I.R. Waite, P.J. D’Arconte, M.R. Meador, M.A. Maupin, and M.E. Gurtz. 1998. Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 98-4052, 67 p.
- Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005. *Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start*. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp.

Canopy Closure and Shrub Density

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:

PlotID:

Transect: 1 2 3

Observer:

Recorder:

Date:

Spherical Densiometer (forest only)

5 m	_____	_____	_____	_____
15 m	_____	_____	_____	_____
25 m	_____	_____	_____	_____
35 m	_____	_____	_____	_____
45 m	_____	_____	_____	_____

Shrubs Number rooted in 1-m belt transect (not including cactus, yucca, snakeweed, and Gambel oak)

Species	Height Classes					
	0 - 10 cm	10.1 - 25 cm	25.1 - 50 cm	50.1-100 cm	1.01 - 2 m	>2.01 m
Tally						
Total						
Tally						
Total						
Tally						
Total						
Tally						
Total						
Tally						
Total						

Data entered by:

Data verified by:

Park Code:

PlotID:

Transect: 1 2 3

Observer:

Recorder:

Date:

Species in 1-m belt

[illegible]

Species in 1-m belt

Exotic Frequency – Quadrats

[illegible]

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

Standard Operating Procedure (SOP) # 11

Soil Aggregate Stability

Version 1.22 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/1/2007	SGarman	Enhanced instructions for integrating this SOP with SOP#8	To ensure that procedures are conducted in concert with other SOPs	1.10
1.10	2/5/2008	DWitwicki	Clarified category for dwarf shrub	Unclear in previous version	1.20
1.20	4/2008	RWeissinger	Formatting only	To improve useability	1.20
1.20	9/2009	DWitwicki	Replace position & hydrophobic soil indicator on data sheet; decrease distance to resample if protected by rock or litter; formatting; clean up; revise stability class table; remove subsurface sampling	Consistency; table not consistent with sample kits; no subsurface sampling	1.21
1.21	1/2011	DWitwicki	Updated figure references		1.22

This SOP provides instructions for using a field kit to estimate soil aggregate stability when exposed to rapid wetting. This SOP is implemented in all plots except in forest and oak scrub ecosites.

Procedures

Soil samples should be collected after vegetation measures along a transect have been completed.

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

- **Park Code** – Use the standard 4-letter code to indicate the park unit.
- **Plot ID** – A pre-assigned, unique number provided for each plot.
- **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.
- **Date** – mm/dd/yyyy.

2. Selection of 18 sampling points.

- A. Consult the list of random sampling points provided by the Principal Investigator.
- B. Locate the first sampling location and record the sampling location (points) to the nearest tenth of a meter along a transect under “Pos” on the data sheet.
- C. Collect the sample 5 cm upslope from the transect.
- D. Move the sample point only if it has been disturbed during previous measurements or the soil surface is protected by a rock or litter. Move the point 5 cm and note the new position on the data sheet.

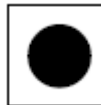
3. Determine the dominant cover class.

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, forb, shrub, or tree canopy cover
- G** = perennial grass canopy and grass/shrub canopy mixture
- F** = perennial forb
- Sh** = shrub/dwarf shrub canopy
- T** = tree canopy (includes PJ)

4. Collect a surface sample.

- A. Excavate a small trench (10-15 mm deep) in front of the area to be sampled (Fig. 1).
- B. 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).



- C. 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.

D. Gently place the sample in a dry sieve (Fig. 4); place sieve in the appropriate cell of a dry box.

5. Make sure the 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.

6. Fill the empty (no sieves) box with deionized or distilled water (Fig. 5).

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

7. Test the samples.

- A. 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. 6). 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.
- B. Start the stopwatch when the first sample touches the water. Use Table 1 to assign samples to stability classes (also see Fig. 7).
- C. 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.
- D. 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.
- E. Raise the sieve completely out of the water and then lower it to the bottom without touching the bottom of the tray.
- F. 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, and this number is circled on the data sheet.
- G. Record the stability class on the data sheet under 'Rating'.



Figure 1. Excavate small trench.



Figure 2. Collect surface sample.



Figure 3. Ensure correct sample size.



Figure 4. Place sample in sieve.



Figure 5. Complete soil stability kit with water and samples.



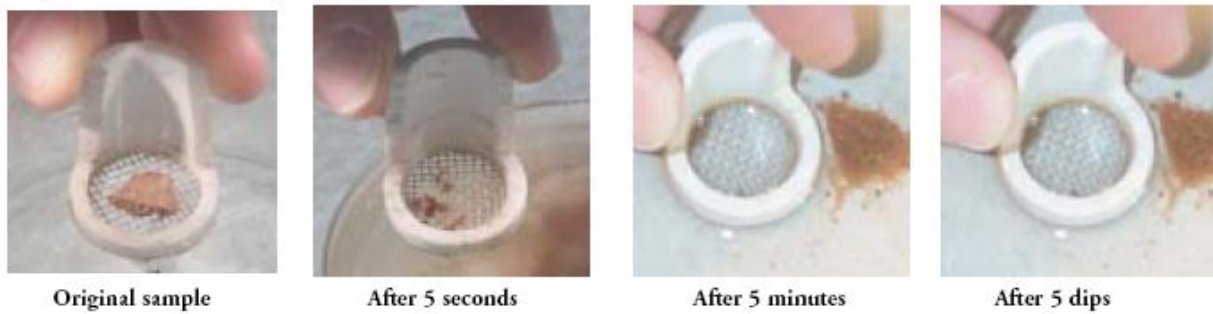
Figure 6. Place first sample in water.

(Figures 1-6 are from Herrick et al. 2005)

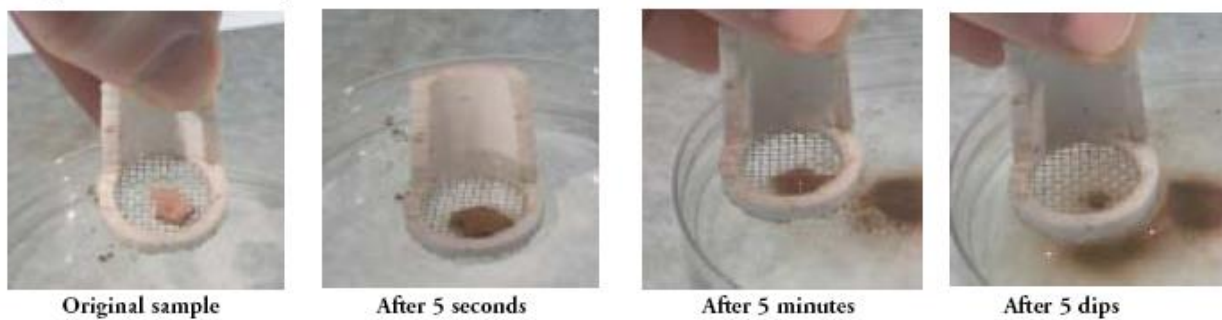
Table 1. Stability class ratings.

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

Sequence for stability class = 1.



Sequence for stability class = 4



Sequence for stability class = 5.



Sequence for stability class = 6.

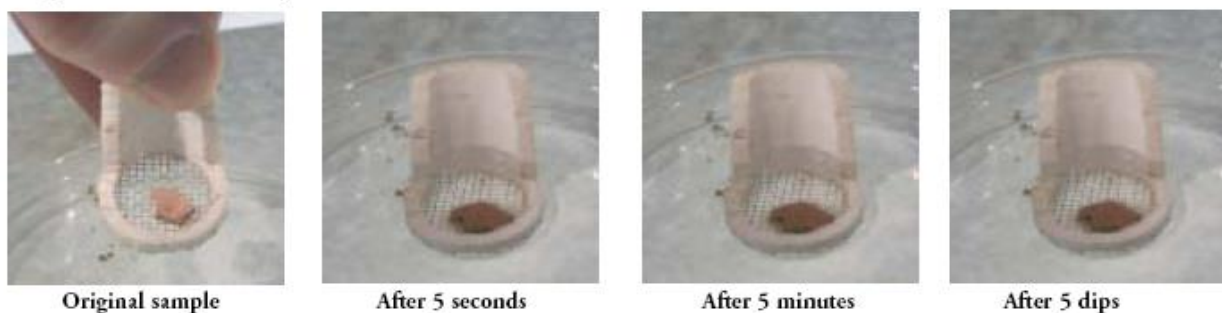


Figure 7. The photos above illustrate the key steps of testing a soil sample for four different stability rankings. Some of the fragments shown in these samples may appear large. They are for illustration only. Be sure to follow the size guidelines (6-8 mm) in step 4 (from Herrick et al. 2005).

References:

Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp.

Soil Stability Test Data Sheet

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code: _____

Plot ID: _____

Observer: _____

Date: _____

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

No. = 1-6 (see below).

Circle rating number if sample is hydrophobic

	Sample 1					Sample 2				Sample 3				Sample 4				Sample 5				Sample 6			
	Pos	Time In	Dip Time	Veg	No.	Time In	Dip Time	Veg	No.	Time In	Dip Time	Veg	No.	Time In	Dip Time	Veg	No.	Time In	Dip Time	Veg	No.	Time In	Dip Time	Veg	No.
Transect 1		0:00	5:00			0:15	5:15			0:30	5:30			0:45	5:45			1:00	6:00			1:15	6:15		
Transect 2		1:30	6:30			1:45	6:45			2:00	7:00			2:15	7:15			2:30	7:30			2:45	7:45		
Transect 3		3:00	8:00			3:15	8:15			3:30	8:30			3:45	8:45			4:00	9:00			4:15	9:15		

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

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

Standard Operating Procedure (SOP) # 12

Site Impact Assessment

Version 1.22 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/1/2007	SGarman	Added instructions for conducting impact assessment around a macroplot	Expanded site impact assessment from just upslope to all area around a macroplot	1.10
1.10	2/5/2008	DWitwicki	1) Added instructions to complete data form each plot visit 2) Clarified areal extent of disturbance in text & on data form 3) Removed specific lines on data form to hypothesize disturbance effects of fire and erosion.	1) Unclear in previous version 2) Unclear in previous version 3) Beyond the scope of our field crew	1.20
1.20	4/2008	RWeissinger	Formatting only	To improve useability	1.20
1.20	3/2009	DWitwicki	Formatting; clean up	Consistency	1.21
1.21	1/2011	DWitwicki	Added exotic plant walk	More information for resource managers	1.22

This SOP provides instructions for qualitatively detecting and describing on-site and off-site impacts on long-term ecological monitoring plots. This assessment is conducted every site visit.

Procedures

For efficiency and to minimize trampling, this SOP can be accomplished while recording other plot 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 Code** – Standard 4-letter code.
- **Plot ID** – Pre-assigned, unique number.
- **Recorder** – Record the initials of the person(s) recording data.
- **Date** – mm/dd/yyyy.

2) On-site disturbances

A. While sampling the transects, observe signs of disturbance within the macroplot. A list of common disturbances can be found in Table 1.

- The list of disturbances is not comprehensive. If a significant disturbance not found on the list is present, it should be recorded.
- If there is no disturbance to report, enter “none” and proceed to off-site disturbances.

Table 1. Common disturbance types in Colorado Plateau uplands.

Disturbance Type	Description
Dirt road	
Paved road	
OHV activity	Denoted by noticeable off-road tracks
Foot/bike path	
Campsite	
Livestock trailing	Denoted by scat and/or trampled vegetation
Livestock grazing	Denoted by scat and/or grazed vegetation
Livestock watering point	
Fire	Denoted by old or recent burn scars
Water	Recent flooding or inundation denoted by debris piles, scour marks, flattened vegetation, etc.
Wind	
Small rodents	
Other large mammal activity	

B. 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.
- If the area is not visible, walk along all three transects and the perimeter of the macroplot and note any disturbances.
- Walk on the downhill side of the transects and do not trample the areas sampled point intercept and belt transects.
- 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 site disturbance.

C. For each disturbance encountered, record:

Disturbance Type: type of disturbance; examples are in Table 1

Size of area affected (m²): approximate the aerial extent of the disturbed area (e.g. 10 x 10 m)

Position relative to transects: distance and direction relative to one of the transects

Description: Include severity, potential effects on fire or erosion processes, etc.

D. When estimating the extent of a long linear feature such as a road, record the length as inf., where inf. is short for infinity and indicates that the feature is too long for you to estimate. Additionally, you may use the figure at the bottom of the data sheet to sketch the approximate size and location of the disturbance.

E. Use additional data sheets as necessary.

3) Off-site disturbances - Upslope

A. 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.

B. 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.

C. 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.

D. Begin walking upslope perpendicular to the transects looking for disturbances within 25 m of both sides of your path.

E. Continue walking upslope until you reach a hilltop or are 500 m from the centroid, whichever occurs first. Use the GPS to determine your distance from the macroplot.

F. For each disturbance encountered, describe the type of disturbance, the aerial extent of the disturbed area, the distance upslope from the macroplot, and the severity of the impact. Provide a description of the disturbance on the data sheet, and when appropriate, record potential effects on fire or erosion processes.

G. 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.

Exotic plant species

Perform a timed 10-minute walk through the plot and record all annual and perennial exotic plant species present. Make sure to record any species that were not detected during vegetation sampling. Describe the number of plants detected, the size of the invasion, and the approximate location within the reach.

It is the park's responsibility to remove invasive exotics, but the crew may decide to pull exotics if only a few plants are present and if the time needed to hike to the reach is great. Record if plants were pulled by the crew and their general location.

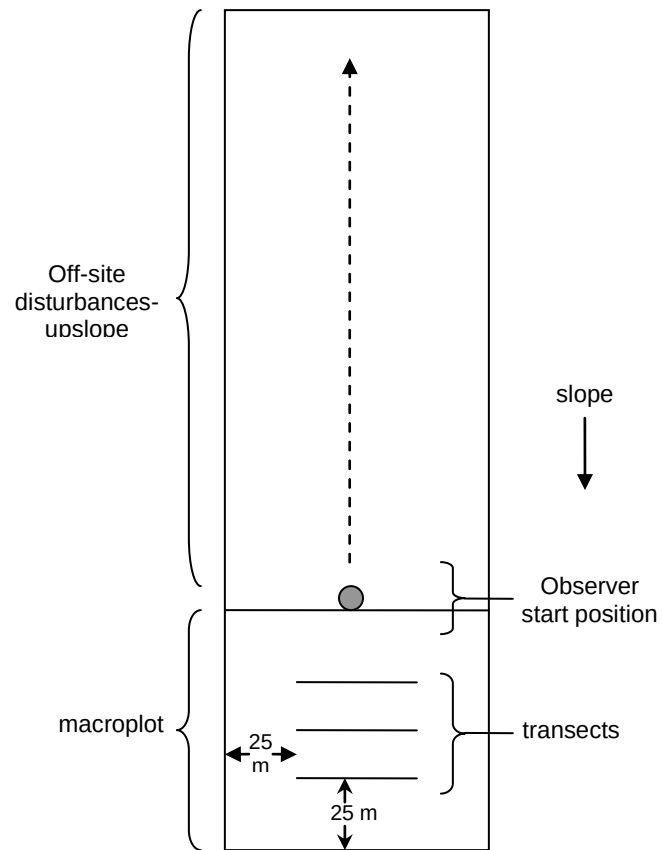


Figure 1. Diagram of area evaluated for on-site and off-site upslope disturbances.

Site Impact Assessment

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:

Plot ID:

Date:

Page ____ of ____

Observer:

Recorder:

On-site Disturbances

Disturbance type: _____

Size of disturbance (m²): _____

Position of disturbance relative to transects: _____

Description (including potential effects on fire or erosion processes): _____

Gambel oak: _____% top kill (record for oak plots only)
_____ % dead

Off-site Disturbances - Upslope

Disturbance type: _____

Size of disturbance (m²): _____

Distance upslope from macroplot (m): _____

Description (including potential effects on fire or erosion processes): _____

Off-site Disturbances – Other Than Upslope

Disturbance type: _____

Size of disturbance (m²): _____

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

Description (including potential effects on fire or erosion processes): _____

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	

transects

1 _____
2 _____
3 _____

slope



Site Impact Assessment

Data entered by:

Data verified by:

p. 2

NCPN Upland Monitoring

Park Code:

Plot ID:

Date:

Observer:

Recorder:

Exotic Plant Species Present: (number of plants/size of the invasion, location, note if pulled)

Other Notes:

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

Standard Operating Procedure (SOP) # 13

Measuring Overstory Trees

Version 1.04 (January 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/2009	DWitwicki	Formatting; clean up	Consistency	1.01
1.01	7/2009	DWitwicki	Sample overstory trees in quadrat 1 only	Census of entire plot was too much	1.02
1.02	3/2010	DWitwicki	Added methods to track downed and decaying trees	To ensure data is not missing	1.03
1.03	1/2011	DWitwicki	Woodland species measured at root crown instead of breast height; clarify tree tag wording	More repeatable; unclear	1.04

This SOP gives step-by-step instructions for measuring sapling and overstory trees in forest and woodland plots using a 5-m belt transect and a macroplot census. It covers how to measure the diameter of trees with different trunk characteristics and abnormalities. SOP #15 details modifications to the method for oak plots.

Sampling Procedures

Record the following standard information on the top of the Tree Data Sheet:

Park Code: Use the standard 4-letter code to indicate the park unit.

Plot ID: A pre-assigned, unique number provided for each plot.

Observer: Record the initials of the person calling out the tree data.

Recorder: Record the initials of the person recording the data.

Page: Fill in the page number and the total number of pages.

Date: mm/dd/yyyy

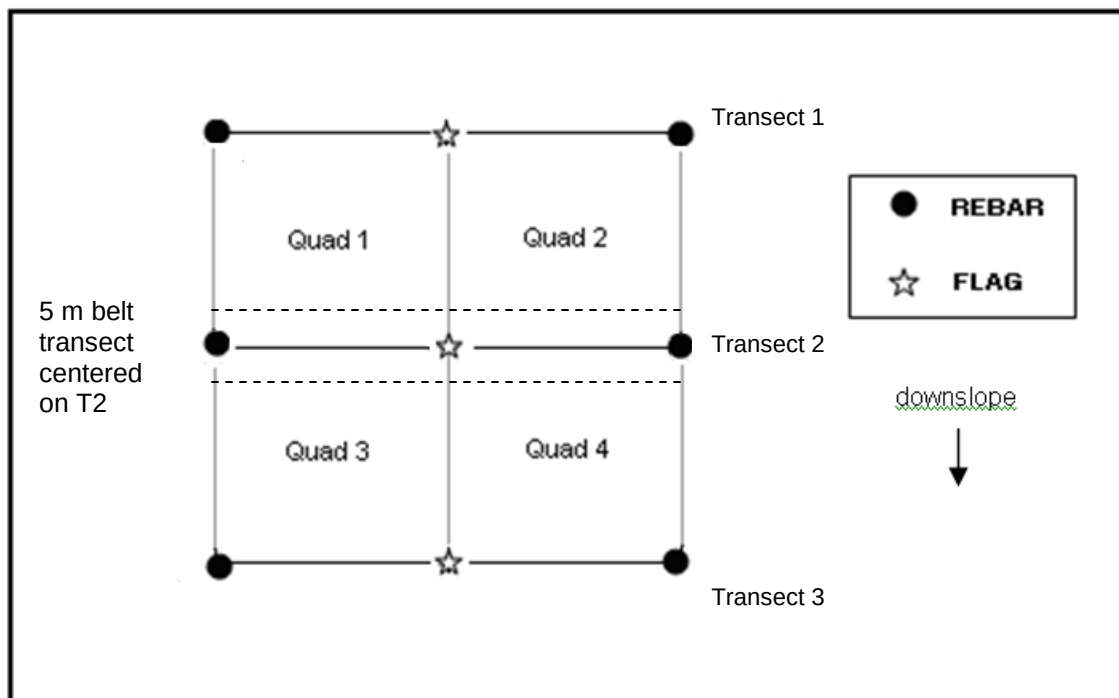
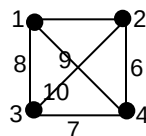


Figure 1. Plot layout diagram for forest and woodland plots.

I. 5-m Belt Transect of Tree Saplings (2.5 – 15 cm DBH)

- Delineate a 5-m belt transect centered on Transect 2 using transect tapes or folding rulers (Figure 1). You will be sampling 2.5 m on either side of the transect.
- Write down the full Latin name of all tree species with individuals between 2.5 and 15 cm DBH.
- Tally the sapling trees using the following diameter classes: 2.5 - 5.0 cm, 5.1 - 10.0 cm, and 10.1 – 15.0 cm.
 - For juniper and other species with multi-stem growth forms, only count young trees as saplings and not branches that fall into this size class.
- Record dead individuals in a separate tally from live individuals. Indicate the density of dead individuals by writing “-dead” after the species name.
- Use a Dot Tally. A dot tally is created by forming the following figure as you count saplings:



- Total the number of individuals for each size class.

II. Macroplot Census of Overstory Trees (>15 cm DBH)

- A. Divide the macroplot into quadrants (Fig. 1), either by marking the centroid with flagging tape or by running two transect tapes to physically divide the plot.
- B. Census trees in quadrant 1 only. Begin at one corner of a quadrant and systematically sample all trees >15 cm in diameter that are at least 50% rooted within the macroplot.
- C. If an overstory tree is not tagged, affix a tag to uphill side of the tree using a 3” nail.
 - a. Align the nail so that it enters the tree at breast height (1.37 m). Drive the nail into the tree at an angle, so that the tag hangs down and away from the tree. Leave several centimeters of nail exposed so the tree has ample space for growth.
 - b. If the tree forks below breast height, both forks should be tagged.
- D. Record the quadrant, tag number, and Latin name of the tree.
 - a. Record the full Latin name the first time a species is encountered, and record subsequent occurrences using a six-letter code comprised of the first three letters of the genus and specific epithet.
 - b. If the species is unknown, write UNKT.
- E. Measure DBH or DRC.
 - a. Measure just above the nail.
 - b. Measure to the nearest 0.1 cm, making sure to read the correct side of the DBH tape.

Do not record the diameter of stumps in the tree census. Instead describe this onsite disturbance in the site impact assessment.

Record Crown Health (forest sites + all dead trees)

Crown Health: Evaluate the density of each tree's crown in relation to crowns of the same species located in a similar position within the canopy, and from a similar habitat. Crown health codes are defined in Table 1 and listed at the bottom of the data sheet. Classes 1 through 4 refer to the estimated amount of the foliage that is intact, expressed as a percent. Class 5 is used to designate standing dead trees with a lean of 45 degrees or less and an overall height greater than 1.37 meters that are still rooted to the ground. Record this code for dead trees in PJ and oak plots.

Class 6 should only be used to record trees that were previously tagged and standing but have fallen down since the last plot visit. This class is used in order to not confuse fallen trees with missing data. After a tree has been recorded once as class 6, it does not need to be recorded on the data sheet in subsequent plot visits.

Standing dead trees whose diameters fall below 15 cm since the last plot visit (usually due to decay) should be recorded as class 5. A comment should also be included in the Notes/Conditions field explaining why a tree < 15 cm dbh was recorded on the data sheet. After a tree has been recorded once as class 5 and < 15 cm dbh, it does not need to be recorded on the data sheet in subsequent plot visits.

Table 1. Crown health classes for forest species

Crown Health Class	Description
1	90-100% live foliage
2	50-89% live foliage
3	16-49% live foliage
4	0.1 – 15% live foliage
5	standing dead
6	dead and down

F. Record Crown Class (forest sites)

Crown Class: Determine the most appropriate crown class for each live tree according to its canopy position. Use Table 2 and Figure 2 to determine crown classes for all tree species. Crown Class codes are listed at the bottom of the tree data sheet. Do not record crown class for trees in woodlands or Gambel oak/mixed montane shrublands.

Table 2. Crown classes for forest plots

Crown Class	Description
Dominant	Trees have crowns extending above the general level of the main canopy of adjacent trees and receive full light from above and partly from the sides.
Codominant	Trees have crowns forming the general level of the main canopy of adjacent trees and receive full light from above and comparatively little from the sides.
Intermediate	Trees have crowns extending into the lower portion of the main canopy of adjacent trees, but are shorter in height than the codominants. They receive little direct light from above and none from the sides. Usually intermediate crown-classed trees have small crowns that are crowded on the sides.
Suppressed/ Overtopped	Trees have crowns entirely below the general level of the canopy of adjacent trees, and receive no direct light from above or from the sides.

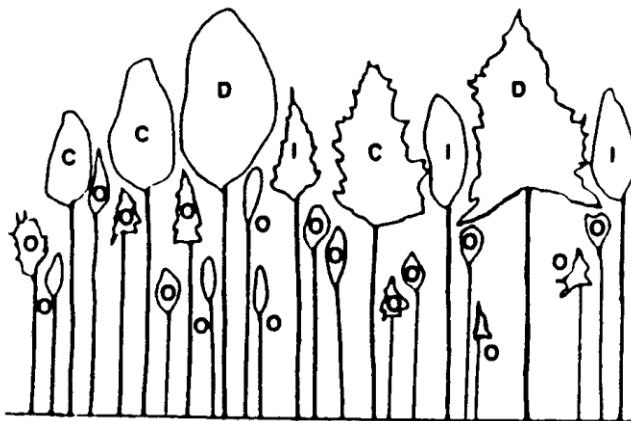


Figure 2. The relative positions of trees using four classes for crown classification. D = Dominant; C = Codominant; I = Intermediate; and S = Suppressed/Overtopped.

H. Record Conditions/Notes: Any significant damage to a living tree should also be recorded on the Tree Data Sheet. Scan each tree carefully for signs of damage, including but not limited to recent fire scars, lightning strike scars, mistletoe infestation, bark beetles, cankers, stem decays, wood-boring insects, tent caterpillars, or broken or dead top.

Rules for measuring DBH

Diameter is measured at for each trunk of a forest species at breast height (1.37 m).

A. Using the DBH tape.

- a. For species with rough bark, press the hook at the end of the tape into the bark then run the tape around the trunk, ensuring that the tape is straight and pulled perpendicular to the axis of the trunk. Tapes not run straight will give an overestimate for the trunk diameter.
- b. For tree species with smooth bark (e.g. aspen), do not press the hook into the bark or damage the tree. Instead, hold the hook in place while you extend the tape around the trunk.
- c. Wrap the tape tightly around the tree and read the number where the tape crosses the zero mark at the beginning (hook end) of the tape (See Figure 3).
- d. Make certain that you are reading the correct side of the DBH tape; often one side has standard centimeters and the other side has units calibrated to give the diameter in centimeters when wrapped around the circumference of the tree. Read off of the calibrated side of the tape.



Figure 3. The proper method for securing a DBH tape.

B. Follow these rules for measuring the diameter of trees exhibiting various growth and bole characteristics. The numbers below correspond with the numbers in the illustrations in Figure 4.

- 1) When on a slope, trees are measured on the uphill side of the tree.
- 2) Diameter is always measured perpendicular to the bole axis at 1.37 m.
- 3) Trees with a lean have their diameter measured 1.37 m up along the bole axis.
- 4) The location of the fork is defined as the point on the trunk where the **centers** of the forks diverge. The trunks of a tree forking at 1.37 m are measured just below the fork.
- 5) The trunks of a tree forking below 1.37 m are counted as separate trees and are measured at 1.37 m above the ground.
- 6) When irregularities occur at DBH, including swellings, bumps, depressions, and branches, diameter is measured **immediately above** the irregularity where the stem takes on a normal form.

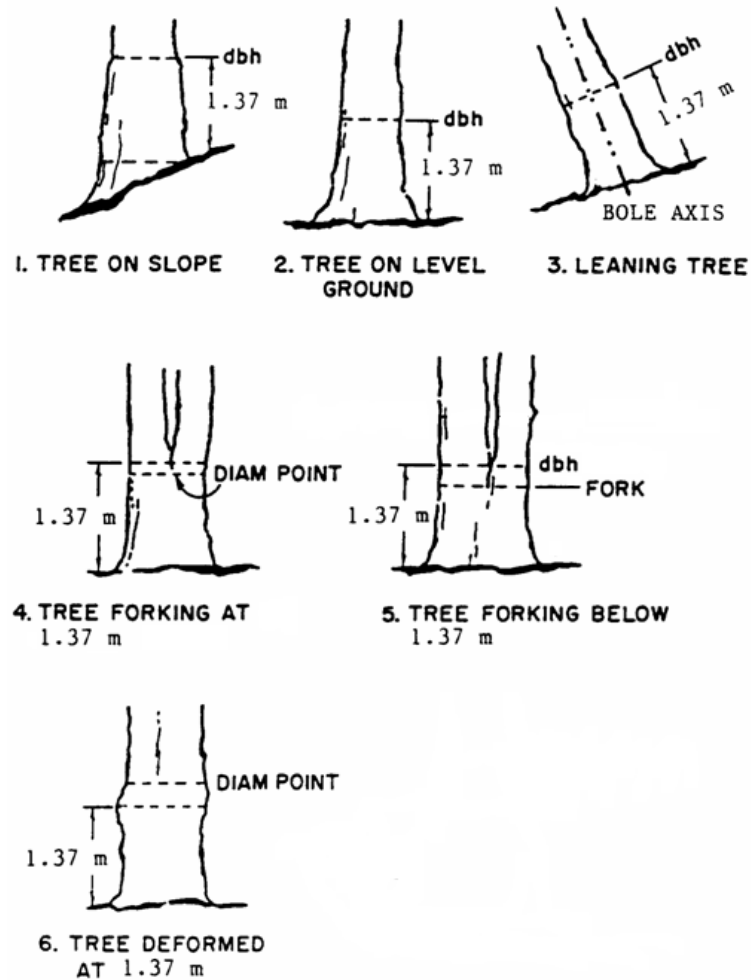


Figure 3. Locations of diameter at breast height (DBH) measurements for a variety of bole form situations. DBH measurements will always be taken perpendicular to the bole axis as illustrated (modified from USDA Forest Service 1985).

Rules for measuring DRC

The diameter of juniper, pinyon pine, gambel oak, and another highly forked woodland tree species are measured at the root crown. Use the diameter tape to measure in centimeters to the nearest 0.1 cm. Do not use this method for unusual individuals of forest tree species that have many boles. Species where DRC will be used instead of DBH will be indicated by the PI. Follow these rules when measuring highly forked woodland trees:

1. Trees with stems that fork underground or with several stems clumped together that appear to be from the same root origin are treated as a single tree. The single diameter of the root crown should be measured directly if branching occurs above ground and the single diameter accurately reflects

the cumulative volume of the stems it supports. Alternatively, if the stems fork below ground level, or the base is deformed and its diameter would grossly overestimate the volume of the individual stems, the DRC should be calculated from the individual stem diameters. Do not group stems together if you are unsure whether or not they belong to the same individual.

2. Measure DRC at the ground line or stem root collar, whichever is higher. DRC should be taken just above any swells or flaring present at the base, and in a location such that the diameter measurements reflect the volume of the above stems. For measurement of multiple stems forked just above the ground, measure DRC just above the fork and above any swells (see Figure 4). If the tree is located on a slope, measure DRC on the uphill side.
3. If a stem is now dead but previously contributed to the crown, count it. Individual stems must be (or have been prior to damage) at least 1.37 m tall and must have a DRC of at least 15 cm to qualify for measurement.
4. Attach a separate tag to each stem. Align the nail with the top edge of the diameter tape. Forked trunks are recorded as separate trees on the data sheet and a bracket is placed in the left hand margin to group trunks arising from a shared base. New tree tags should be attached as needed on plot revisits to saplings that have grown into mature trees with a diameter greater than or equal to 10.

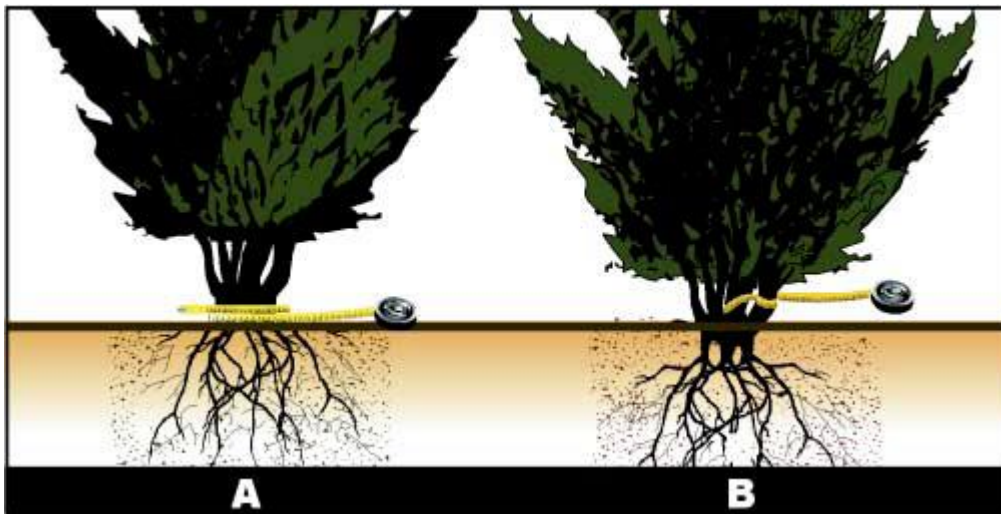


Figure 4. Measuring multiple stems with DRC. Measurement of: A) multiple stems forked above ground, and B) stems forked underground. Measure just above the fork and above any swells. (from USDI 2003)

References

- Cass, W. B., N. A. Fisichelli, and J. A. Hughes. 2007. Forest Monitoring Component of Shenandoah National Park Long-Term Ecological Monitoring, Version 1.3. National Park Service, Shenandoah National Park Monitoring Program, Luray, Virginia.
- USDA Forest Service. 1985. Field Instructions for the Southeast. Southeastern Forest Experiment Station, Asheville, N.C. (In-house manual).
- USDI National Park Service. 2003. Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center, 274p.

5m - Belt Transect Data Sheet - Transect 2 only

NCPN Upland Monitoring

Data entered by:

Data verified by:

Park Code:

Plot ID:

Date:

Observer:

Recorder:

Record live and dead in separate tallies

[illegible]

Overstory Census

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:

PlotID:

Date:

Page ____ of ____

Observer:

Recorder:

[illegible]

Crown Health

- 1 90-100%
- 2 50-89%
- 3 16-49%
- 4 0.1-15%
- 5 Standing dead
- 6 Dead and down

Crown Class

- D** Dominant
C Codominant
I Intermediate
S Suppressed

Some Possible Tree Conditions

- | | |
|------------------------|---------------------|
| fire scars | broken top |
| lightning strike scars | dead top |
| mistletoe infection | stem decay |
| bark beetles | wood-boring insects |

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

Standard Operating Procedure (SOP) #14

Measuring Fuels

Version 1.02 (January 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	7/2009	DWitwicki	Removed community type from data sheet; clarified definition of litter; formatting	Not necessary	1.01
1.01	1/2011	DWitwicki	Rewording, clarifications	Consistency and clarity	1.02

This SOP gives step-by-step instructions for monitoring fuels using a modified Brown's Transect. This SOP is implemented in all forest and woodland vegetation types. SOP #15 details modifications to the method for oak plots.

Overview

Fuels sampled through this protocol are divided into three categories: litter, duff, and woody fuels.

Woody fuels are defined as branches, stems, and twigs (but not cones, bark, needles and leaves) that have fallen or broken off and lie on or above the ground.

Litter is defined as undecomposed or partially decomposed organic material that can be readily identified (e.g. leaves, bark, cones, other non-woody plant material).

Duff is defined as the layer of decomposing organic material below the leaf litter and above the mineral soil. This layer is distinguished from litter by its degree of decomposition - within duff the origin of the organic matter can no longer be identified (e.g. as leaves, twigs, etc.). The material in the duff layer is typically held together by fungal mycelia.

Woody fuels are measured in English units in order to make the data compatible and comparable with other regional data sets and fuels models.

Collecting and Recording Data

Enter the following standard information on the top of the Fuels Data Sheet (Appendix A):

Park Code: Use the standard 4-letter code to indicate the park unit.
Plot ID: A pre-assigned, unique number provided for each plot.
Observer: Record the initials of the person calling out the fuels data.
Recorder: Record in the initials of the person recording the data.
Page: Fill in the page number and the total number of pages.
Date: mm/dd/yyyy

The following sampling procedures are carried out on four fuels transects that extend out 50 feet (15.24 m) from the plot (Figure 1). Two fuels transects originate at the end of transect 1 while the other two fuels transects originate at the origin of transect 3. Fuels transects are not permanently marked.

As the transects are established, fill in these headings on the data sheet.

Bearing: Use the information in Table 1 to determine the bearing for each fuels transect.
Record these bearings on the appropriate boxes on the data sheet.

Fuel transect	Bearing
A	Bearing of the plot slope + 180
B	Same as transect 1
C	Bearing of transect 3 + 180
D	Bearing of the plot slope

Slope: For each transect, slope percent is recorded on the data sheet below the bearing. Measure slope (from end to end) to the nearest one percent. The observer with a clinometer should stand over the rebar at transect origin and sight at a known height on the second person located at the 50 feet (15.24 m) mark. The known height is the approximate location of the observer's eye height on the second person.

Setting up the transects

Read the metal tag on the rebar to locate the end of transect 1 and the origin of transect 3. Use a chain pin to fasten the "0" end of the meter tape to the appropriate position. Use a compass and the fuels transect bearing to run the transect the appropriate direction. Use another chain pin to fasten the tape at the 50 feet (15.24 m) mark. Avoid trampling the sampling area on the fuels transects.

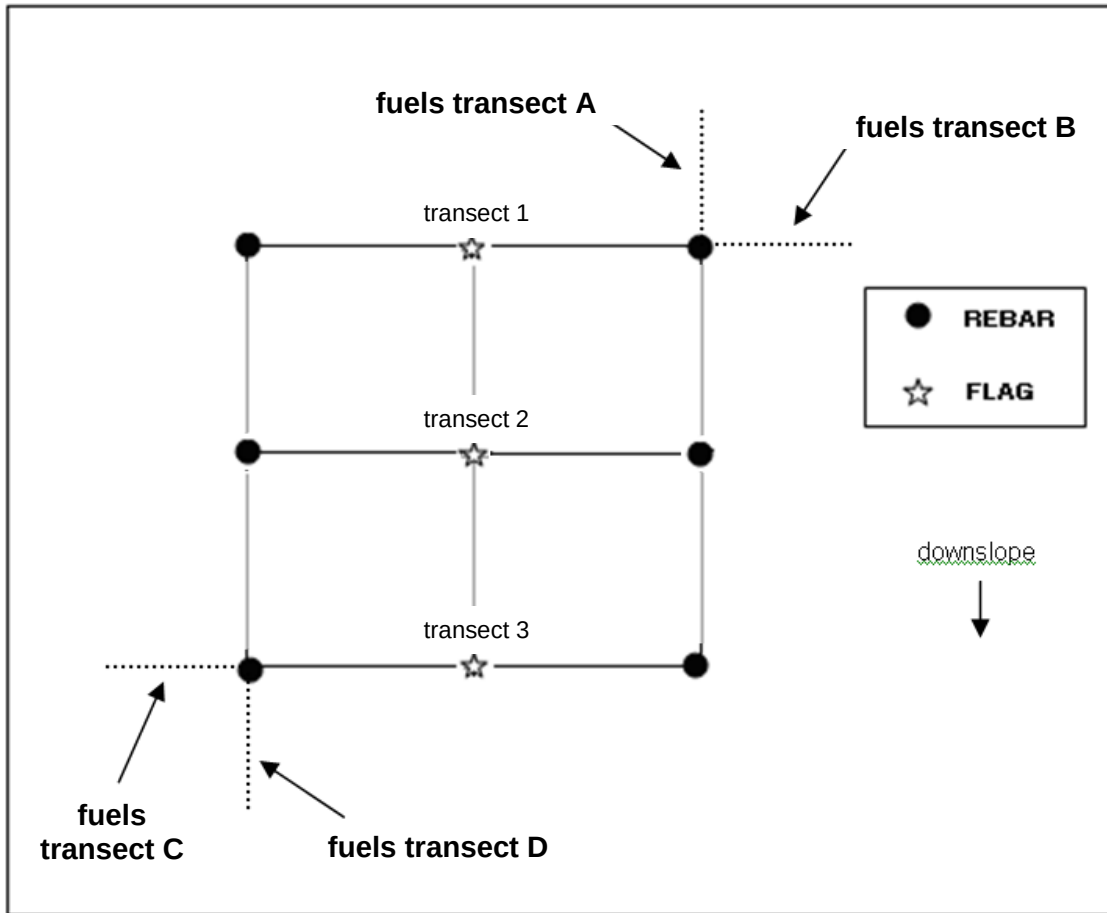


Figure 1. Layout of fuels transects.

Sampling –Woody Fuels

From the origin at the plot corner sample along the right edge of the tape. Any dead and down woody material intersected by the tape is tallied in the columns under the corresponding size class (Figure 1). Do not count stems and branches attached to standing shrubs or trees.

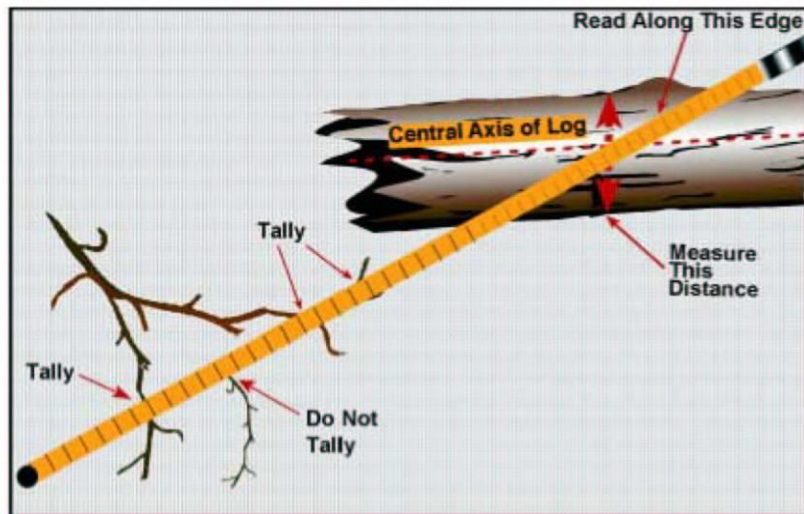


Figure 2. Tally rules for dead and down fuel (from Coulston 2003). Count all intersections including each individual intersection of a curved piece. All intersections must include the central axis in order to be tallied.

There are four size classes of woody fuels:

- 0.0 inches < **1-hour fuels** ≤ 0.25 inches
- 0.25 inches < **10-hour fuels** ≤ 1.0 inches
- 1.0 inches < **100-hour fuels** ≤ 3.0 inches
- 1000-hour fuels** > 3.0 inches

Use the Go-No-Go gauge with openings of 0.25, 1, and 3 inches to easily determine the appropriate size class of material encountered along the transect (Figure 3). You will dot tally the 1-hour, 10-hour, and 100-hour size classes for the distances listed in Table 1. Fill in the totals after you complete the appropriate length transect.

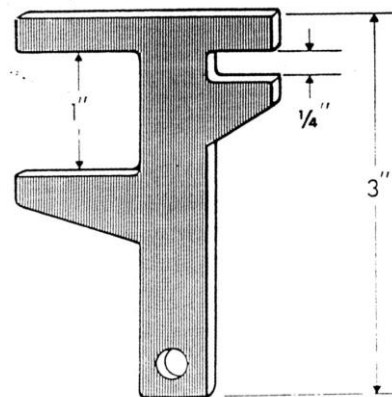


Figure 3. Example of a Go-No-Go Gauge.
(Brown, 1974)

Table 1. Transect lengths for fuel classes.

Fuel Class	Transect Length
1 hour	0-6 ft. (1.83 m)
10 hour	0-6 ft. (1.83 m)
100 hour	0-12 ft (3.66 m)
1,000 hour	0-50 ft. (15.24 m)

Diameters of 1000-hour fuels are measured at the point where they are intersected along the sampling plane. Measurement of all 1000-hour fuels is taken perpendicular to its central axis at the point where the tape crosses (Figure 1). Fill in the following information for each 1000-hour fuel encountered on the transect:

Transect: Fill in the correct transect (A, B, C, or D).

Diameter: Measure the diameter to the nearest 0.5 inch. If the piece of wood is not resting on the ground and is within reach, use a DBH tape to ascertain the diameter. Otherwise, measure the diameter by holding a ruler or tape measure above the log. To avoid parallax error, position your eyes directly over each end of the tape in sequence. If the portion of the bole intersected by the sampling plane is out of reach overhead, estimate the diameter. Visually assess rotten logs as a cylinder and estimate the diameter. This reconstructed diameter should reflect the existing wood mass, not the original sound diameter.

Decay Class: Record whether the log is sound or rotten. Consider a piece of fuel rotten when it is obviously punky or can be easily kicked apart at the intersection point.

Sampling – Litter and Duff

Take depth measurements for litter and duff (as defined above) at 7 points along each fuel transect – at 2, 4, 6, 8, 10, 12, and 14 m. Record the depth the nearest tenth of a centimeter. Do not take measurements at the corner rebar because it is an unnatural structure that traps materials.

At each sampling point, gently insert a trowel into the ground until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Use a clear ruler to vertically measure the litter and duff to the nearest tenth of an inch. Refill holes created by this monitoring technique. Do not include twigs and larger stems in litter depth measurements. Record duff and litter depth for each point on the Fuels Data Sheet.

If you hit a rock below litter or duff instead of mineral soil, record the depth of litter and duff above the rock.

References:

- Brown, J. K. 1974. Handbook for Inventorying Downed Woody Materials. USDA Forest Service, General Technical Report INT-16.
- Coulston, John W. et. al. 2003. Forest Health Monitoring 2003 National Technical Report. U.S. Department of Agriculture, Forest Service, Southern Research Station.
- USDI National Park Service. 2003. Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center, 274p.

Fuels Data Sheet (p.1)

Data entered by:

Data verified by:

NCPN Upland Monitoring

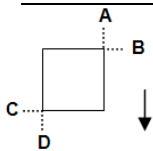
Park Code:**PlotID:**

Date:

Page ____ of ____

Observer:

Recorder:



fuels transect

D	A	B	C	D
bearing (°)				
slope (%)				

of intercepts

transect	1-hr (0-0.25 in.)	10-hr (0.25-1 in.)	100-hr (1-3 in.)
A			
Totals:			

B			
Totals			

C			
Totals			

D			
Totals			

transect
length

0-6 feet
(1.83 m)

0-6 feet
(1.83 m)

0-12 feet
(3.66 m)

1000-hr fuels (> 3 in.)

[illegible]

0-50 feet
(15.24 m)

Fuels Data Sheet (p.2)

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:

PlotID:

Date:

Page ____ of ____

Observer:

Recorder:

Litter and Duff Depth

point on transect (m)	depth (cm)							
	A		B		C		D	
	litter	duff	litter	duff	litter	duff	litter	duff
2								
4								
6								
8								
10								
12								
14								

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

Standard Operating Procedure (SOP) # 15

Sampling Gambel Oak/Mixed Montane Shrub Plots

Version 1.03 (March 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	7/2009	DWitwicki	Clarified instructions for tagging large dbh oak; formatting; added oak point-intercept data sheet	consistency	1.01
1.01	3/2010	DWitwicki	Removed shrub line-intercept	Repetitive data with point-intercept cover.	1.02
1.02	3/2011	DWitwicki	Fuels no longer sampled in oak; cover of top kill no longer estimated	Measurements not ecologically relevant for oak, not repeatable	1.03

This SOP outlines procedures for collecting and recording data for oak scrub/mixed montane shrub plots, including numerous modifications to other SOPs.

Plot setup/revisit

Plots should be set up according to SOP #6 with the following exceptions (Figure 1):

- Transects are 20 m long.
- Transects are separated by 10 m.

Understory sampling

Follow SOP #8 to sample understory cover with the laser. Start at 0.25 m and collect a point every 0.25 m for a total of 80 points sampled on each transect. Use the Point-Intercept (Oak) Data Sheet.

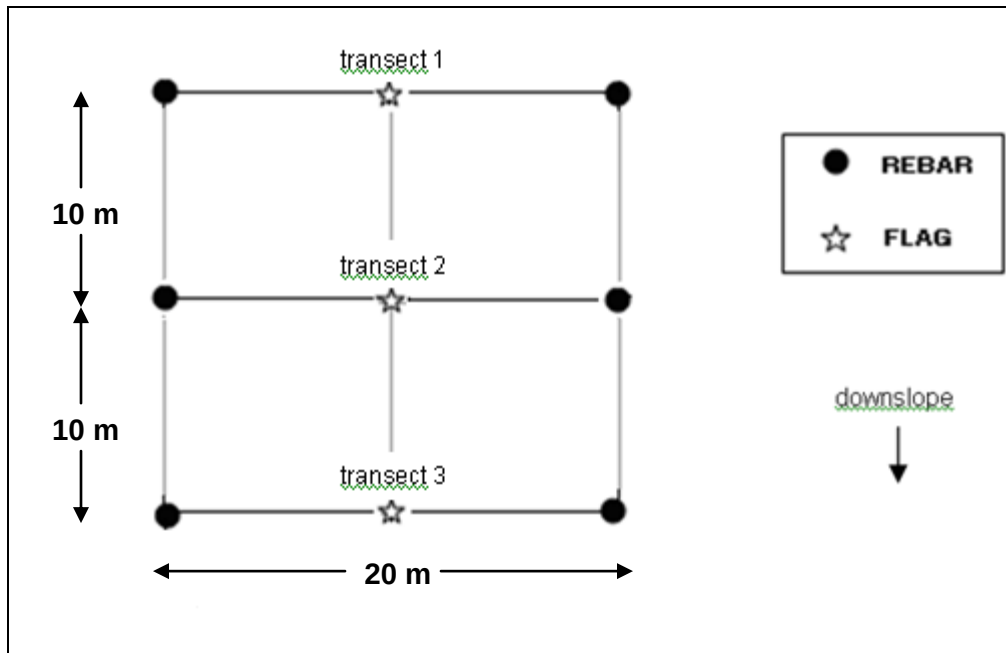


Figure 1. Plot setup for oak scrub/mixed montane shrub plots.

Exotic Frequency

Follow SOP #10 to sample exotic frequency in 1-m² quadrats. Record frequency every 2 m along each transect starting at the 0-m mark. Use the Exotic Frequency (Oak) Data Sheet.

Species Richness

Follow SOP #10 to sample species richness in a 1-m belt upslope of each transect.

Measuring trees

Follow SOP #13 to record and permanently mark any trees in the 20 m x 20 m plot. Unlike forest and woodland plots, record trees in all four quadrants. Do not record crown class for oak scrub/mixed montane shrub plots. In addition to trees, record and permanently mark any Gambel oak greater than 10 cm dbh following the procedures in SOP #13.

Site impact assessment

Follow SOP#12 to record disturbances at each site. Also record the following additional information for each plot.

Some parks are specifically interested in top kill and other mortality trends of Gambel oak. Top kill is defined as dead branches or parts of branches on the upper part of an otherwise healthy

shrub. Top kill does not include dead branches remaining after fire (usually charred) that are located above regrowth. Estimate the percentage of Gambel oak cover affected by top kill in the 20 m x 20 m plot. Also look for completely dead Gambel oak and estimate the percentage of Gambel oak cover affected in the 20 m x 20 m plot.

References:

Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005.
Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp.

Point-Intercept (Oak)

Data entered by:

Data verified by:

p.1

NCPN Upland Monitoring

Park Code:

PlotID:

Date:

Observer:

Recorder:

Transect: 1 2 3

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
0.25					
0.5					
0.75					
1.0					
1.25					
1.5					
1.75					
2.0					
2.25					
2.5					
2.75					
3.0					
3.25					
3.5					
3.75					
4.0					
4.25					
4.5					
4.75					
5.0					
5.25					
5.5					
5.75					
6.0					
6.25					

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
6.5					
6.75					
7.0					
7.25					
7.5					
7.75					
8.0					
8.25					
8.5					
8.75					
9.0					
9.25					
9.5					
9.75					
10.0					
10.25					
10.5					
10.75					
11.0					
11.25					
11.5					
11.75					
12.0					
12.25					
12.5					

Additional canopy layers can be added on the other side

Top canopy
Species code

Lower canopy layers
Species code
L = Litter
W = Woody debris

Soil Surface

S = Bare soil
U = Crust, undiff.
CY = Cyanobacteria
LC = Lichen
M = Moss
L = Litter
Species code (for basal hit)

SR = Small rock
LR = Large rock
BR = Bedrock
SL = Scat, livestock
SW = Scat, wildlife
W = Woody debris

Disturbance

Ant = Ant mound
Auto = Motor vehicle
Bike = Bicycle
Exc = Wildlife excavation
HT = Human track/trail
LT = Livestock track/trail
WT = Wildlife track
Wash = Wash
Oth = Other anthropogenic
Und. = Undifferentiated

Use “-D” for dead parts of species

p.2

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
12.75					
13.0					
13.25					
13.5					
13.75					
14.0					
14.25					
14.5					
14.75					
15.0					
15.25					
15.5					
15.75					
16.0					
16.25					

Point (m)	Top Canopy	Lower canopy		Soil Surface	Disturb.
		1	2		
16.5					
16.75					
17.0					
17.25					
17.5					
17.75					
18.0					
18.25					
18.5					
18.75					
19.0					
19.25					
19.5					
19.75					
20.0					

Additional canopy layers

Point (m)	Lower Canopy		
	3	4	5

Point (m)	Lower Canopy		
	3	4	5

Exotic Frequency/Species Richness (Oak)

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:**PlotID:**

Transect:

1 2 3

Observer:

Recorder:

Date:

Exotic Frequency – Quadrats

[illegible]

Species in 1-m belt

[illegible][illegible]

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

Standard Operating Procedure (SOP) # 16

Unknown Plants

Version 1.01 (March 2009)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	3/2009	DWitwicki	Updated unknown species code; formatting; clean up	Consistency	1.01

This SOP outlines procedures for collecting and recording data for unknown plant species in monitoring plots.

Procedure

Sometimes it may be difficult or impossible to determine the specific identity of individual plants encountered during sampling. Crews may be unfamiliar with a plant or unable to distinguish one species from other similar species at the time of sampling. Before sampling, review previously collected unknown species from the ecological site and use existing unknown names whenever possible.

When an unknown plant is encountered:

1. Search the immediate area surrounding the point or macroplot, looking for specimens of the unknown plant that are more readily identifiable (i.e., due to the presence of flowers or fruits from current or previous seasons).
2. If an identifiable specimen cannot be found, create a unique name using the following code: unk + 4 letter park code + plot number + your initials + collection number for the plot (e.g. unkCANY137-ST1).
3. Record this code in the appropriate column on the data sheet instead of the species name.
4. Take a photograph of the unknown plant.
5. As you proceed through the plot, continue to attempt to find identifiable specimens of unknowns.

6. It is permissible to identify a plant only to the genus level if no identifiable parts are present for keying, or if hybridization makes species delineation difficult (e.g., *Opuntia* sp., *Yucca* sp., etc.).

Collecting unknown plants

Once it has become apparent that no identifiable plants can be found or that a plant with identifiable features cannot be keyed out in the field, a collection of the plant should be made.

1. Collect specimens from outside of the monitoring macroplots whenever possible.
 2. Attempt to collect as many identifiable parts as possible, including flowers, fruits, leaves, and roots. It is especially important to collect roots of forbs and grasses. You may need to collect from more than one plant to achieve this goal.
 3. If you must collect from inside a monitoring plot, remove only a minimal amount of plant material. Do not remove roots of perennial species that are collected within the plot.
 4. Wrap a piece of masking tape around the plant and use a fine-point Sharpie to label it with the unknown species code. If the sample is very small, put it in a small, labeled resealable plastic bag.
 5. Carefully place the specimen inside a resealable plastic bag labeled with the plot number, unknown species code, date and collector.
 6. Put the samples in your bag and in a shady spot until you get back to camp. Attempt to identify the plants when back at camp.
 7. If the specimen cannot be identified right away, preserve the bag in a cooler as soon as possible. Make sure the specimen does not get wet.
6. Fill out an unknown species data sheet for each specimen. It is especially important to fill out data sheets for specimens that do not have identifiable characteristics in this sampling year, but may be identified in future years.

Data Sheets

When filling out the data sheet, give a detailed description of each characteristic. This allows greater potential for future identification when crews return to the site. Complete the following information on the data sheet:

- **Park Code:** A four letter code unique to a particular park
- **Plot ID:** The pre-assigned plot ID
- **Transect #:** 1-3
- **Position on Transect:** The point along a transect (e.g. 0 m, 10 m, 6.4 m, etc.).
- **Unknown Code:** unk + 4 letter park code + plot number + your initials + collection number for the plot (e.g. unkCANY137-ST1).
- **Date:** Use the format mm/dd/yyyy.

- **Collected by:** Initials of person collecting sample.
- **Photos:** Yes or No
- **Plant type and General Description:** Circle the appropriate categories and provide a detailed description of the overall appearance.
- **Most Salient Feature:** A unique characteristic that identifies the plant from others.
- **Leaf Characteristics (optional):** Describe the leaf type, leaf margin, leaf surface, petiole, etc.
- **Stem Characteristics (optional):** Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.
- **Flower Characteristics (optional):** Describe the floral formula, location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.
- **Microhabitat Characteristics:** Describe the microhabitat in which it was found if unique on the plot (e.g. wash bottom, limestone outcrop, etc.).
- **Collected:** Circle yes or no, whether a specimen was collected.
- **Best Guess:** Preliminary guess about species in field.

Appendix A.
Unknown Plant Species Data Sheet

Unknown Plant Species Data Sheet

Data entered by:

Data verified by:

NCPN Upland Monitoring

Park Code:

Plot ID:

Date:

Collected by:

Transect: 1 2 3

Position on transect (m):

Photos:

Unknown species code: _____

Plant Type & General Description: *tree shrub grass forb other*_____

Forbs and grasses: *annual perennial*

Perennial Grasses: *bunchgrass rhizomatous*

Most salient feature:

Leaf Characteristics (optional):

Leaf Type: (compound/simple, arrangement, etc.)

Margin:

Other: (pubescence, sap, stipules, etc)

Stem Characteristics (optional): (shape, pubescence, bud)

Flower Characteristics (optional): (color, location, floral formula)

Microhabitat Characteristics:

Collected: *Yes No*

Best Guess:

Confirmed to be:

Identified by:

Date:

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

Standard Operating Procedure (SOP) # 17

After the Field Season

Version 1.01 (January 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	1/2011	STopp, DWitwicki	Added detail	Increase usability	1.01

This SOP details procedures performed at the end of the field season, including equipment maintenance and data management.

Procedures

1. Equipment maintenance. Inspect all equipment for damage and note any missing equipment. Clean and repair all equipment prior to returning it to the project leader.
2. Equipment and library inventory. Ensure that adequate supplies are on hand for the next field season and create a list of supplies that need to be ordered.
3. Complete identification of unknown plants. The field crew leader is responsible for ensuring complete resolution of all unknown plants. Plants are identified to species, family, or at least life form. Where appropriate, annotate the data sheets with the correct identifications and ensure that species are entered correctly in the database. Confirm unknowns in the database.
4. New species follow-up. The field crew leader is responsible for ensuring that plant species not on current park lists are submitted for NPSpecies updates. The field crew leader is also responsible for mounting, labeling, and preparing voucher specimens for any new species collected in a park unit. Update park plant species lists and the species list in the database.
5. Field herbaria. The field crew leader mounts and labels appropriate specimens for the field herbarium.

6. Data management. The field crew leader is responsible for ensuring that all data sheets are completed properly.
7. Data entry. The field crew leader is responsible for ensuring that all data are entered and verified according to procedures outlined in SOP #18. Also download all photographs to the X:\ drive and make sure they are correctly labeled.
8. Field season review procedures. Prior to the departure of the field crew, the project manager will query the field crew for issues with existing monitoring protocols and field logistics and will seek recommendations for improvements.
9. Logistics. The field crew leader updates access documents with new and updated access and logistical information, such as road closures, park personnel turnover, etc.
10. Organization. Organize all maps and paperwork from the previous field season. Clean and organize conference room. Clean out and prepare plant presses for the next field season.

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

Standard Operating Procedure (SOP) # 18

Data Management

Version 1.11 (September 2009)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	8/1/2008	H. Thomas	Changes associated with 2008 protocol.	To document database and data management procedure changes related to 2008 protocol changes, e.g., new field methods.	1.10
1.10	9/2009	H. Thomas & D. Witwicki	Changes associated with 2009 protocol.	To document database and data management procedure changes related to 2009 protocol changes, e.g., new forest/woodland methods.	1.11

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).

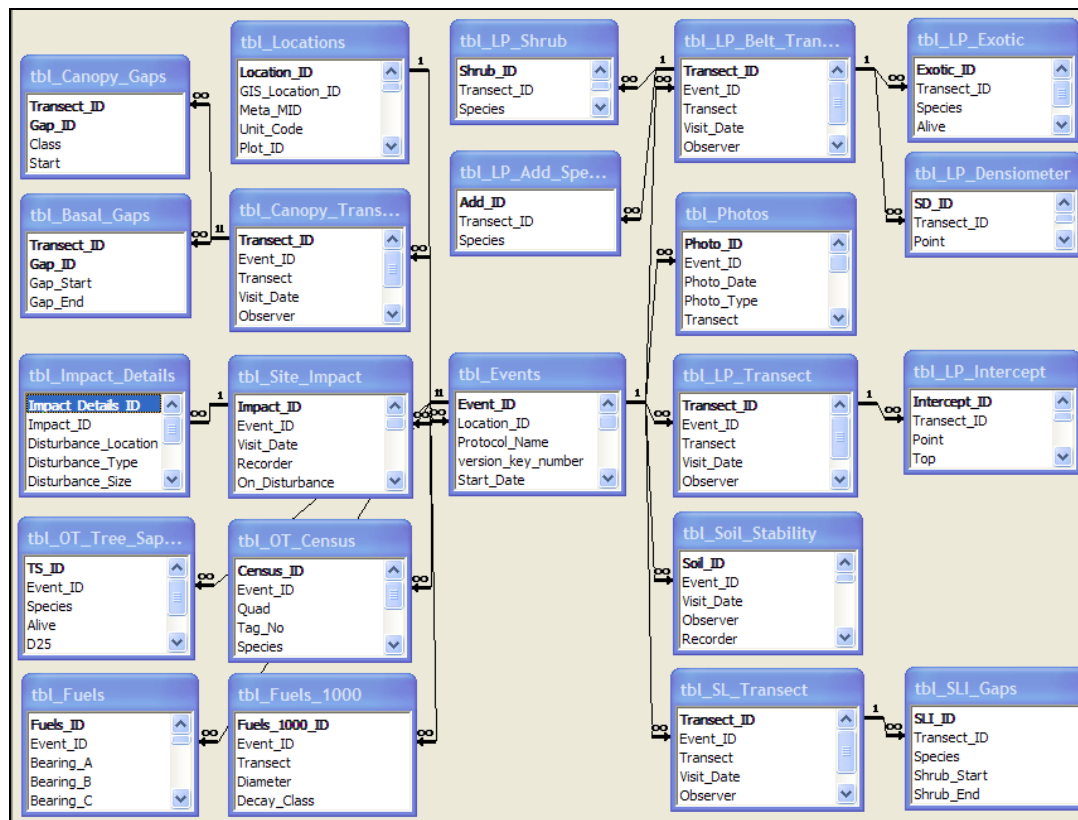


Figure 1 Data Model for Upland Database

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. The observations recorded during a site visit vary depending upon the Vegetation Type of the plot (e.g., forest, grassland/shrubland, oak scrub, woodland). The main types of observations recorded are described briefly below:

- For each of the three transects associated with a plot:
 - Cover of vegetation and soil surface features is measured using the line-point intercept sampling technique and recorded in *tbl_LP_Transect* and *tbl_LP_Intercept* (starting in 2008). In 2008, two additional tables were used (*tbl_LP_Lower_Canopy* and *tbl_LP_Disturbance*). Starting in 2009, however, these two tables are no longer used due to a database design change (the information previously stored in these tables is now stored in *tbl_LP_Intercept*).
 - Gap intercept estimates between plant canopies are obtained and recorded in *tbl_Canopy_Transect* and *tbl_Canopy_Gaps*.
 - Gap intercept estimates between plant bases are obtained and recorded in *tbl_Canopy_Transect* and *tbl_Basal_Gaps*.
 - Density of live shrubs, tree seedlings, and exotic perennials is measured in a 1-m belt transect and recorded in tables *tbl_LP_Belt_Transect*, *tbl_LP_Exotic*, *tbl_LP_Seedling*, and *tbl_LP_Shrub* (starting in 2008).
 - Additional species detected in the 1-m belt transect are recorded in *tbl_LP_Belt_Transect* and *tbl_LP_Add_Species* (starting in 2009).
 - Estimates of overstory cover in the 1-m belt transect are obtained and recorded in *tbl_LP_Belt_Transect* and *tbl_LP_Densiometer* (starting in 2009).
 - Line-intercepts of shrub canopy in oak plots are obtained and recorded in *tbl_SL_Transect* and *tbl_SLI_Gaps*.
- Density of tree saplings is measured in a 5-m belt transect and recorded in *tbl_OT_Tree_Saplings* (starting in 2009).
- Attributes of overstory trees are measured in Quadrant 1 and recorded in *tbl_OT_Census* (starting in 2009).
- Fuels are measured in four separate transects (three transects for oak plots) and recorded in *tbl_Fuels* and *tbl_Fuels_1000* (starting in 2009).
- Estimates of soil aggregate stability are obtained and recorded in *tbl_Soil_Stability*.
- Several photos are taken during each site visit and recorded in *tbl_Photos*.
- On-site and off-site impacts are assessed and recorded in tables *tbl_Site_Impact* and *tbl_Impact_Details* (*tbl_Impact_Details* was added in 2008).

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.

Starting in the 2009 field season, Panasonic Toughbooks were used to record data electronically in the field. Separate copies of the working database are loaded onto each of two Toughbooks prior to a given field trip. These database copies are initially empty. At some point after the field trip, the data in these copies are merged into the working database.

For the remainder of this document, the term "upland database" refers to either the working database or one of its copies that resides on a Toughbook. 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	Datum	Max_PDOP	Coord_Units
N_Coord	UTM_Zone	Max_HDOP	Coord_System

Plot location data is expected to be relatively static over time. Thus, GPS data will normally only be imported when a plot is initially established. 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*. In such cases, the "Location Coordinate Change" data entry form should be completed. Refer to the user's guide in Appendix B for data entry procedures for location coordinate changes.

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 manager gives the GPS units to the GIS specialist.
- The GIS specialist, project manager, 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 manager.
- If the GIS specialist and/or data management staff is unable to meet the deadline for importing the data, the project manager is notified. The project manager 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.

With electronic data collection in the field, the above-described procedures are followed for the most part. However, some additional procedures are followed to accommodate data entry in the field while maintaining a single copy of the plot location data. Since these procedures are new in 2009, they are still in development and are only outlined here:

- Prior to each field trip, data management staff ensures that all plots expected to be established/visited are pre-loaded into the working database. This plot information is obtained from the project manager. For new plots, only a “skeleton” record is loaded, i.e., only the required fields (Unit Code, Plot ID, and Vegetation Type) are populated.
- The working database is then used to create an empty database that is loaded onto the Toughbooks. Each empty database contains no observation data, just populated lookup tables and plot information.
- The Toughbooks are then used to record observation data in the field. For new plots, plot location information is recorded using GPS units, and plot establishment data is recorded on the Toughbooks.
- After each field trip, corrected GPS data are uploaded to *tbl_Locations* in the working database. A merging tool is then used to merge the data on the Toughbooks into the working database. This tool appends all the observation data and updates *tbl_Locations* with any plot establishment 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. The primary goal of data entry is *to record data in digital form*

with 100% accuracy, whether transcribing the data from paper records or keying the data into a field laptop as a crew member dictates.

The upland database user's guide (refer to Appendix B) provides data entry instructions and identifies differences between office and field data entry procedures. The project manager makes certain that persons performing data entry are familiar with the user's guide, understand how to enter data and follow the protocols, and understand how to operate field laptops. Data entry technicians are responsible for becoming familiar with the field data forms, field laptops, database software, database structure, and any standard codes for data entry. The data manager, in conjunction with the project manager, 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.

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 or documented in a log according to the instructions provided in Section 4.

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). *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. Note that the data verification procedures described in the next section apply primarily to data recorded using hard copy data sheets.

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

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.

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 manager. 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. This procedure must be followed when new staff enters data, and should continue until the project manager 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 transects having shrub density 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 manager 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* or the *field data correction log* 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. The field data correction log will be used to record corrections made to data recorded electronically in the field. 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 manager 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 manager 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 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):

- **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).
 - **Field_Forms:** Contains scanned field forms for current year.
 - **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.
 - **Backups:** Contains one or more backup copies of database files made during data entry (not retained permanently).
- **NCPN_Working_Files:** Contains miscellaneous files used for monitoring, such as plant lists and park information.
- **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 reports and any other reports produced during current year.
 - **Native_Format:** Contains source files used to create current year reports.

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 hundredths (e.g., version 1.01, version 1.02, 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 Location ²	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\<year>\	
Reports	Reports\<year>\	Contains archived report files (PDF and source files) for a given year
Field Forms	Data\<year>\Field_Forms\	Contains digital field forms (PDF) for a

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 key number, e.g., Version_Key_1

Data Product(s)/ File(s)	Archive Location²	Comments
		given year
Photos	R:\Archive\ NCPN_Photos_Archive\ NCPN_Photos\ Upland	• Archive location is an absolute path • Renamed photo files archived as part of NCPN photo database processing - refer to <u>NCPN Photo Management Guidance Document</u> (NCPN-NPS 2008a) for details
Original Photos	R:\Archive\ NCPN_Photos_Archive\ Raw_Photo_Data_Archive\ Monitoring\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

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 (NCPN-NPS 2007c) 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 2008b, 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 2009)
Photo DB	Photo records are added to the NCPN Photo Database.	Photo Management Guidance Document (NCPN-NPS 2008a)
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 1-22) 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.* Refer to the [NCPN Protocol Versioning Guidance Document](#) (NCPN-NPS 2009) for detailed protocol versioning procedures.

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. Photo Management Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008b. Project Tracking 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.
- NCPN-NPS 2009. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

Appendix A Documentation of Database Tables (v4.1)

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
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) - date of revisit.	dbDate	8
Comments	Plot revisit comments.	dbMemo	0
Observer	Plot revisit observer.	dbText	50
Fuels_Observer	Fuels observer	dbText	50
Fuels_Recorder	Fuels recorder	dbText	50
Fuels_Date	Date of fuels observation	dbDate	8
Census_Observer	Overstory census observer	dbText	50
Census_Recorder	Overstory census recorder	dbText	50
Census_Date	Date of census observation	dbDate	8
Sapling_Observer	Overstory sapling observer	dbText	50
Sapling_Recorder	Overstory sapling recorder	dbText	50
Sapling_Date	Date of overstory sapling observation	dbDate	8

Table Name: tbl_Fuels

Description: Table of woody fuels (1-hr, 10-hr, 100-hr), litter, and duff measurements.

Field Name	Field Description	Field Type	Field Width
Fuels_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Bearing_A	Bearing of the plot slope + 180 in degrees	dbInteger	2
Bearing_B	Bearing of transect 1 in degrees	dbInteger	2
Bearing_C	Bearing of transect 3 + 180	dbInteger	2
Bearing_D	Bearing of the plot slope	dbInteger	2
Slope_A	Slope of transect A to nearest half percent	dbSingle	4
Slope_B	Slope of transect B to nearest half percent	dbSingle	4
Slope_C	Slope of transect C to nearest half percent	dbSingle	4
Slope_D	Slope of transect D to nearest half percent	dbSingle	4
1HR_A	One hour fuel intercept for transect A	dbInteger	2
1HR_B	One hour fuel intercept for transect B	dbInteger	2
1HR_C	One hour fuel intercept for transect C	dbInteger	2
1HR_D	One hour fuel intercept for transect D	dbInteger	2
10HR_A	Ten hour fuel intercept for transect A	dbInteger	2
10HR_B	Ten hour fuel intercept for transect B	dbInteger	2
10HR_C	Ten hour fuel intercept for transect C	dbInteger	2
10HR_D	Ten hour fuel intercept for transect D	dbInteger	2
100HR_A	Hundred hour fuel intercept for transect A	dbInteger	2
100HR_B	Hundred hour fuel intercept for transect B	dbInteger	2
100HR_C	Hundred hour fuel intercept for transect C	dbInteger	2
100HR_D	Hundred hour fuel intercept for transect D	dbInteger	2
2Litter_A	Litter depth at 2 meter point for transect A in centimeters	dbDecimal	16
4Litter_A	Litter depth at 4 meter point for transect A in centimeters	dbDecimal	16
6Litter_A	Litter depth at 6 meter point for transect A in centimeters	dbDecimal	16
8Litter_A	Litter depth at 8 meter point for transect A in centimeters	dbDecimal	16
10Litter_A	Litter depth at 10 meter point for transect A in centimeters	dbDecimal	16
12Litter_A	Litter depth at 12 meter point for transect A in centimeters	dbDecimal	16
14Litter_A	Litter depth at 14 meter point for transect A in centimeters	dbDecimal	16

Field Name	Field Description	Field Type	Field Width
2Litter_B	Litter depth at 2 meter point for transect B in centimeters	dbDecimal	16
4Litter_B	Litter depth at 4 meter point for transect B in centimeters	dbDecimal	16
6Litter_B	Litter depth at 6 meter point for transect B in centimeters	dbDecimal	16
8Litter_B	Litter depth at 8 meter point for transect B in centimeters	dbDecimal	16
10Litter_B	Litter depth at 10 meter point for transect B in centimeters	dbDecimal	16
12Litter_B	Litter depth at 12 meter point for transect B in centimeters	dbDecimal	16
14Litter_B	Litter depth at 14 meter point for transect B in centimeters	dbDecimal	16
2Litter_C	Litter depth at 2 meter point for transect C in centimeters	dbDecimal	16
4Litter_C	Litter depth at 4 meter point for transect C in centimeters	dbDecimal	16
6Litter_C	Litter depth at 6 meter point for transect C in centimeters	dbDecimal	16
8Litter_C	Litter depth at 8 meter point for transect C in centimeters	dbDecimal	16
10Litter_C	Litter depth at 10 meter point for transect C in centimeters	dbDecimal	16
12Litter_C	Litter depth at 12 meter point for transect C in centimeters	dbDecimal	16
14Litter_C	Litter depth at 14 meter point for transect C in centimeters	dbDecimal	16
2Litter_D	Litter depth at 2 meter point for transect D in centimeters	dbDecimal	16
4Litter_D	Litter depth at 4 meter point for transect D in centimeters	dbDecimal	16
6Litter_D	Litter depth at 6 meter point for transect D in centimeters	dbDecimal	16
8Litter_D	Litter depth at 8 meter point for transect D in centimeters	dbDecimal	16
10Litter_D	Litter depth at 10 meter point for transect D in centimeters	dbDecimal	16
12Litter_D	Litter depth at 12 meter point for transect D in centimeters	dbDecimal	16
14Litter_D	Litter depth at 14 meter point for transect D in centimeters	dbDecimal	16
2Duff_A	Duff depth at 2 meter point for transect A in centimeters	dbDecimal	16
4Duff_A	Duff depth at 4 meter point for transect A in centimeters	dbDecimal	16
6Duff_A	Duff depth at 6 meter point for transect A in centimeters	dbDecimal	16
8Duff_A	Duff depth at 8 meter point for transect A in centimeters	dbDecimal	16
10Duff_A	Duff depth at 10 meter point for transect A in centimeters	dbDecimal	16
12Duff_A	Duff depth at 12 meter point for transect A in centimeters	dbDecimal	16
14Duff_A	Duff depth at 14 meter point for transect A in centimeters	dbDecimal	16
2Duff_B	Duff depth at 2 meter point for transect B in centimeters	dbDecimal	16
4Duff_B	Duff depth at 4 meter point for transect B in centimeters	dbDecimal	16
6Duff_B	Duff depth at 6 meter point for transect B in centimeters	dbDecimal	16
8Duff_B	Duff depth at 8 meter point for transect B in centimeters	dbDecimal	16
10Duff_B	Duff depth at 10 meter point for transect B in centimeters	dbDecimal	16
12Duff_B	Duff depth at 12 meter point for transect B in centimeters	dbDecimal	16
14Duff_B	Duff depth at 14 meter point for transect B in centimeters	dbDecimal	16
2Duff_C	Duff depth at 2 meter point for transect C in centimeters	dbDecimal	16
4Duff_C	Duff depth at 4 meter point for transect C in centimeters	dbDecimal	16
6Duff_C	Duff depth at 6 meter point for transect C in centimeters	dbDecimal	16
8Duff_C	Duff depth at 8 meter point for transect C in centimeters	dbDecimal	16
10Duff_C	Duff depth at 10 meter point for transect C in centimeters	dbDecimal	16
12Duff_C	Duff depth at 12 meter point for transect C in centimeters	dbDecimal	16
14Duff_C	Duff depth at 14 meter point for transect C in centimeters	dbDecimal	16
2Duff_D	Duff depth at 2 meter point for transect D in centimeters	dbDecimal	16
4Duff_D	Duff depth at 4 meter point for transect D in centimeters	dbDecimal	16
6Duff_D	Duff depth at 6 meter point for transect D in centimeters	dbDecimal	16
8Duff_D	Duff depth at 8 meter point for transect D in centimeters	dbDecimal	16
10Duff_D	Duff depth at 10 meter point for transect D in centimeters	dbDecimal	16
12Duff_D	Duff depth at 12 meter point for transect D in centimeters	dbDecimal	16
14Duff_D	Duff depth at 14 meter point for transect D in centimeters	dbDecimal	16

Table Name: tbl_Fuels_1000

Description: Table of woody fuels (1000-hr) measurements.

Field Name	Field Description	Field Type	Field Width
Fuels_1000_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect associated with 1000-hr fuel measurements.	dbText	1
Diameter	Diameter to nearest .5 inch	dbSingle	4
Decay_Class	Decay class: sound, rotten, not recorded	dbText	15

Table Name: tbl_Impact_Details

Description: Table of site impact assessment details (added in 2008)

Field Name	Field Description	Field Type	Field Width
Impact_Details_ID	Unique record identifier - primary key	dbText	50
Impact_ID	Foreign key to tbl_Site_Impact	dbText	50
Disturbance_Location	Observation-location type: onsite, off-site upslope, off-site other than upslope.	dbText	15
Disturbance_Type	Disturbance type.	dbText	50
Disturbance_Size	Size of disturbance.	dbText	255
Disturbance_Position	Position of disturbance relative to transects. On-site disturbances only.	dbText	255
Disturbance_Distance	Distance from macroplot. Off-site disturbances only.	dbText	255
Disturbance_Direction	Direction from macroplot in degrees azimuth.	dbText	50
Disturbance_Description	Description of disturbance including potential effects on fire or erosion processes.	dbMemo	0

Table Name: tbl_Location_History

Description: Site and plot definition history table (added in 2008)

Field Name	Field Description	Field Type	Field Width
Location_History_ID	M. Location identifier (Loc_ID)	dbText	50
Location_ID	foreign key to tbl_Location	dbText	50
Unit_Code	Park Code.	dbText	4
Plot_ID	Plot identifier	dbInteger	2
Modify_Date	Date of update	dbDate	8
Recorder	Person modifying data	dbText	50
E_Coord	UTM East of Centroid (X_Coord)	dbDouble	8
N_Coord	UTM North of Centroid (Y_Coord)	dbDouble	8
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

Field Name	Field Description	Field Type	Field Width
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
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_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

Field Name	Field Description	Field Type	Field Width
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	Quantity 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, deep, very deep, unknown	dbText	50
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. Discontinued use 5/2008.	dbDouble	8
Plot_N_Coord	UTM North of Centroid (Y_Coord) if plot established on different visit from site characterization. Discontinued use 5/2008.	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

Field Name	Field Description	Field Type	Field Width
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
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
Parent_Material	Parent Material	dbText	100
Grazed_field	Is it a grazed field?	dbBoolean	1
Vegetation_Type	Vegetation type	dbText	50
SlopeA	F/W Slope for plot side A in percent	dbSingle	4
SlopeAUD	Slope A up or down	dbText	4
SlopeB	F/W Slope for plot side B in percent	dbSingle	4
SlopeBUD	Slope B up or down	dbText	4
SlopeC	F/W Slope for plot side C in percent	dbSingle	4
SlopeCUD	Slope C up or down	dbText	4
SlopeD	F/W Slope for plot side D in percent	dbSingle	4
SlopeDUD	Slope D up or down	dbText	4

Table Name: tbl_LP_Add_Species

Description: Table of additional species in 1 meter belt transect

Field Name	Field Description	Field Type	Field Width
Add_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Additional species observed	dbText	15

Table Name: tbl_LP_Belt_Transect

Description: Table of transect information for 1-meter belt transect measurements.

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
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

Table Name: tbl_LP_Densiometer

Description: Table of Spherical Densiometer point intersection counts in 1 meter belt transect.

Field Name	Field Description	Field Type	Field Width
SD_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Point	Point on transect	dbText	4
Total1	Total count, measurement 1	dbInteger	2
Total2	Total count, measurement 2	dbInteger	2

Field Name	Field Description	Field Type	Field Width
Total3	Total count, measurement 3	dbInteger	2
Total4	Total count, measurement 4	dbInteger	2

Table Name: tbl_LP_Exotic

Description: Table of exotic perennial species in 1 meter belt transect.

Field Name	Field Description	Field Type	Field Width
Exotic_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Exotic species code	dbText	15
Alive	Is species alive?	dbBoolean	1
Total	Total count	dbInteger	2

Table Name: tbl_LP_Intercept

Description: Table of line-point intercept measurements.

Field Name	Field Description	Field Type	Field Width
Intercept_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Transect	dbText	50
Point	Intercept point - increments of 0.5m up to 50m or 0.25m up to 20m	dbDecimal	16
Top	Top canopy species code	dbText	15
Alive	Is top canopy species alive?	dbBoolean	1
Surface	Soil surface code	dbText	15
Surface_Alive	If soil surface is a species, is it alive?	dbBoolean	1
LCS1	Lower canopy species 1 - Database flattened 2/24/2009 to accommodate field data entry and work around Access limitations.	dbText	15
LCA1	Lower canopy alive 1	dbBoolean	1
LCS2	Lower canopy species 2	dbText	15
LCA2	Lower canopy alive 2	dbBoolean	1
LCS3	Lower canopy species 3	dbText	15
LCA3	Lower canopy alive 3	dbBoolean	1
LCS4	Lower canopy species 4	dbText	15
LCA4	Lower canopy alive 4	dbBoolean	1
LCS5	Lower canopy species 5	dbText	15
LCA5	Lower canopy alive 5	dbBoolean	1
LCS6	Lower canopy species 6	dbText	15
LCA6	Lower canopy alive 6	dbBoolean	1
LCS7	Lower canopy species 7	dbText	15
LCA7	Lower canopy alive7	dbBoolean	1
LCS8	Lower canopy species 8	dbText	15
LCA8	Lower canopy alive 8	dbBoolean	1
LCS9	Lower canopy species 9	dbText	15
LCA9	Lower canopy alive 9	dbBoolean	1
LCS10	Lower canopy species 10	dbText	15
LCA10	Lower canopy alive 10	dbBoolean	1
D1	Disturbance code 1	dbText	15
D2	Disturbance code 2	dbText	15
D3	Disturbance code 3	dbText	15
D4	Disturbance code 4	dbText	15
D5	Disturbance code 5	dbText	15

Table Name: tbl_LP_Seedling

Description: Table of tree seedlings in 1 meter belt transect.

Field Name	Field Description	Field Type	Field Width
Seedling_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Seedling species code	dbText	15
Total	Total count	dbInteger	2

Table Name: tbl_LP_Shrub

Description: Table of shrub counts in 1 meter belt transect.

Field Name	Field Description	Field Type	Field Width
Shrub_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Shrub species code	dbText	15
Alive	Is shrub species alive?	dbBoolean	1
HC10	0-10cm height class total	dbInteger	2
HC25	10.1-25cm height class total	dbInteger	2
HC50	25.1-50cm height class total	dbInteger	2
HC100	50.1-100cm height class total	dbInteger	2
HC2m	1.01-2m height class total	dbInteger	2
HCGT2	>2.01m height class total	dbInteger	2

Table Name: tbl_LP_Transect

Description: Table of transect information for point intercept measurements.

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
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

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_Monument

Description: Table of monument tree information.

Field Name	Field Description	Field Type	Field Width
Monument_ID	Unique record identifier - primary key	dbText	50
Location_ID	Foreign key to tbl_Locations	dbText	50
Monument_Code	Corner code	dbText	5
Tag_No	F/W Tag number of monument tree	dbInteger	2
Species	Species code of monument tree	dbText	15
DBH	F/W Diameter at breast height in centimeters	dbSingle	4

Field Name	Field Description	Field Type	Field Width
Bearing	F/W Bearing from monument tree to plot corner in degrees	dbInteger	2
Rebar_Distance	F/W Distance from center point of monument tree to plot corner in meters	dbSingle	4

Table Name: tbl_OT_Census

Description: Table of overstory tree census information.

Field Name	Field Description	Field Type	Field Width
Census_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Quad	Quadrat number	dbInteger	2
Tag_No	Tag number	dbInteger	2
Species	Species code	dbText	15
DBH	Diameter at breast height in centimeters	dbSingle	4
Crown_Health	Crown health class	dbInteger	2
Crown_Class	Crown class	dbText	50
Notes	Notes about any significant damage to a living tree	dbText	255

Table Name: tbl_OT_Tree_Saplings

Description: Table of sapling tallies in 5 meter belt transect.

Field Name	Field Description	Field Type	Field Width
TS_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Species	Sapling species code	dbText	15
Alive	Is sapling species alive?	dbBoolean	1
D25	2.5 - 5.0 cm diameter class total	dbInteger	2
D51	5.1 - 10.0 cm diameter class total	dbInteger	2
D101	10.1 - 15.0 cm diameter class total	dbInteger	2

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 description	dbText	25
Roll	Roll for film photos	dbText	10
Frame	Frame for film photos; sequential number for digital photos	dbInteger	2
Digital_File	Digital file name	dbText	50
Photographer	Photographer	dbText	50
Direction	Direction of photograph (discontinued use in 2008)	dbText	3
Location	Location of photo point along transect in meters	dbDecimal	16
Other_Identifier	Other digital photo identifier	dbText	50
Comments	Photo comments	dbMemo	0
NCPN_Image_ID	Digital file name in NCPN Photo Database	dbText	50

Table Name: tbl_Quadrat

Description: Table of quadrat information (discontinued use in 2009)

Field Name	Field Description	Field Type	Field Width
Quadrat_ID	Unique record identifier - primary key	dbText	50

Field Name	Field Description	Field Type	Field Width
Transect_ID	Foreign key to tbl_Quadrat_Transect	dbText	50
Quadrat	Quadrat number - 1 to 5	dbByte	1
Observer	Name of person observing	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
Cyan_Cover	Percent cyanobacteria cover in 10 m2 quadrat - 2006 only	dbText	3
Cyan_Cover_1M2	Percent cyanobacteria cover in 1 m2 quadrat >= 2007	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 - 2006 only	dbText	3
Lichen_Cover_1M2	Percent lichen cover in 1 m2 quadrat >= 2007	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 - 2006 only	dbText	3
Moss_Cover_1M2	Percent moss cover in 1 m2 quadrat >= 2007	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

Field Name	Field Description	Field Type	Field Width
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
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_Tree	Percentage tree cover 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_Plant_Basal	Percentage plant basal 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

Field Name	Field Description	Field Type	Field Width
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 (discontinued use in 2009)

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 (discontinued use in 2009)

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 (discontinued use in 2009)

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 (discontinued use in 2008 - see tbl_Impact_Details)	dbText	50

Field Name	Field Description	Field Type	Field Width
On_Size	Size of area affected in m2 (discontinued use in 2008 - see tbl_Impact_Details)	dbInteger	2
On_Position	Position of disturbance relative to transects (discontinued use in 2008 - see tbl_Impact_Details)	dbText	255
On_Effect	Effect of disturbance on erosional processes on macroplot (discontinued use in 2008 - see tbl_Impact_Details)	dbMemo	0
On_Fire	Alteration of fire behavior on macroplot caused by disturbance (discontinued use in 2008 - see tbl_Impact_Details)	dbMemo	0
On_Additional	Additional on-site disturbance description (discontinued use in 2008 - see tbl_Impact_Details)	dbMemo	0
Off_Disturbance	Off-site disturbance type (discontinued use in 2008 - see tbl_Impact_Details)	dbText	50
Off_Size	Size of area affected in m2 (discontinued use in 2008 - see tbl_Impact_Details)	dbInteger	2
Off_Distance	Distance upslope from macroplot in meters (discontinued use in 2008 - see tbl_Impact_Details)	dbInteger	2
Off_Effect	Effect of disturbance on erosional processes on macroplot (discontinued use in 2008 - see tbl_Impact_Details)	dbMemo	0
Off_Fire	Alteration of fire behavior on macroplot caused by disturbance (discontinued use in 2008 - see tbl_Impact_Details)	dbMemo	0
Off_Additional	Additional off-site disturbance description (discontinued use in 2008 - see tbl_Impact_Details)	dbMemo	0
Site_Sketch	BLOB of site sketch or jpg picture of disturbance.	dbLongBinary	0
Percent_Top_Kill	Percentage of Gambel oak cover in plot affected by top kill (added in 2009).	dbInteger	2
Percent_Dead	Percentage of Gambel oak cover in plot that is completely dead (added in 2009).	dbLong	4

Table Name: tbl_SL_Transect

Description: Table of transect information for shrub line-intercept gaps

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
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

Table Name: tbl_SLI_Gaps

Description: Table of Shrub Line-Intercept Gaps

Field Name	Field Description	Field Type	Field Width
SLI_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_SL_Transect	dbText	50
Species	Species code	dbText	50
Shrub_Start	Start of shrub cover to nearest centimeter	dbLong	4
Shrub_End	End of shrub cover to nearest centimeter	dbInteger	2

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	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
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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

Field Name	Field Description	Field Type	Field Width
T2645_Pos	Transect 2 6:45 minute position	dbDouble	8
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	dbDouble	8
T2730_Veg	Transect 2 7:30 minute Vegetation: NC, G, F, Sh, T	dbText	2
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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	dbDouble	8
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

Field Name	Field Description	Field Type	Field Width
Unknown_ID	Unique record identifier - primary key	dbText	50
Species_ID	Foreign key to parent table - discontinued use - 3/2009	dbText	50
Unknown_Code	Temporary code for unknown species	dbText	50
Collected_by	Person collecting specimen	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
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_Code	Confirmed species code	dbText	50
Have_Photos	Are there photos?	dbBoolean	1
Forb_Grass_Type	Annual or Perennial	dbText	10
Perennial_Grasses	Perennial grass type: Bunchgrass or Rhizomatous	dbText	15
Identified_by	Person making final identification	dbText	50
Identified_Date	Date of identification	dbDate	8
Position	Position on Transect (m)	dbInteger	2

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
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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_Crown_Class

Description: Lookup table for Crown Class

Field Name	Field Description	Field Type	Field Width
Crown_Class	Crown class	dbText	25

Table Name: tlu_Crown_Health_Class

Description: Lookup table of crown health classes

Field Name	Field Description	Field Type	Field Width
Crown_Health_Class	Crown health class	dbInteger	2
Class_Description	Health class description	dbText	50

Table Name: tlu_Densimeter_Point

Description: Lookup table of valid densimeter points

Field Name	Field Description	Field Type	Field Width
Point	Densimeter measurement point	dbText	4
Sort_Seq	Sort sequence	dbInteger	2

Table Name: tlu_Density_Category

Description: Lookup table of high density categories

Field Name	Field Description	Field Type	Field Width
Category	Density category	dbLong	4
Cat_Desc	Density category description	dbText	10

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_Eco_Site

Description: Lookup table for primary ecological site

Field Name	Field Description	Field Type	Field Width
Eco_Site	Primary ecological site 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_LP_Disturbance

Description: Lookup table of Line-Point disturbances

Field Name	Field Description	Field Type	Field Width
Dist_Code	Disturbance code	dbText	5
Disturbance	Disturbance description	dbText	50

Table Name: tlu_LP_Soil_Surface

Description: Lookup table of Line-Point soil surface

Field Name	Field Description	Field Type	Field Width
Surface_Code	Soil surface code	dbText	5
Surface_Description	Soil surface description	dbText	50
LC_Code	Lower canopy code - 1=applies also to lower canopy	dbByte	1

Table Name: tlu_Monument_Code

Description: Lookup table of monument tree corner codes

Field Name	Field Description	Field Type	Field Width
Monument_Code	5 character monument corner code.	dbText	5

Table Name: tlu_NCPN_Plants

Description: Contains all NCPN master plant species

Field Name	Field Description	Field Type	Field Width
Master_Family	Master_Family	dbText	50
Master_PLANT_Code	Master Species PLANTS Code	dbText	20
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	20
Utah_Species	Utah Species (Welsh et al 2003)	dbText	50
Co_PLANT_Code	Colorado Species PLANTS Code	dbText	20
Co_Species	Colorado Species (Weber & Wittmann 2001)	dbText	50
Wy_PLANT_code	Wyoming species PLANTS code	dbText	20
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
Lifeform	Lifeform derived from USDA Plants	dbText	255
Duration	Duration derived from USDA Plants	dbText	255
Nativity	Nativity derived from USDA Plants	dbText	255
Trinomial	True if species code represents a trinomial name	dbBoolean	1
Unique_Species	True if species code represents a genus and species	dbBoolean	1

Field Name	Field Description	Field Type	Field Width
	designation		
New_Record	Is it a new record?	dbBoolean	1
LU_Code	Shorthand (a.k.a. 6-Letter) Lookup Code	dbText	25

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
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

Table Name: tlu_Soil_Surface_Area

Description: Lookup table for Soil Survey Area

Field Name	Field Description	Field Type	Field Width
Soil_Survey_Area	Soil survey area.	dbText	50

Table Name: tlu_Soil_Texture

Description: Lookup table for soil texture

Field Name	Field Description	Field Type	Field Width
Soil_Texture	Particle size distribution of fine earth fraction and clay particles	dbText	50

Table Name: tlu_Veg_Type

Description: Lookup table for vegetation type

Field Name	Field Description	Field Type	Field Width
Vegetation_Type	Vegetation type	dbText	50

Appendix B Integrated Upland Database User's Guide

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1 Introduction

This document provides instructions for using version 4.1.5 of the NCPN Integrated Upland Monitoring database. The 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.
- *MouseWheel.dll*: This DLL file is required to prevent inadvertent record insertions via the mousewheel.
- *Plot_Establishment.dot*: This Word template file is required to generate plot revisit data sheets.

All of the above files are located in the following folder on the NCPN I&M network drive (i.e., the X drive):

X:\ Active_Monitoring_Projects\Upland\Data\Database\Current

This folder will be referred to subsequently as the Current folder. It contains the *working database*, i.e., the database used to enter data for the current season. The working database does not contain data from previous years – such data are stored in the *master database*. The master database contains the full, certified project dataset and is located on the read-only Archive drive. To allow convenient access to the master database, there is a read-only copy in the following location in the upland project folder (location below). This folder will be referred to subsequently as the Master folder.

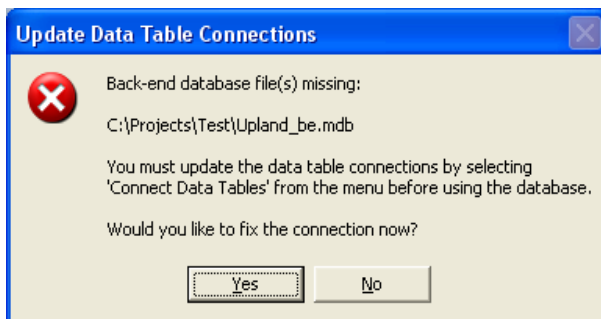
X:\ Active_Monitoring_Projects\Upland\Data\Database\Master

2 Installation

Data management staff will ensure that all the files needed to run the database application are installed on your machine. This will normally include the frontend file (*Upland.mdb*), the DLL files (*MouseWheel.dll* and *ijl15.dll*), and optionally the plot revisit template file (*Plot_Establishment.dot*) if you need to generate plot revisit data sheets. The backend database file, *Upland_be.mdb*, is the database that will contain the data and thus, should be kept on the X drive for office data entry. Keeping the backend database file on the X drive allows multiple frontends to link to it so that multiple data entry sessions can be conducted concurrently, and also ensures that the database is backed up regularly. For field data entry, backend files will be installed on each Toughbook laptop. Data management staff will also handle the installation of all files on the field laptops.

3 Getting Started

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



This message is generated because the frontend database does not yet know the location where your backend database is saved. To connect to the backend data file, reply “Yes” to the above message. You will then see the Update Data Table Connections form:

Update Data Table Connections

Update links to back end database tables

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

Back-end data NRDT back-end database file

Current name: Upland_be.mdb

Path: C:\Projects\Test\Upland_be.mdb

New file:

Path:

Browse

Close form

Update links

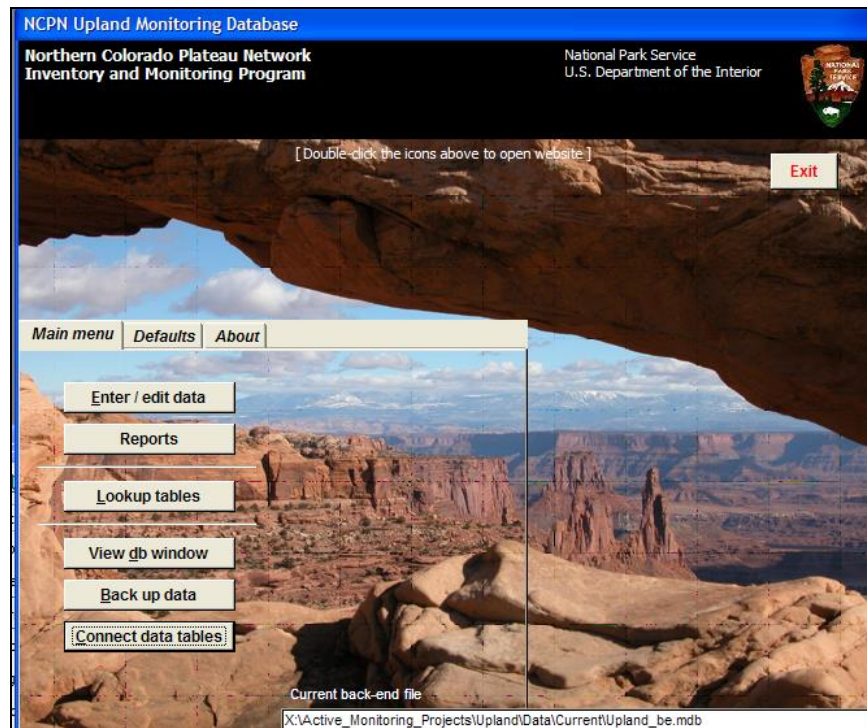
You can click the “Browse” button to navigate to the location of your backend database:

- Office data entry: the **Current** folder
- Field data entry: C:\Upland_Database\Current

Select the backend database file (*Upland_be.mdb*), 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.

Note: If the backend file has “HOLD” appended to it (e.g., *Upland_be_HOLD.mdb*), this means that the database is locked. This usually occurs when Data Management staff needs to perform maintenance on the database. In such cases, you should **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.

It is important that your frontend database be linked to the correct copy of the backend database. 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 to make sure you are entering data into the correct backend file.***



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 “Reports” button opens the Reports menu.
- 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 pick list. Contact data management staff to have your information added to this list. There are also checkboxes on the tab to select optional automated functions which are available.

The third tab displays information about the database. You should see “Version 4.1.5” (or a higher number) displayed at the top of this tab. 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 data management staff the details. The “SOP Version Admin” button provides functionality related to managing the protocol SOP history of this database. ***This button is for data management staff only.*** Procedures for this process are detailed in the *NCPN Protocol Versioning Guidance Document* (NCPN-NPS 2009). The current master SOP version key for this protocol is stored in each new visit event record added to the database.

4 Backing Up the Database

A backup can be created from within the database by clicking the “Back up data” button on the main menu. Backups are named as follows:

Upland_be_yyyymmdd_hhmm.mdb, where *yyymmdd* represents the current date and *hhmm* the current time (e.g., *Upland_be_20090428_1150.mdb*).

The “Back up data” button will name the backup file using the above-given naming convention. The location and frequency of backups are different for field vs. office data entry:

- **Field data entry:**
 - Location: **Backups** folder on USB drive. Data management staff will move backups from USB drive to NCPN file server in between each field trip.
 - Frequency: After completing each plot.
- **Office data entry:**
 - Location: **Backups** folder (in X:\ Active_Monitoring_Projects\Upland\Data\Database). Data management staff, in consultation with project manager, will periodically review the **Backups** folder and remove any unnecessary backup files. 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.
 - Frequency: Once per day (unless there is no data entry on a given day).

5 Data Entry

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

- Field data entry: Before entering data in the field, you should learn how to use the database by entering data in the office. It will be much easier to learn the database in an office setting than when you are out in the field with a Toughbook.
- Office data entry: Make sure that the data sheets for each plot are sorted in ascending order by transect before you start entering data. This will help prevent you from entering the wrong data for a given transect.

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:

Set application default values

OK

User: Topp_Sarah

Park: CANY

Datum: NAD83

Zone: 12

New user

Soil Survey Area

Select your name in the User pick list and verify that the application defaults are correct. Change any values as needed. If you are a new user and not listed in the User pick list, contact data management staff to have your information added to the database. Once all application defaults are correct, click the “OK” button and the Data Gateway form appears.

5.2 Data Gateway Form

The Data Gateway form displays plots by park:

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 **CANY** Selected for Monitoring **On**

Unit*	Plot ID*	Entered/updated*	Selected for Monitoring			
CANY	3	6/16/2009 5:03:29 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	5	6/16/2009 5:03:23 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	6	6/16/2009 5:03:14 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	9	6/16/2009 5:02:56 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	10	6/16/2009 5:02:52 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	13	6/16/2009 5:02:43 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	14	6/16/2009 5:02:15 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	18	6/16/2009 5:02:07 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	22	6/16/2009 5:01:49 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	24	6/16/2009 5:01:38 PM	☒	View Visits	Add New Visit	Site Characterization
CANY	25	6/16/2009 5:01:35 PM	☒	View Visits	Add New Visit	Site Characterization

Double-clicking on a column header (e.g., Plot ID) will sort by that column. By default, the Data Gateway lists only the plots for your default park. To see plots for a different park, select another park in the “Filter by park” drop-down. 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. By default, the Data Gateway lists only plots that have been selected for monitoring. To see all plots, set the “Selected for Monitoring” drop-down to “Off”.

There are three buttons associated with each plot. These buttons are used as follows:

- If the plot is a newly established plot, choose the “Site Characterization” button to enter the site characterization and plot establishment data (see Section 5.3).
- If entering revisit data, first choose “View Visits” to determine whether a visit record has been created (e.g., you may have started entering the record during a previous data entry session).
 - If no visit record exists, choose “Add New Visit” to add a record for the visit (see Section 5.4).
 - If a visit record exists, choose “Edit Visit” and continue editing the record on the main data entry form (see Section 5.5).

If you do not see a record for your plot on the Data Gateway form, follow the instructions below depending on whether you are entering data in the field or in the office:

- Field data entry: Click the “Add a new site” button. Enter the Site Characterization information if available. If not, enter the park code, plot ID, and vegetation type (this is the minimum information required to enter visit data). Make a note of the newly added plot so that you can notify data management staff when you return from the field.
- Office data entry: Do not use the “Add a new site” button. Instead, contact data management staff so that they can import the location data for the plot.

5.3 Site Characterization/Plot Establishment

After clicking the “Site Characterization” button, the Edit/Add Site Characterization form displays. Enter the site characterization data into this form, but only for accepted sites (record rejected sites on paper). Below are some important tips to remember when entering site characterization/plot establishment data:

- ***Make sure Vegetation Type is populated properly, since this field determines which data entry forms will appear for the plot.***
- You can enter values not on the “Other Ecological Site” pick list (up to 50 characters).
- To enter plot establishment data:
 - Make sure the Site Selection box is checked and then click the “Plot Establishment” button in the upper left corner.
 - Enter all plot establishment fields except UTM and Elevation fields (these fields will be imported into database from corrected GPS data).
 - The End Rebar Location fields default to 50m for all plot types, so be sure to change if needed (especially for oak plots).
 - Be sure to enter values for Plot Side Slopes (required for newly established forest and woodland plots) and Monument Trees (if applicable).

After completing both the Plot Establishment and Site Characterization forms, close both forms to return to the Data Gateway form.

5.4 Add New Visit

As mentioned previously, always check for an existing visit before adding a new one (use “View Visits” on the Data Gateway form). After clicking the “Add New Visit” button, the Plot Revisit form displays. Enter the plot revisit data into this form. If, during a revisit, you need to modify location coordinates or other plot establishment information (e.g., rebar location change), see Section 5.4.1. Otherwise, click “Continue” and proceed to the main data entry form (see Section 5.5).

5.4.1 Modify Location Coordinates

In some cases, you may need to modify location coordinate information during a revisit, e.g., if rebar has to be relocated or if data were recorded incorrectly during plot establishment. You can enter such changes by clicking the “Modify Location Coordinates” button. Update the appropriate fields using the Location Coordinate Change form. You must select your name in the “Changes made by” pick list and then confirm the change when prompted. You will then be returned to the Plot Revisit form. Click “Continue” on the Plot Revisit form to proceed to the main data entry form (see Section 5.5). ***Do not use the Location Coordinate Change form to make changes during plot establishment. To make such changes, open the Site Characterization form and use the Plot Establishment button.***

Some specific instructions for location coordinate changes are given below for field vs. office data entry:

- Field data entry: Mark any location changes on a plot revisit sheet (cross out existing values and write in new values), even if you enter them in the field. This will help ensure data management staff is aware of the change.
- Office data entry: Check plot revisit data sheet for any location changes so they are not overlooked.

5.5 Main Data Entry Form

The main data entry form allows you to enter new data and edit existing data. The top of the form shows the Plot ID, Park, Centroid UTM's, Start Date, Observer, and Visit Comments. The latter three fields can be edited. The “Change Plot Coordinates” button can be used to modify location coordinate information (see Section 5.4.1). The main data entry form also contains a tab for each of the applicable data entry forms for the plot, which depends on the vegetation type of the plot (see Table 1). The example data entry form shown below displays the applicable tabs for a forest plot.

The complete set of data entry forms, along with references to more details about each, is as follows: Photos (Section 5.5.1), Point Intercept (Section 5.5.2), 1-Meter Belt Transect (Section 5.5.3), Gap Intercepts (Section 5.5.4), Soil Stability (Section 5.5.5), Overstory Trees (Section 5.5.6), Fuels (Section 5.5.7), and Site Impact (Section 5.5.8).

Table 1 Data Entry Forms by Vegetation Type

Vegetation Type	Data Entry Forms Displayed
Forest	Photos, Point Intercept, 1-Meter Belt, Overstory Trees, Fuels, Site Impact
Grassland/shrubland	Photos, Point Intercept, 1-Meter Belt, Gap Intercepts, Soil Stability, Overstory Trees, Site Impact
Oak	Photos, Point Intercept, Overstory Trees, Fuels, Site Impact
Woodland	Photos, Point Intercept, 1-Meter Belt, Soil Stability, Overstory Trees, Fuels, Site Impact

5.5.1 Photos

The “Photos” tab lets you document all required photographs taken during the visit (see SOP #7 for repeat photograph procedures). Note that any additional photos taken (listed in the “Other photos” section of the photo data sheet) are not recorded in the upland database. These photos should be uploaded to the file server, along with the plot photos (see Section 5.5.1.1).

Before taking photos with a digital camera, always verify that the camera date is set correctly (to current date). When entering photo data, whether in the office or in the field, the following fields should be entered: Location, Roll # (only for film cameras), Frame (only for film cameras), Photo Date, Photographer, Location on Transect, and Comments (if applicable). The values in the Location pick list correspond to the photo points described in SOP #7:

- T1 - origin
- T2 - origin
- T3 - origin
- T1 - end
- T2 - end
- T3 - end
- T1 - 0m - crust
- T2 - 20m - crust
- T3 - 40m - crust

If using an Olympus Stylus digital camera, enter the Digital File Name in the following format: Pmdd9999, where m = month (Jan – Sep = 1 – 9, Oct = A, Nov = B, Dec = C); dd = day (01-31); 9999 = sequential photo number displayed by the camera. If not using an Olympus Stylus digital camera, leave Digital File Name blank and record the sequence number of the photo in the Frame or Photo # field. In such cases, Digital File Name will need to be populated later via some additional steps (see Section 5.5.1.2). Regardless of camera type, NCPN Image ID will always be populated by data management staff at a later time.

The photo points taken for a plot depend on the vegetation type. For example, no biological soil crust photos are taken for forest and oak plots. The example below shows the photo data for a grassland/shrubland plot:

Location	Roll #	Frame or Photo #	Photo Date	Photographer	Location on Transect (m)	Digital File Name	NCPN Image ID	Comments
T1 - origin		0	5/30/2010	Lund	-3	P5300349		
T2 - origin		0	5/30/2010	Lund	-3	P5300347		
T3 - origin		0	5/30/2010	Kast	-3	P5300351		
T1 - 0m - crust		0	5/30/2010	Lamson	0	P5300350		
T2 - 20m - crust		0	5/30/2010	Lund	20	P5300348		
T3 - 40m - crust		0	5/30/2010	Kast	40	P5300352		
		0			0			

5.5.1.1 Photos: Uploading to File Server

Upland monitoring photos are initially stored in the folder location below on the NCPN file server by year and then park/plot.

X:\Archive\NCPN Photos\Monitoring_To_be_Entered

For example, 2009 photos for plot CEBR 23 would be stored in

Archive\NCPN Photos\Monitoring_To_be_Entered\Upland_2009\CEBR_UPLAND\CEBR_23

Photos not associated with a plot are stored in an “Other_Photos” folder. Note that these folders are temporary. Once the photos are entered into the NCPN Photo Database (sometime after each field season), the photos will be moved to the appropriate folder on the R drive.

5.5.1.2 Photos: Populating Digital File Name

Entering the Digital File Name requires some extra steps, so this is often done as a separate process, after all other photo data have been entered. To populate the Digital File Name for the photos taken at a given plot, open the folder containing the photos for the plot (folder location below) and then follow the steps below for each photo:

X:\Archive\NCPN Photos\Monitoring_To_be_Entered\Upland_YYYY\PARK_PLOT (e.g., Upland_2009\CEBR_UPLAND\CEBR_23)

- View the photo using either Windows Explorer (Filmstrip view is recommended) or a photo viewing program, such as Windows Picture and Fax Viewer (right click a photo and choose “Open with Windows Picture and Fax Viewer”).

- Rotate the photo if necessary so that the horizon is level (e.g., photos should not appear “sideways”). Rotation can be done using the rotation buttons available in both Windows Explorer and Windows Picture and Fax Viewer.
- Match the sequence number of the photo file name to the appropriate photo record in the database. The sequence number may be recorded in either the Frame or Digital File Name fields (e.g., photo file “P8080024” in the CEBR_23 folder matches the record having Digital File Name = “100-024”).
- Use any other data available in the photo (plot, date, and transect on signboard) to verify that the database record matches the photo.
- Copy the photo file name and paste it into the Digital File Name field on the data entry form (note: do not include the “.jpg” file extension).

Repeat the above steps until all photo files in the plot folder have been matched with the corresponding photo database record. Move the *PARK_PLOT* folder (e.g., CEBR_23) to the “**0_Photo_DB_Ready**” folder. This is an important step because it indicates that the photos for this plot are ready to be entered into the Photo Database (it can also help everyone track the progress of photo processing).

Note that there should be a one-to-one match between photo files and photo records in the database. If not, this indicates a potential discrepancy that should be resolved (or documented if it cannot be resolved). If you find any discrepancies, check the Photo Comments field since discrepancies may be noted there (e.g., “signboard should say T1”).

5.5.2 Point Intercept

The “Point Intercept” tab allows you to enter data collected for each point using the line-point intercept sampling method (see SOP #8). Below are some important tips to remember:

- You are not required to enter data in transect order, **but you should initialize all 3 forms in transect order before entering any data**. Click the “Initialize Form” button on each transect form (the “Initialize Form” should change from green to red once the form is ready). The intervals that appear on the form depend on the vegetation type of the plot: 0.25-meter intervals are used for oak plots and 0.5-meter intervals for all other plot types.
- To help ensure that data are entered for the correct transect, a notification message appears any time you navigate to a different transect. Still, **you should always check the Transect # (upper left) to make sure you are entering data for the correct transect!** Keep in mind that data entered for the wrong transect can only be corrected by re-entering it.
- Transect Visit Date defaults to Plot Start Date, so you only need to enter this date if it’s different from Plot Start Date.
- Observer and Recorder are not required, so be sure to enter this information.

There is a row for each point on the data entry form. You can use the tab key to navigate through all the fields on each row. There is also a scroll bar on the right for row navigation. Use the “More LC” button if you need to record more than three Lower Canopy entries. Similarly, use the “More Disturbance” button if you need to record more than one Disturbance entry. Lower Canopy and Disturbance entries must be entered consecutively in their respective fields (e.g., Lower Canopy 1, Lower Canopy 2, etc.). If you try to leave blanks in between entries, you will get an error. There are checks for the duplicate species rules that apply to the point intercept data, so you will get an error if you violate any of these rules.

All species in the pick lists are sorted by the shorthand codes (a.k.a. 6-letter codes), which are formed by concatenating the first three characters of the Genus and Species names. Some species could not be assigned codes using this 6-letter format because they would result in duplicate codes. Codes for these species are listed in Section 5.5.9. Use the “Master Lookup” button if you need to look up a species by

master name or code (Section 5.5.10). Note that unknown species appear in all species pick lists. Procedures for recording unknown species are given in Section 5.5.11.

After completing the data entry for all points for a transect, click the “Verify Soil Surface” button at the top to ensure you have entered Soil Surface values for all points. Enter any missing values and re-run the verify button as many times as needed until all Soil Surface values have been entered.

Data Entry Form - Filter by sampling event

Site 23 Park CEBR
 UTM E/N E: 337387.394 N: 4169754.575
 Start Date 8/8/2009 Observer Topp
 Change Plot Coordinates Visit Comments:
 Close

Photos Point Intercept 1-m Belt Overstory Trees Fuels Site Impact

Transect 1 Visit Date 8/8/2009 Observer Topp Recorder Crook Verify Soil Surface

Initialize Form Master Lookup Unknown Species More LC More Disturbance

Point (m)	Top Canopy	A/D	Lower Canopy One	A/D	Lower Canopy Two	A/D	Lower Canopy Three	A/D	Soil Surface	Dist
0.5		Y	WD	N		Y		Y	WD	N
1	MERARI	Y	WD	N		Y		Y	WD	N
1.5		Y	WD	N	MERARI	Y		Y	L	N
2	ABILAS	Y	WD	N		Y		Y	L	N
2.5	ABILAS	Y		Y		Y		Y	L	N
3	ABILAS	Y	L	N		Y		Y	L	N
3.5	ABILAS	Y	LIGPOR	Y		Y		Y	L	N
4	ABILAS	Y	L	N		Y		Y	L	N
4.5		Y	WD	N		Y		Y	L	N
5	ABILAS	Y	RIBMON	Y	MERARI	Y		Y	L	N
5.5	RIBMON	Y	MERARI	Y		Y		Y	L	N
6	RIBMON	Y		Y		Y		Y	L	N
6.5	RIBMON	Y		Y		Y		Y	L	N
7		Y		Y		Y		Y	WD	N
7.5	RIBMON	Y		Y		Y		Y	L	N
8		Y		Y		Y		Y	SW	N
8.5		Y		Y		Y		Y	L	N
9	PICENG	N		Y		Y		Y	L	N

5.5.3 1-Meter Belt Transect

The “1-m Belt” tab allows you to enter data collected using the 1-meter belt transect sampling method (see SOP #10). Below are some important tips to remember:

- You are not required to enter data in transect order.
- To help ensure that data are entered for the correct transect, a notification message appears any time you navigate to a different transect. Still, ***you should always check the Transect # (upper left) to make sure you are entering data for the correct transect!*** Keep in mind that data entered for the wrong transect can only be corrected by re-entering it.
- Transect Visit Date defaults to Plot Start Date, so you only need to enter this date if it’s different from Plot Start Date.
- Observer and Recorder are not required, so be sure to enter this information.

- All entries have delete buttons in case you need to delete an erroneous entry. However, in order to delete a record, you must have the required fields filled in.
- You can use Shift-Tab to move the cursor to the previous field.

All species in the pick lists are sorted by the shorthand codes (a.k.a. 6-letter codes), which are formed by concatenating the first three characters of the Genus and Species names. Some species could not be assigned codes using this 6-letter format because they would result in duplicate codes. Codes for these species are listed in Section 5.5.9. Use the “Master Lookup” button if you need to look up a species by master name or code (Section 5.5.10). Note that unknown species appear in all species pick lists. Procedures for recording unknown species are given in Section 5.5.11.

Duplicate species are not allowed within each of the three Density sub-forms (Live Shrubs, Tree Seedlings, and Exotic Perennial Species), so you will get an error if you try to enter a duplicate species. For field data entry, you can use the tally buttons at the bottom of each Density sub-form to increment/decrement any of the Total fields. Place the cursor in the Total field you want to increment/decrement and click the appropriate tally button. Additional sub-forms may appear on the 1-m Belt tab depending on the vegetation type. For example, forest plots have Spherical Densiometer and Additional Species sub-forms for recording data collected via these methods (see SOP #10).

Data Entry Form - Filter by sampling event

Site 23 Park CEBR
UTM E/N E: 337387.394 N: 4169754.575
Start Date 8/8/2009 Observer Topp
Change Plot Coordinates Visit Comments:
Close

Photos | Point Intercept | **1-m Belt** | Overstory Trees | Fuels | Site Impact

Transect 1 Visit Date 8/8/2009 Observer Topp Recorder Crook Master Species Unknown Species

Density | Spherical Densiometer | Additional Species

Number of Live Shrubs Rooted in 1 Meter Belt Transect

Shrub Species	Height Class Totals						Delete Record
	0-10cm	10.1-25cm	25.1-50cm	50.1-100cm	1.01-2m	>2.01m	
RIBMON				2	1		Delete Record
*							Delete Record

+1 +5 -1 -5 0

Record: 1 of 1

Tree Seedlings

Species Name	Total	Delete
ABILAS	20	Delete
*	0	Delete

+1 +5 -1 -5 0

Record: 1 of 1

Exotic Perennial Species

Species Name	Total	Delete
POAPRA	1	Delete
*		Delete

+1 +5 -1 -5 0

Record: 1 of 1

5.5.4 Gap Intercepts

Basal and Canopy gaps for grassland/shrubland plots are entered under the “Gap Intercepts” tab. Below are some important tips to remember:

- You are not required to enter data in transect order.

- To help ensure that data are entered for the correct transect, a notification message appears any time you navigate to a different transect. Still, ***you should always check the Transect # (upper left) to make sure you are entering data for the correct transect!*** Keep in mind that data entered for the wrong transect can only be corrected by re-entering it.
- Transect Visit Date defaults to Plot Start Date, so you only need to enter this date if it's different from Plot Start Date.
- Observer and Recorder are not required, so be sure to enter this information, as well as Shrub Species.

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 addition, you cannot enter gaps < 20 cm. If you try to enter a gap < 20 cm, the database will generate an error. When entering data in the office, if you find a gap < 20 cm on a data sheet, you should not record that gap in the database, i.e., skip two rows on the datasheet and use the second stop measurement. Also, make a note next to the invalid gap on the data sheet that it was not entered because it is < 20 cm.

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.

Once a number is entered and you tab to the next cell, the information is automatically stored. If you have to remove a gap that is too short or change a previously entered number, you need to hit the “Refresh” button in the upper right hand side for the computer to recognize the change. This may cause one or two entries to disappear. Once you re-enter the new number you must also hit the Refresh button in order to continue.

Data Entry Form - Filter by sampling event

Site 3 Park CARE UTM E/N E: 472061.549 N: 4262092.128 Start Date 5/29/2009 Observer Condie Change Plot Coordinates Visit Comments: Tags at this plot are etched, not stamped. Close

Photos Point Intercept 1-m Belt Gap Intercepts Soil Stability Overstory Trees Site Impact

Transect 1 Visit Date 5/29/2009 Observer Lund Recorder Lenhart Shrub Species Eriogonum leptocladon, Atriplex c

Canopy Gaps Basal Gaps

Class	Start (cm)	Class	Start (cm)	Class	Start (cm)	Class	Start (cm)	Class	Start (cm)
v	0	v	1722	v	3567				
g	17	g	1728	g	3570				
v	66	v	1770	v	3675				
g	70	g	1796	g	3691				
v	114	v	1849	v	3823				
g	121	g	1855	g	3855				
v	166	v	2018	v	3940				
g	190	g	2022	g	3979				
v	253	v	2170	v	4089				
g	290	g	2237	g	4113				
v	392	v	2268	v	4134				
g	428	g	2351	g	4201				
v	454	v	2394	v	4298				
s	495	g	2398	g	4302				
g	551	v	2549	v	4334				
s	596	g	2572	g	4356				
g	605	v	2767	v	4391				
v	634	g	2783	g	4407				
g	690	v	2835	v	4516				
v	825	g	2858	g	4555				
g	843	v	2890	v	4597				
v	926	g	2927	g	4606				
g	931	v	3010	v	4755				
v	979	g	3015	g	4908				
g	992	v	3047						
v	1087	g	3061						
a	1117	v	3172						

Refresh

5.5.5 Soil Stability

The “Soil Stability” tab provides fields for entering data collected while estimating soil aggregate stability following the procedures in SOP #11. Soil stability data is entered for grassland/shrubland and woodland plots. If entering data from a Soil Stability data sheet, be aware that the Transect/Sample tables are transposed on the data entry form vs. the data sheet. Visit Date defaults to Plot Start Date, so you only need to enter this date if it’s different from Plot Start Date. Observer and Recorder are not required, so be sure to enter this information. The Veg field has a default code (‘nr’), so be sure to change the default code to the appropriate soil surface code.

Data Entry Form - Filter by sampling event

Site 3 Park CARE UTM E/N E: 472061.549 N: 4262092.128 Start Date 5/29/2009 Observer Condie

Change Plot Coordinates Visit Comments: Tags at this plot are etched, not stamped. Close

Photos | Point Intercept | 1-m Belt | Gap Intercepts | Soil Stability | Overstory Trees | Site Impact

Date 5/29/2009 Observer NPS Recorder Lenhart

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	857	NC	1	☐	5:15	606	Sh	5	☐	5:30	649	G	1	☐
5:45	1657	G	5	☐	6:00	1406	NC	1	☐	6:15	1449	G	6	☐
6:30	2457	NC	1	☐	6:45	2206	Sh	1	☐	7:00	2249	G	6	☐
7:15	3257	NC	1	☐	7:30	3006	NC	6	☐	7:45	3049	NC	1	☐
8:00	4057	NC	6	☐	8:15	3806	G	6	☐	8:30	3849	NC	6	☐
8:45	4857	G	5	☐	9:00	4606	Sh	6	☐	9:15	4649	NC	6	☐

Comments

5.5.6 Overstory Trees

The “Overstory Trees” tab allows you to enter data for the 5-meter belt transect and macroplot census methods (see SOP #13). The tab contains two sub-forms for entering both types of data. Visit Date on both data entry forms defaults to Plot Start Date, so you only need to enter if different from Plot Start Date. Observer and Recorder (on both data entry forms) are not required, so be sure to enter this information.

All species in the pick lists are sorted by the shorthand codes (a.k.a. 6-letter codes), which are formed by concatenating the first three characters of the Genus and Species names. Some species could not be assigned codes using this 6-letter format because they would result in duplicate codes. Codes for these species are listed in Section 5.5.9. Use the “Master Lookup” button if you need to look up a species by master name or code (Section 5.5.10). Note that unknown species appear in all species pick lists. Procedures for recording unknown species are given in Section 5.5.11.

The 5-meter belt transect sub-form allows a maximum of two occurrences per species – one dead and one alive. Attempts to violate this rule will generate an error message. For field data entry, you can use the tally buttons at the bottom of the 5-meter belt transect sub-form to increment/decrement any of the Total fields. Place the cursor in the Total field you want to increment/decrement and click the appropriate tally button. All entries have delete buttons in case you need to delete an erroneous entry.

Below are two special cases that may occur for overstory census data:

- If a tree is dead but still standing and has DBH $\leq$ 15cm, choose “standing dead” for Crown Health and you will be allowed to enter DBH $\leq$ 15.
- If a tree that was previously standing is now dead and down, choose “dead, fallen” for Crown Health (DBH is not required in this case).

Data Entry Form - Filter by sampling event

Site 16 Park CEBR
UTM E/N E: 338821.1 N: 4168551.951
Start Date 8/9/2009 Observer Topp
Change Plot Coordinates Visit Comments: T3-0 is just uphill from a large down Abies log
Close

Photos | Point Intercept | 1-m Belt | Overstory Trees | Fuels | Site Impact

Date Observer Recorder

Number of Tree Saplings in 5 Meter Belt Transect

Master Lookup
Unknown Species

Shrub Species	Alive?	Diameter Class Totals			Delete
		2.5-5.0cm	5.1-10.0cm	10.1-15.0cm	
POPTRE	No	0	0	1	Delete
ABILAS	Yes	7	8	1	Delete
PICENG	Yes	4	1	1	Delete
	Yes	0	0	0	Delete

+1 +5 -1 -5 0

Record: 1 of 3

Date Observer Recorder

Overstory Census

Master Lookup
Unknown Species

Quad	Tag #	Species	DBH (cm)	Crown Health	Crown Class	Notes/Conditions	Delete
1	198	PICENG	31.6	1	Intermedia		Delete
1	199	POPTRE	48.1	1	Dominant		Delete
1	200	PICENG	25.3	1	Intermedia		Delete
1	541	POPTRE	41.9	5	none		Delete
1	542	PICENG	25.5	1	Dominant		Delete

Record: 1 of 15

5.5.7 Fuels

The “Fuels” tab allows you to record fuels information as specified in SOP #14. Observation Date defaults to Plot Start Date, so you only need to enter if different from Plot Start Date. Observer and Recorder are not required, so be sure to enter this information. The top section of the tab contains sub-forms for entering fuels transect information, tallies for 1-hr, 10-hr, and 100-hr fuels, and litter and duff depth measurements. Navigation in the top section of the tab is set up so that you can tab through the fields in transect order. The bottom section of the tab contains a sub-form for entering 1000-hr fuels information.

For field data entry, you can use the tally buttons at the bottom of the “# of intercepts” sub-form to increment/decrement any of the Total fields. Place the cursor in the Total field you want to increment/decrement and click the appropriate tally button. The 1000-hr fuels sub-form has delete buttons in case you need to delete an erroneous entry.

Data Entry Form - Filter by sampling event

Site 5 Park CURE
UTM E/N E: 284757.041 N: 4260889.793
Start Date 9/22/2008 Observer Condie
Change Plot Coordinates Visit Comments:
Close

Photos | Point Intercept | 1-m Belt | Overstory Trees | Fuels | Site Impact

Observation Date 9/22/2008 Observer Weissinger Recorder Weissinger

fuels transect

	A	B	C	D
bearing (deg)	300	30	210	120
slope (%)	5	14	11	2

of intercepts

transect	1-hr (0-0.25 in)	10-hr (0.25-1 in)	100-hr (1-3 in)
A	1		
B	2	1	
C	7	3	1
D	8	2	

+1 +5 -1 -5 0

Litter and Duff Depth

point on transect (m)	depth (cm)							
	A		B		C		D	
	litter	duff	litter	duff	litter	duff	litter	duff
2	1.9	1	3.5	1.3	1.4	0.2	1.3	0.5
4	1.8	0	0.5	0.1	0.5	0.3	4	0.2
6	0.5	0.7	3.8	0.3	4.7	0.2	3.3	0.4
8	4.1	0.9	4.3	0	0	0	2.9	0.4
10	2.3	0	0	0.2	1.6	0.1	1.9	0.3
12	1.1	0.6	1	0.1	1.5	0.2	4.4	0
14	1.8	0.8	1.2	0.3	3.5	0	0.7	0.2

1000-hr fuels (> 3 in)

Transect	Diameter (in)	DecayClass	Delete
a	5	sound	Delete
a	9.5	sound	Delete
b	3.5	rotten	Delete
b	3.75	rotten	Delete
b	4.25	rotten	Delete
b	4.5	rotten	Delete
b	5.25	rotten	Delete

Record: 1 of 18

5.5.8 Site Impact

The “Site Impact” tab contains a sub-form to match each of the three main categories of disturbances described in SOP #12: *onsite*, *offsite – upslope*, and *offsite – other than upslope*. You must choose one of these three values from the “Observation Location Type” pick list, and the corresponding sub-form will display. Below are some important tips to remember:

- Visit Date defaults to Plot Start Date, so you only need to enter if different from Plot Start Date.
- Recorder is not required, so be sure to enter this field.
- If there is no disturbance, choose *none* from the “Disturbance Type” pick list.
- You can enter values not on the “Disturbance Type” pick list (up to 50 characters).
- For oak plots, the “Percent Gambel Oak top kill” and “Percent Gambel Oak Dead” fields appear at the top of the form and should be entered as per SOP #15.

In addition, each plot visit can have a scanned site sketch saved with the site impact record. If entering data in the field, any sketches must be drawn on a paper data sheet and entered into the database later since the sketches must be scanned (Section 5.5.8.1).

5.5.8.1 *Site Impact: Scanning and Entering Site Impact Sketches*

To create an image file of the sketch and enter into the database, follow the instructions below:

- Scan the sketch:
 - Open HP Director on the computer with the HP scanner attached (the scanner will turn itself on).
 - Select Settings – Text and Graphics – set to 100 dpi.
 - Select Preview before scanning.
 - Select Scan Document.
 - Place sheet face down, and have page extend beyond top of page by approx. 4”.
 - Wait for beep and preview to show up on screen, then press Accept.
 - When prompted whether you wish to add another, select No.
 - Save to the **Site_Impact_Scans** folder in Upland/Current.
 - Name the file *ParkCode_PlotID* (e.g., DINO_255) and save as a JPEG (.jpg) file.
- Enter the image file into the database:
 - Edit the appropriate site visit record.
 - Click the “Disturbance sketch/photo” button to open the “Load JPG” form.
 - Click “Load Jpeg from disk” and navigate to the location of the .jpg file. Once the file has been selected, it displays in the form.
 - Click “Save this map in site record” to save the .jpg file with the record, and then “Close” to exit the form.
 - You can click “Disturbance sketch/photo” again to verify that the image has been saved.

5.5.9 *Species Shorthand (a.k.a. 6-Letter) Codes*

Key to codes outside of standard 6-letter format

- 1) First 3 letters of Genus + entire species name (e.g. ASTSABULONUM)
- 2) Special species codes (for similar species names in Aster, Astragalus, Camissonia, Campanula, Erigeron, & Eriogonum):

ASTERSPATHULATUS
 ASTRAGSPATULATUS
 ASTERWELSHII
 ASTRAGSWELSHII
 CAMISSONIAPARRYI
 CAMPANULAPARRYI
 ERIGCAESPITOSUS
 ERIOGCAESPITOSUM
 ERIGCORYMBOSUS
 ERIOGCORYMBOSUM
 ERIOGCORYMBOSUMS (includes var.)
 ERIGLONCHOPHYLLUS
 ERIOGLONCHOPHYLLUM

- 3) Hybrids- "X" between genus and species (e.g. POPXCAN)

- 4) General unknowns

UNK	unknown species (unknown life form)
UNKAF	unknown annual forb
UNKAG	unknown annual graminoid
UNKF	unknown forb
UNKG	unknown graminoid
UNKH	unknown herb (forb or grass)
UNKPF	unknown perennial forb
UNKPG	unknown perennial graminoid
UNKS	unknown shrub
UNKT	unknown tree

- 5) Trinomials- additional letter for the first letter of the variety (e.g. ARAHOLF for Arabis holboellii var. fendleri). Do not use trinomial codes.

5.5.10 Looking up Species by Master Name/Code

If you do not know the state name or code, click the “Master Lookup” button to open the Master Species Lookup form. This form allows you to search by master code, master species name, master family, or master common name. Use the “Sort List by MASTER” button to specify which search field you prefer. The screen shot below shows a master species name lookup of “Pleuraphis jamesii”.

The screenshot shows a web-based form titled "Master Species Lookup". At the top, it says "Master PLANTS Code ABAR". Below this, there's a search bar with "pleuraphis jamesii" entered. To the right of the search bar is a dropdown menu labeled "Sort List by MASTER" with options: "PLANT Code", "Species", "Family-Species", and "Common Name". The "Species" option is selected. Below the search bar is a table with the following columns: Master Plant Code, Master Family, Master Species, Master Common Name, Utah Code, Utah Species, CO Code, CO Species, and WY. The table contains several rows of data, including "PLJA" for Poaceae, "PLEUR12" for Poaceae, "PLOD" for Asteraceae, and "PLSE" for Asteraceae.

Master Plant Code	Master Family	Master Species	Master Common Name	Utah Code	Utah Species	CO Code	CO Species	WY
PLJA	Poaceae	Pleuraphis jamesii	Galleta	HIJA	Hilaria jamesii	HIJA	Hilaria jamesii	
PLRI3	Poaceae	Pleuraphis rigida	Big galleta	HIRI	Hilaria rigida			
PLEUR12	Poaceae	Pleuraphis sp.	galleta grass	PLEUR12	Pleuraphis sp.	PLEUR12	Pleuraphis sp.	PLE
PLOD	Asteraceae	Pluchea odorata	Camphor-weed	PLOD	Pluchea odorata			
PLSE	Asteraceae	Pluchea sericea	Arrowweed	PLSE	Pluchea sericea			

Selecting that species in the pick list displays the detailed record for that species, including the master information (code, species, family, etc.) and the available state names and codes.

Master Species Lookup

Master PLANTS Code: PLJA

Master Species: **Pleuraphis jamesii**

Sort List by MASTER: ☐ PLANT Code ☒ Species ☐ Family-Species ☐ Common Name

Master Species (ITIS): Pleuraphis jamesii Master Family: Poaceae

Master Common Name: Galleta Additional Synonyms:

Taxonomic Notes:

	PLANT Code	Species		Family
Utah	HIJA	Hilaria jamesii	(Welsh et al 2003)	Gramineae
Colorado	HIJA	Hilaria jamesii	(Weber & Wittmann 2001)	Poaceae
Wyoming			(Dorn 2001)	

Present in Parks

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

Close Form

5.5.11 Entering Unknown Species

The database allows you to enter unknown species following the procedures in SOP #16. There are two types of unknown species records in the database: *generic unknown species* and *user-defined unknown species*. The generic unknown species are those listed below:

Code	Name
UNKAG	unknown annual graminoid
UNKPG	unknown perennial graminoid
UNKG	unknown graminoid
UNKAF	unknown annual forb
UNKPF	unknown perennial forb
UNKF	unknown forb
UNKS	unknown shrub
UNKT	unknown tree
UNKH	unknown herb (forb or grass)
UNK	unknown species (unknown life form)

Both generic and user-defined unknown species are displayed in all species pick lists. Only use the generic unknown species codes if there is not enough material to identify the species later. Otherwise, you should use user-defined unknown species codes.

User-defined unknown species will appear in the species pick lists with the unknown code and description displayed (sorted by unknown code). You should always try to use an existing unknown if possible. If

you cannot tell from the pick list description whether an unknown meets your needs, click the “Unknown Species” button (at the top of the data entry forms containing species). This will open the Unknown Species List form, which displays unconfirmed unknown species (also sorted by unknown code). There is a filter at the top of this form in case you need to see confirmed unknowns. However, you should normally only choose unconfirmed unknowns when entering species data.

Unknown Species Code	Plant Description	Confirmed As
unkCARE3-st1	Description of shrub here.	
unkCARE3-st2	Description of tree here.	

Click the “Details” button to see the complete record for an unknown species. If you do not find the unknown that you need on the list, click the “Add New” button at the top of the Species List form. This will open an empty Unknown Species Details form so that you can add a new unknown. When adding a new unknown, assign the unknown code using the following convention (per SOP #16): unk + 4 letter park code + plot number + your initials + collection number for the plot (e.g. unkCARE3-ST1). Unknown codes must begin with the “unk” prefix and must be unique. You will get an error if you try to create an unknown code that violates these rules. In the General Description field, enter a few descriptive words that will help you remember it. You may see the same plant on another plot, and you will want to use the same code for the same plant, whichever plot you find it on.

Identification and confirmation of unknown species should be done by field crew leaders or other designated individuals who have the required skills and expertise. To confirm a species once it has been

identified, click the “Unknown Species” button to open the Unknown Species List form. Click the “Details” button next to the species you wish to confirm to open the details form. Fill in “Confirmed To Be”, “Identified by”, and “Identified Date”. When you close the details form, the “Confirmed As” field on the Unknown Species List form will now display the confirmed species code (the Master Plant Code).

6 Reports

Choosing the “Reports” button on the Main Menu form opens the Reports Menu. The reports currently available on the Reports Menu are the Overstory Plot Revisit (Section 6.1), the Plot Revisit Data Sheet (Section 6.2), and the Species Presence by Plot Report (Section 6.3).

6.1 Overstory Plot Revisit

The Overstory Plot Revisit Report lists the overstory tree information (Quad, Tag #, Species, DBH, Crown Class, Crown Health, and Notes) for a selected plot visit. To run this report, choose “Overstory Plot Revisit” from the Reports Menu, select the Park, Plot, and Visit Year, and then click “Preview Report”. This report should be run against the master database, since it needs to retrieve data from previous visits.

6.2 Plot Revisit Data Sheet

The Plot Revisit Data Sheet is a data sheet that is pre-populated with the location information (including directions to the plot) for a given plot. To run this report, the Plot_Establishment.dot template file must be in the same folder as your frontend database file. Choose “Plot Revisit Data Sheet” from the Reports Menu, and the Plot Revisit Data Sheet selection form displays. On this form, select the Park and Plot ID and click “Generate Report”. The Plot Revisit Data Sheet is then created as a Word document, which you can then print, save, etc. using Word. If there are revisit comments from the most recent plot visit, you will see a prompt asking if you want to include these comments in the report. If you want to include revisit comments, you will need to link to the master backend file, since that is where data from previous visits is stored.

6.3 Species Presence by Plot Report

The Species Presence by Plot Report lists all species found on a given plot and the years that they were found. It is sorted by Plot, Master Family, and State Species Name. Choose “Species Presence by Plot” report from the Reports Menu, and the Species Report Select form displays. On this form, select the Park, Year (optional), and Plot ID (optional) and click “Report by Park”. This report can be run against the working database or the master database, but it is recommended that you run it against the master database to get the most complete listing of species.

7 References

- NCPN-NPS 2009. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, 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 manager or other staff designated by the project manager. 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 upland QA/QC database unless stated otherwise. The upland QA/QC database (Upland_QAQC.mdb) is stored in the active project folder, along with current year QA/QC documentation (location given subsequently in this section).

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 manager 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, point, 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 review after data entry (Section 2.1), summary queries and tallies (Sections 3.2, 4.1.2, and 4.2.1), and visual review of spatial data (Section 4.1.2). Note that visual review after data entry (Section 2.1) applies only to data collected via paper field sheets. For data collected via field laptops, visual review during data entry becomes more important.

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, Rebar Location (origin and end fields for each transect), and all Plot Side Slope and Monument Tree fields (where applicable). 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).

3 QA/QC for Quantitative Data

Most quality checks are programmed into the database specs so that incorrect values may not be entered (see Upland_Database_Specs_2009.doc for details, located in Data\Requirements_Docs in the active project folder). Fields may be limited by the appropriate ranges of values or data entry may be required before moving on to the next field. The procedures in this section are additional checks that should be performed after verification is complete. Issues are documented following procedures in Section 1. All files mentioned in this section are stored in the active project folder:

X:\Active_Monitoring_Projects\Upland\Project_Life_Cycle\Data_Quality

QA/QC procedures for quantitative data are presented as follows: Section 3.1 describes quality checks performed for species data, Section 3.2 describes quality checks for data completeness, and Section 3.3 describes quality checks for measurement data.

3.1 Species Data Validation

The first step in species data validation is to resolve unknown species. The usual procedures for resolving unknown species are followed here, except that the unknown codes for species that cannot be confirmed are changed to generic unknown species codes (UNKAG, UNKPG, UNKG, UNKAF, UNKPF, UNKF, UNKS, UNKT, UNKH, UNK). Use the “Update Unknown Species” form (frm_admin_Unknowns) to confirm and replace any unknown species. After confirming and replacing all unknowns, run the macro mac_Check_Unk_Sp. This macro queries each of the tables containing species codes and identifies any remaining user-defined unknown codes (see Table 1). Any remaining user-defined unknown codes should be changed to the appropriate generic unknown code. Run mac_Check_Unk_Sp again (multiple times if needed) until there are no remaining user-defined unknown codes.

One final unknown species check is to make sure there are no orphan unknown species codes (i.e., user-defined unknown codes appearing in the observation tables with no corresponding record in *tbl_Unknown_Species*). Although this condition should not happen, it is an additional safeguard since a major upgrade was made to the unknown species functionality this year. Run the macro mac_Check_Orphan_Unk_Sp to perform this check. This macro queries each of the tables containing species codes and identifies any such orphan unknown species records (see Table 1). Resolve any orphan unknowns found (most likely by replacing with a generic unknown code) and re-run the macro as needed.

Table 1 Unknown Species Data Quality Checks

Condition Checked	Macro/Query Name	Comments/Instructions
User-defined unknown species codes	mac_Check_Unk_Sp	Finds unconfirmed or unreplaced user-defined unknown species codes in observation tables (tbl_LP_Add_Species,

Condition Checked	Macro/Query Name	Comments/Instructions
		tbl_LP_Exotic, tbl_LP_Seedling, tbl_LP_Shruh, tbl_OT_Tree_Saplings, tbl_OT_Census, tbl_LP_Intercept, tbl_SLI_Gaps, tbl_Monument).
Orphan unknown species records	mac_Check_Orphan_Unk_Sp	Finds orphan unknown species in observation tables (same tables as listed above).

After resolving unknown species, the remaining species data validation is done. The master species list in the database is updated with new plant species codes as needed during the data entry process. These new species codes are identified by comparing the master species list to the previous year's master species list. Data validation procedures performed on the master list and on the species observation data in the database are described in Table 2. Additionally, species recorded in the 1-m belt, 5-m belt, and overstory census are checked to make sure they are the correct life form, duration, and nativity (i.e., shrubs for shrub density, trees for all tree counts, and only exotic perennial species in exotic perennial section).

Table 2 Species Data Quality Checks

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
New species codes in master list	tlu_NCPN_Plants: Master_Plant_Code	QC_New_Species	- Compare previous year's species list with current species list to identify new species codes. - Compare each new species code with USDA PLANTS list to determine whether code is valid: - If valid, make sure all appropriate attributes are added to the species list. - If invalid, resolve species code and update database.
Shrubs species in 1-m belt	tbl_LP_Shruh: Shruh Species Code	QC_Shruh_Species	Identifies non-shruh species codes listed for shrub density in the 1-m belt.
Tree seedlings species in 1-m belt	tbl_LP_Seedling: Seedling Species Code	QC_Seedling_Species	Identifies non-tree species codes listed for tree seedling density in the 1-m belt.
Exotic perennial species in 1-m belt	tbl_LP_Exotic: Exotic Species Code	QC_Exotic_Species	Identifies inappropriate species codes listed for exotic perennial density in the 1-m belt.
Tree sapling species in 5-m belt	tbl_OT_Tree_Saplings: Species	QC_Sapling_Species	Identifies non-tree species codes listed for tree sapling density in the 5-m belt.
Overstory tree species	tbl_OT_Census: Species	QC_OT_Species	Identifies non-tree species codes listed in the overstory census.
Monument tree species	tbl_Monument	QC_Monument_Species	Identifies non-tree species codes listed as monument trees.

3.2 Data Completeness

The queries in Table 3 are run to detect missing records (note that queries for checking for specific missing values are described subsequently) or other data issues related to completeness. The final results of each query are documented.

Table 3 Quantitative Data Completeness Checks for Missing Records

Condition Checked	Query Name	Comments/Instructions
Listing of all plots established by Park, Plot, Ecosite, 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, Ecosite, 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.
Plots without side slope records	QC_Plots_without_Side_Slopes	- Plot side slope records are required for newly established forest and woodland plots. - Resolve any plots without side slope records.
Plot visits without canopy gap records	QC_Visits_without_Canopy_Gaps	- Canopy gap records are required for all visits to grassland/shrubland plots. - Resolve any visits without canopy gap records.
Plot visits without basal gap records	QC_Visits_without_Basal_Gaps	- Basal gap records are required for all visits to grassland/shrubland plots. - Resolve any visits without basal gap records.
Plot visits without soil stability records	QC_Visits_without_Soil_Stability	- A soil stability record is required for all visits to grassland/shrubland and woodland plots. - Resolve any visits without soil stability records.
Plot visits without sapling or overstory tree records	QC_Visits_without_Trees	A sapling and overstory tree record is required for all visits

Condition Checked	Query Name	Comments/Instructions
		- to forest and woodland plots. - Resolve any visits without sapling and overstory tree records.
Plot visits without fuels records	QC_Visits_without_Fuels	- A fuels record is required for all visits to forest, woodland, and oak plots. - Resolve any visits without fuels records.
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.
Missing or extra point intercept transects	QC_Count_PI_Transects	Finds visits where the number of point intercept transects $\neq 3$.
Missing or extra sets of points	QC_Count_PI_Points	Finds transects on grassland/shrubland, forest, or woodland plots where the number of points $\neq 100$.
Missing or extra sets of points - oak	QC_Count_PI_Points_Oak	Finds transects on oak plots where the number of points $\neq 80$.
Missing or extra belt transect records	QC_Count_Belt_Transects	Finds visits where the number of belt transects $\neq 3$.
Missing or extra sets of gap entries	QC_Count_Gap_Transects	Finds visits to grassland/shrubland plots where the number of transects with gap entries is $\neq 3$.
Missing or extra sets of shrub line-intercept transects	QC_Count_SL_Transects	Finds visits to oak plots where the number of transects with shrub line-intercept entries is $\neq 3$.
Missing or extra sets of densiometer entries	QC_Count_Densiometer	Finds visits to forest plots where the number of densiometer entries is $\neq 5$.
Missing or extra soil stability records	QC_Count_Soil_Stability	Finds visits to grassland/shrubland and woodland plots where the number of soil stability records $\neq 1$.
Missing belt transect data	QC_Belt_Data_without_Shrubs_Seedlings_Exotics	Finds transects where no shrubs or tree seedlings or exotics were detected

The queries in Table 4 are run to detect missing values in specific fields. The final results of each query are documented.

Table 4 Quantitative Data Completeness Checks for Missing Values

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Missing surface values in point-intercept	tlu_LP_Intercept: Soil Surface	QC_LP_Surface	- Identifies missing surface values (blanks or “NR”) for point-intercept - Correct or fill blanks with “NR” if no data
Missing veg codes for soil stability	tbl_Soil_Stability: T1500_Veg, T1545_Veg, T1630_Veg, T1715_Veg, T1800_Veg, T1845_Veg, T2515_Veg, T2600_Veg, T2645_Veg, T2730_Veg, T2815_Veg, T2900_Veg, T3530_Veg, T3615_Veg, T3700_Veg, T3745_Veg, T3830_Veg, T3915_Veg	QC_Soil_Stability_Veg	- Identifies missing veg codes (blanks or “NG”) for soil stability - Correct or fill blanks with “NG” if no data
Missing ratings for soil stability	tbl_Soil_Stability: T1500_Rating, T1545_Rating, T1630_Rating, T1715_Rating, T1800_Rating, T1845_Rating, T2515_Rating, T2600_Rating, T2645_Rating, T2730_Rating, T2815_Rating, T2900_Rating, T3530_Rating, T3615_Rating, T3700_Rating, T3745_Rating, T3830_Rating, T3915_Rating	QC_Soil_Stability_Rating	Identifies missing rating values (blanks) for soil stability
Missing bearings for fuels	tbl_Fuels: Bearing_A, Bearing_B, Bearing_C, Bearing_D	QC_Fuels_Bearing	Identifies missing bearing values (blanks) for fuels
Missing slopes for fuels	tbl_Fuels: Slope_A, Slope_B, Slope_C, Slope_D	QC_Fuels_Slope	Identifies missing slope values (blanks) for fuels

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Missing intercepts for 1-hr, 10-hr, and 100-hr fuels	tbl_Fuels: 1HR_A, 1HR_B, 1HR_C, 1HR_D, 10HR_A, 10HR_B, 10HR_C, 10HR_D, 100HR_A, 100HR_B, 100HR_C, 100HR_D,	QC_Fuels_Intercepts	Identifies missing intercept values (blanks) for 1-hr, 10-hr, and 100-hr fuels
Missing decay class for 1000-hr fuels	tbl_Fuels_1000: Decay_Class	QC_Fuels_Decay	Identifies missing decay class values (“Not recorded”) for 1000-hr fuels
Missing quad for overstory trees	tbl_OT_Census: Quad	QC_OT_Quad	Identifies missing quad records (blanks) for the overstory census
Missing tag numbers for overstory trees	tbl_OT_Census: Tag_No	QC_OT_Tag	Identifies missing tag records (blanks) for the overstory census
Missing crown health records for overstory trees in forest plots	tbl_OT_Census: Crown_Health	QC_OT_Crown_Health	Identifies missing crown health records (blanks) for the overstory census in forest plots
Missing crown class records for overstory trees in forest plots	tbl_OT_Census: Crown_Class	QC_OT_Crown_Class	Identifies missing crown class records (blanks or “none” where crown health <>5) for the overstory census in forest plots
Missing oak site impact records	tbl_Site_Impact: Percent_Top_Kill , Percent_Dead	QC_Site_Impact_Oak	Identifies missing records of percent top kill and percent dead in oak plots
Missing shrub tallies	tbl_LP_Shrub: HC10, HC25, HC50, HC100, HC2m, HCGT2	QC_Belt_Shrubs_without_Totals	Finds missing tallies where a shrub species is listed.
Missing exotics tallies	tbl_LP_Exotic: Total	QC_Belt_Exotics_without_Totals	Finds missing tallies where an exotic species is listed.
Missing tree seedling tallies	tbl_LP_Seedling: Total	QC_Belt_Seedling_without_Totals	Finds missing tallies where a tree seedling species is listed.
Missing tree sapling tallies	tbl_OT_Tree_Saplings: D25, D51, D101	QC_Belt_Sapling_without_Totals	Finds missing tallies where a tree sapling species is listed.

3.3 Measurement Data Validation

Most measurement validation is incorporated into the database specs, however, additional review of data is necessary to catch errors not restricted by database specs. Plot-level summaries are created for all data by park and ecological site. These summaries should be visually reviewed

each year for unreasonable values. Data summaries should also be compared to the previous year's records to identify values with suspect rates of change (see SOP #19).

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 manager. 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 3.2 have been completed. Table 5 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 5 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	tbl_Location:	QC_Soil_Survey_Area	Query identifies invalid soil

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
values	Soil_Survey_Area	_<PARK>	survey areas for each park. 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.
Missing values	tbl_Location: Hillslope_Position	QC_Hillslope_Position	Identifies missing values (blanks) for hill slope position
Missing values	tbl_Location: Slope_Complexity	QC_Slope_Complexity	Identifies missing values (blanks) for slope complexity
Missing values	tbl_Location: Slope_Shape_Down	QC_Slope_Shape_Down	Identifies missing values (blanks) for downhill slope shape
Missing values	tbl_Location: Slope_Shape_Across	QC_Slope_Shape_Across	Identifies missing values (blanks) for across slope shape
Missing values	tbl_Location: Percent_Slope	QC_Percent_Slope	Identifies missing values (blanks) for percent slope
Missing values	tbl_Location: Soil_Texture	QC_Soil_Texture	Identifies missing values (blanks) for soil texture
Missing values	tbl_Location: Sand_Modifier	QC_Sand_Modifier	Identifies missing values (blanks) for sand modifier
Missing values	tbl_Location: Rock_Fragment_Qty	QC_Rock_Fragment_Qty	Identifies missing values (blanks) for rock fragment quantity
Missing values	tbl_Location: Rock_Fragment_Size	QC_Rock_Fragment_Size	Identifies missing values (blanks) for rock fragment size
Missing values	tbl_Location: Effervescence	QC_Effervescence	Identifies missing values (blanks) for effervescence
Missing values	tbl_Location: Depth	QC_Depth	Identifies missing values (blanks) for soil depth
Missing values	tbl_Location: Grazed_field	QC_Grazed	Identifies missing values (blanks) for grazed
Misspelled words	tbl_Location: Parent_Material, Probable_Component, Soil_Comments, Veg_Comments, Other_Eco_Site, Site_Selection_Comments, Plot_Directions, Dominant_Vegetation	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 6) 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 6 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 6 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 "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	tbl_Location:	QC_Location_GPS_T10,	Run both queries and compare

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
values for GPS transect data: transect 1 – origin (T1O)	T1_Elevation, T1O_UTME, T1O_UTMN	QC_Import_GPS_T1O	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 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	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

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
3 – end (T3E)			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 and correct any problems. Elevation ranges (meters): - ARCH (1200, 1750) - BLCA (1600, 2700) - BRCA (1980, 2800) - CANY (1130, 2200) - CARE (1175, 2740) - CEBR (2400, 3300) - CURE (1400, 2180) - DINO (1400, 2800) - TICA (1650, 2480) - ZION (1080, 2700) - 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 6 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.

4.2 Photo Data

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

4.2.1 Photo Data Verification

Each grassland/shrubland, forest, and oak plot visit should have 6 photos. Each woodland plot visit should have 9 photos. In this step, plot visits not having the required number of photos are identified and resolved. Table 7 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 (e.g., photos assigned to the wrong plot). 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. Note that this verification supplements the usual proofing of photo data that occurs after it has been entered into the database (see Section 2.1).

Table 7 Photo Data Verification Queries

Condition Checked	Query Name	Comments/Instructions
Lists non-woodland plots visited and number of photos	QC_Photos_Per_Visit_Non_Woodland	Resolve any plots not having 6 photos.
Lists woodland plots visited and number of photos	QC_Photos_Per_Visit_Woodland	Resolve any plots not having 9 photos.
Lists all plots visited, Vegetation Type, and 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 Photo Data Validation

After photo verification is completed (Section 4.2.1), additional data quality checks are performed (see Table 8). 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 8 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 (film cameras only). - Location values are between -50 and 60 or Null.
Invalid values	tbl_Photos: Frame	QC_Photo_Frame	- Frame values should be in the range: 1-9 for digital cameras 1-38 for film cameras - 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 9 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 9 Data Quality Checks for Other Textual Data

Condition Checked	Table Name: Field Name(s)	Query Name	Comments/Instructions
Misspelled words	tbl_Events: Comments	QC_Events	Check each of the field names listed and correct any spelling errors.
Misspelled words	tbl_Photos: Comments	QC_Photos	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”. - For all such records, verify that “none” is the appropriate value and then set to “none” if needed. - Correct any spelling errors.
Misspelled words	tbl_OT_Census: Notes	QC_OT_Census	Check each of the field names listed and correct any spelling errors.
Missing values	tbl_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.

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

Standard Operating Procedure (SOP) # 19

Data Analysis and Reporting

Version 1.01 (September 2009)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	9/2009	DWitwicki	Combine dryland and forest instructions, update table formats & variance assessment procedures	Procedures modified since last version	1.01

This 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 versions 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.

Before data analysis and reporting, plot-level measures are derived from the raw 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 acceptable species names (see 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-yr after initial implementation and possibly every year thereafter depending on the number of plots visited each year.

NCPN will report on upland monitoring in: 1) annual reports; 2) annual briefs; and 3) periodic comprehensive reports. These different formats are designed to address different issues and to communicate the results of this protocol to a wide range of audiences.

2.0 Derivation of Plot-level Measures

The detailed observations recorded 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. Formula for deriving plot-scale measures are listed in Table 2.

2.1. Procedures

a) Richness is simply the number of unique species on a plot. Unless the underlying sub-sample size varies (i.e., number of 1-m belts), 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).

b) Percent cover is derived for each species, life form, ground cover attribute, and disturbance. It is derived by summing the number of point-intercepts where each species, life form, ground cover attribute, or disturbance is hit, and dividing by the total number of point-intercept readings across all three transects, times 100. (eq. 1, Table 2).

Table 1. Plot-level measures for grasslands/shrublands, woodlands, forests, and oak scrub.

Measure	Attribute or Context	Spatial scale(s) of observation	Grassland / Shrubland	Woodland	Forest	Oak scrub	Summary Procedures*
Plant species richness	Number of species detected	point intercept for understory, 1-m belt transects for shrubs & tree seedlings, 5-m belt transect for saplings, ¼ plot for trees	x	x	x	x	a
Percent cover	Life form (trees, shrubs, annual and perennial grasses, forbs/herbs)	point-intercept along all three transects (150 m)	x	x	x	x	b
	Individual plant species	point-intercept along all three transects (150 m)	x	x	x	x	b
	Overstory canopy cover	15 point samples across plot			x		c
	Surface features (undifferentiated crust, cyanobacteria, lichen, moss, bare soil, litter, woody debris, small and large rock, bedrock)	point-intercept along all three transects (150 m)	x	x	x	x	b
	Disturbance features (livestock and wildlife scat, ant mound, wildlife excavation, tracks from wildlife, livestock, humans, bicycles, or motor vehicles, other).	point-intercept along all three transects (150 m)	x	x	x	x	b
Density	Individual tree species and total tree density	Quadrant 1 for trees; one 5-m belt for saplings		x	x		d
	Individual tree seedlings, shrubs, and exotic perennials by species; and total tree seedlings, shrubs, and exotic perennials combined by group	1-m belt transects upslope of all 3 transects	x	x	x		d
Mean canopy gap size; distribution of canopy gap sizes	Line-intercept length of canopy gaps; percentage of transects with different gap size classes	Along all three transects (150 m)	x				e
Mean basal gap size; distribution of basal gap sizes	Line-intercept length of gaps between plant bases; percentage of transects with different gap size classes	Along all three transects (150 m)	x				f
Soil stability class (from all samples, protected areas, and unprotected areas)	Slake test stability class (1-6) Protected-area samples are collected under vegetation. Unprotected-area samples lack 'overstory' vegetation.	18 point samples across plot	x	x			g
Fuel loading	woody fuel volumes; duff and litter depth	four ~15-m transects		x	x	x	h

* Letters in this column correspond to sections in 2.1 where summary procedures are detailed

c) Overstory cover is the average of all densiometer readings across a plot expressed as a percent. It is derived by summing the number of canopy intercepts and dividing by the total number of possible canopy intercept readings across all three transects, times 100. (eq. 1, Table 2).

d) Density of shrubs, seedlings, and exotic perennials is the number of each species by size class divided by the total area of the 1-m belt transects, which gives density on a per 1-m² basis. This number can be scaled to any level, such as number per 10 m² or per ha. Sapling density is calculated in the same way using the area of the single 5-m belt. Tree density is simply the number of boles by species (or all trees combined). The basis of this density value would be one quadrant (¼ total plot area). Moreover, density per ha can be acquired by scaling from quadrant area to 1 ha (10,000 m²).

e) Canopy gaps are summarized by mean gap size and distribution of gap sizes. Mean gap size is derived by simply averaging the gap sizes recorded on all three transects (eq. 2, Table 2). For distribution of gap sizes, calculate the percentage of all three transects covered in gaps <25 cm and canopy, 25-50 cm gaps, 51-100 cm gaps, 101-200 cm gaps, and >200 cm gaps.

f) Basal gaps are summarized using the same calculations as canopy gaps (eq. 2, Table 2).

g) There are three calculations for soil stability: 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).

h) Fuel volumes are derived using the formula from Brown (1974). Volumes are calculated separately for each size class: 1-hour, 10-hour, and 100-hour fuels are calculated using Equation 3 (Table 2) while 1000-hour sound and 1000-hour rotten fuels are calculated using Equation 4 (Table 2). The mean diameter of fuels >3 inches (1000-hour fuels) is also calculated.

i) Litter and duff depth provide measures of fine fuels. Mean litter and duff depth are derived by simply averaging litter or duff depths recorded on all three transects (eq. 2, Table 2).

Table 2. Formula for deriving plot-level measures.

Percent Cover

$$PC = ((h / n) * 100) \quad (1)$$

where;

PC = percent cover

h = the number of points where each species, ground cover attribute, life form, or overstory is hit

n = the total number of points per plot

Mean (Canopy or Basal Gap Size, Diameter of 1000-hr Fuels, Litter or Duff Depth)

$$M = \left(\sum_{i=1}^v g_i \right) / v \quad (2)$$

where;

M = mean in cm

g_i = gap size (or depth) in cm for gap (or depth) i

v = the total number of gap (or depth) measures

Fuel Volume

1-hr, 10-hr, and 100-hr:

$$V = (11.64 * n * d^2 * s * c) / N_{\ell} \quad (3)$$

1000-hr:

$$V = (11.64 * \sum d^2 * s * c) / N_{\ell} \quad (4)$$

where;

V = fuel volume in tons per acre

n = the total number of intersections for each size class (1-hr, 10-hr, 100-hr) per plot

d = diameter in inches

s = specific gravity

Fuel class	1-hr	10-hr	100-hr	1000-hr	
				sound	rotten
Specific gravity	0.48	0.48	0.40	0.40	0.30

c = slope correction factor

$$c = \sqrt{1 + \left(\frac{\%slope}{100} \right)^2}$$

N_ℓ = total length of transects sampled in feet for each size class

3.0 Data Quality Assessment

Data entry procedures include species-name validation and domain checks at the sub-sample level (see 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. For example, 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 transects 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, and by field verification if possible. New occurrence of a species should be evaluated by comparison with the 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 are screened on the basis of rate of change.

Key information output from this assessment is illustrated in Table 2. General plot-level information is recorded for reference (Table 2-1). The attributes outside the prescribed

range of change and related information are recorded to aid in resolving suspect measures (Table 2-2).

Table 2. Output from the rate-of-change assessment.

2-1. Plot-level information.

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

2-2. 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 plot 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 3. This information is generated for each plot included in the most recent monitoring event. General plot-level information is recorded for reference (Table 3-1). For newly recorded species, the name, life form, and plot-level cover are output to facilitate further evaluation (Table 3-2). For historical species not recorded in the recent event, information pertaining to the last observation is listed (Table 3-3). 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 cover.

Table 3. Output from species verification procedure.

3-1. Plot-level information.

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

3-2. List of newly recorded species.

Species	Life form	% cover

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

Species	Life form	No. yrs with observations	Yr of last observation	Measures from last observation
				% cover

4.0 Annual Summaries, Reports, & Briefs

The function of the annual summary report is to document accomplishments of the most recent monitoring event (i.e., field season), to provide an overview of the data collected in the event, and provide an update on any key resources of management concern. Data summaries are performed and reported at the ecological site or ecological site type 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

a) Record the number of plots visited for each ecological site and the number of years each plot has been monitored, including the latest monitoring event (Table 4). 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.

Table 4. Upland monitoring sites visited in 2006.

Ecological Site	No. of plots	No. of re-visits
Semidesert Shallow Sandy Loam	5	2
Semidesert Sandy Loam	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 detected or total richness (Table 5) by ecological site.

ii) Summarize percent cover of overstory and live vegetation by life form for each ecological site included in the monitoring event (Table 6).

iii) Summarize percent cover of dominant live plant species for each ecological site included in the monitoring event (Table 7). What constitutes ‘dominant’ may

vary among ecological sites, among years, and among park units. The intent is to summarize information about the plots without listing every species. Document the criteria used to define dominant in the report.

iv) Summarize the density of shrubs by ecological site (Table 8).

v) Summarize the density of seedlings, saplings, and trees for each ecological site (Table 9).

vi) Summarize percent cover of all exotic plant species by ecological site (Table 10). Also report the density of exotic perennial species in this table if detected in the 1-m belt.

vii) Summarize percent cover of all threatened and endangered (T&E) species by ecological site (Table 11) Any reports containing this information should be classified as sensitive and not released to the general public.

viii) Summarize percent cover of surface features, including biological crust attributes, by ecological site (Table 12).

ix) Summarize gap measures by ecological site type, showing mean gap size (Table 13) and distribution of gaps sizes (Figure 1).

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

xi) Summarize fuel volumes, dbh of 1000-hour fuels, and depth of litter and duff by ecological site (Table 15).

Table 5. Mean (range) number of plant species detected per monitoring plot for each ecological site.

Ecological Site	No. of plots	No. of species detected
Desert Sandy Loam	11	9 (6-16)
...	...	...

Table 6. Mean (range) percent cover of overstory and live vegetation by life form for each ecological site.

Ecological site	Overstory	Tree	Shrubs	Perennial grasses	Annual grasses	Forbs/Herbs
Desert Sandy Loam	na	0	6.3 (0–19.3)	6.1 (1.0–17.0)	1.7 (0–5.3)	14.7 (0–28.3)
...	...	...	...	...	...	...

Table 7. Mean (range) percent cover of dominant live species for each ecological site.

Ecological site	Latin name	Common name	Life form	Duration	Nativity	Percent cover
Desert Sandy Loam	<i>Hilaria jamesii</i>	Galleta	Graminoid	Perennial	Native	2.4 (0-7.7)
...	...	...	...	...	...	...

Table 8. Mean (range) density of shrub species per 10-m² area by ecological site.

Ecological site	Latin name	Common name	No. of plots with species present	Density (no. of shrubs/10 m ²)		
				Mean	Minimum	Maximum
Desert Shallow Sandy Loam	<i>Coleogyne ramosissima</i>	Blackbrush	7	2.3	0	3.9
...	...	...	...	...	...	...

Table 9. Mean (range) density of seedlings, saplings, and trees per hectare by ecological site; and mean (range) dbh of trees >15 cm dbh.

[illegible]

Table 10. Mean (range) live exotic plant species detected by ecological site.

Ecological site	Latin name	Common name	Life form	Duration	No. of plots with exotic species detected	Percent cover	Density of individuals detected (no. of exotics/10 m ²)*
Semidesert Sandy Loam	<i>Bromus tectorum</i>	Cheatgrass	Graminoid	Annual	1	0.2 (0–1.3)	na
...	...	...	...	...	...	...	...

*only recorded for perennial species

Table 11. Mean (range) live threatened or endangered plant species detected by ecological site.

Ecological site	Latin name	Common name	Life form	Duration	No. of plots with T & E species detected	Percent cover
Semidesert Alkali Sandy Loam	<i>Sclerocactus wrightiae</i>	Wright's fishhook cactus	Dwarf Shrub	Perennial	1	0.03 (0–0.03)
...	...	...	...	...	...	...

Table 12. Mean (range) percent cover of surface features by ecological site.

[illegible]

Table 13. Mean (range) canopy and basal gap size by ecological site.

Ecological site	Canopy Gap (cm)	Basal gap (cm)
Semidesert Sand	100 (52–197)	161 (86–244)
...	...	...

Table 14. Mean (range) soil-aggregate stability measures by ecological site.

Vegetation type	Ecological site	Total	Protected*	Unprotected*
Grassland	Desert Sandy Loam	4.4 (3.6–5.4)	2.3 (0–5.0)	4.3 (3.4–5.4)
...	...	...	...	...

*Protected are samples collected under vegetation; unprotected are samples collected in the open.

Table 15. Mean (range) fuel volume, dbh of 1000-hour fuels, and depth of litter and duff by ecological site.

[illegible]

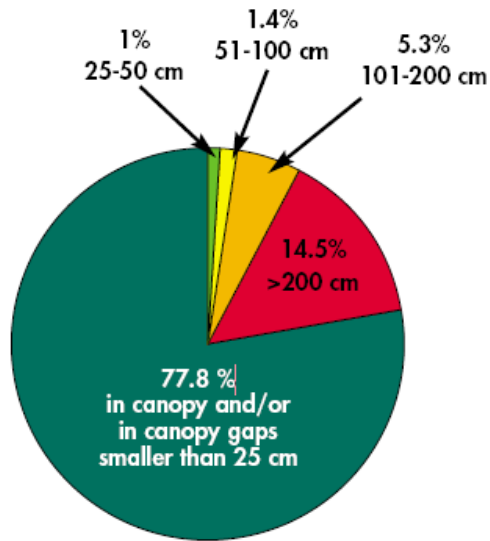


Figure 1. Distribution of canopy gap sizes

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.

4.3 Procedures – Annual Briefs

Each year, information from annual reports and other analyses is further summarized in 1-2 page briefs that provide resource managers with a concise summary of issues of concern. NCPN produces two types of briefs: vital signs briefs and park briefs. The upland vital signs brief summarizes findings from upland monitoring in all NCPN parks. Park briefs are produced for each NCPN park unit and contain a section on upland monitoring. Existing vital signs briefs and park briefs should be consulted for formatting.

5.0 Sampling-Design Variance Assessment & Report

Sampling designs for each ecological site in each NCPN park unit were created to ensure early warning of system degradation and to detect 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 life forms.

The sampling design for each park unit with upland monitoring is documented in a separate report. These reports should be consulted to determine the proposed sampling objective of the current sampling design for each park unit. Upland monitoring at numerous NCPN park units was initiated using three years of pilot monitoring. Variance of this data should be used to evaluate power for trend of potential long-term sampling designs.

For parks without pilot monitoring, it is prudent to examine the realized levels of variance components after at least 5-yr of monitoring to evaluate the efficacy of the extant sampling design. 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 and the number of revisits. However, periodic checking of the assumptions of the sampling design affords timely opportunity to invoke enhancements to meet the original monitoring and sampling objectives. Even well-researched estimates can become obsolete over time due to substantive changes in system conditions, such as those resulting from climatic change.

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 a mixed-effects ANOVA model (Larsen et al. 1995). Use the appropriate SAS code (Table 16) for balanced or unbalanced sampling designs. In the SAS code for generating this estimation (Table 16), 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. This code generates values of variance for site, year, and year*site (residual variance).

b) If there is a trend over time (i.e., the year variable is significant), the data will need to be detrended so that year variance is not inflated. Use one of the mixed models in Table 19 in order to account for time. If time is significant, the year variance should decrease. If time is not significant, then the original model should be sufficient. Alternatively,

using inflated year variance in a power-for-trend assessment will favor a more conservative sampling design.

c) 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 (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 (Table 17).

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 meet the original sampling objectives.

Table 16. SAS code for generating ln-transformed estimates of variance components using a mixed effects model.

16-1. For a balanced sampling design

```
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;
```

16-2. For an unbalanced sampling design

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

Table 17. 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
...	...	...	...	...	...	...	...	...	...	...

5.2 Procedure –Variance and Power-for-trend Report

The initial assessment of variance should be performed after three years of pilot monitoring or in the first detailed assessment of status and trends. Results of this initial assessment should be reported separately for pilot analysis and otherwise reported in a section of the status and trends report. Results will consist of Table 17 and any alternative designs deemed more efficient in terms of the original sampling objective. A trend may be reported as a yearly rate or a rate over a set number of years. This conversion is outlined for increasing (eq. 5, Table 18) and decreasing (eq. 6, Table 18) rates of trend.

Table 18. Formula for converting a yearly rate of trend to a rate of trend over a set number of years.

Conversion for rate of trend

$$I = e^{rt} \quad (5)$$

$$D = 1 - e^{-rt} \quad (6)$$

where;

I = % increase over t years

D = % decrease over t years

r = the yearly rate of increase or decrease

t = the total time period of increase or decrease

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 Table 1. 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 separate reports 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 a fixed effect while site and year are random effects. Site refers to the plot and year is the same as time. Both site and year are treated as categorical variables; time is treated as a continuous variable. 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. Use the appropriate SAS code to evaluate trend (Table 19) for balanced or unbalanced sampling designs. 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. Plot-scale measures with corresponding time, site, and year values are directly used in the mixed-effects model.

Table 19. SAS code for a mixed-effects model to evaluate significance of trend.

19-1. For a balanced sampling design

```
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;
```

19-2. For an unbalanced sampling design

```
INFILE '<pathname\filename>';
  INPUT time site response; year=time; LogResp = log(response+1);
RUN;
PROC mixed method=REML;
  class site year;
  MODEL LogResp = time/cl covb DDFM=KENWARDROGER ;
  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. 7 in Table 20). Variance measures of mean status are derived from the covariance matrix of the regression coefficients (eq. 8 in Table 20), which is output by the SAS model shown in Table 19 (i.e., via the covb option).

Table 20. Formula for deriving status and trend estimates.

Mean Status From a Trend Line

$$ST_t = b_0 + b_1 * t \quad (7)$$

ST_t = estimate of mean status at time = t
b₀ = the estimated intercept parameter
b₁ = the estimated slope parameter
t = the most recent time period of the data (in the same units used to generate b₀ and b₁)

$$\text{SeSTt} = \sqrt{(\sigma_{b0}^2 + 2t \sigma_{b0b1} + \sigma_{b1}^2 t^2)} \quad (8)$$

SeST_t = the standard error of the mean-status estimate at time = t
 σ^2_{b0} = the variance of the intercept parameter
 σ_{b0b1} = the covariance of the regression parameters
 σ^2_{b1} = the variance of the slope parameter
t = the most recent time period of the data

Table 21. Summary of trend and status assessments in park unit x, ecological site y.

[illegible]

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 22 (eq. 9). 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. 12, Table 22). The mean and standard error of status for the total monitored population in a park is included in the report.

Table 22. Formula for the variants of the Horvitz-Thompson Estimator.

Horvitz-Thompson Estimator

$$y_{\pi} = \left(\sum_{i=1}^v y_i / \pi_i \right) / N \quad (9)$$

where;

y_{π} = estimate of the mean

v = the number of plots in the sample

y_i = observed value for plot i

π_i = the inclusion probability that plot i is in the sample

N = total number of unique monitoring plots (all strata combined)

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

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

where;

p_i = the selection probability of plot i

n = number of plots in a sample

The variance of the mean is:

$$\text{var}(y_{\pi}) = \left[\sum_{i=1}^v \left(\frac{1}{\pi_i^2} - \frac{1}{\pi_i} \right) y_i^2 + 2 \sum_{i=1}^v \sum_{j>1}^v \left[\frac{1}{\pi_i \pi_j} - \frac{1}{\pi_{ij}} \right] y_i y_j \right] / N^2 \quad (10)$$

where;

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

where;

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

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

$$y_{\pi} \pm t \sqrt{\text{var}(y_{\pi})} \quad (11)$$

Generalized Horvitz-Thompson Estimator

$$y_g = \sum_{i=1}^v (y_i / \pi_i) / \sum_{i=1}^v (1 / \pi_i) \quad (12)$$

$$\begin{aligned} \text{var}(y_g) = & \left[\sum_{i=1}^v \left((1 - \pi_i) / \pi_i^2 \right) (y_i - y_g)^2 \right. \\ & \left. + 2 \sum_{i=1}^v \sum_{j>1}^v \left[(\pi_{ij} - \pi_i \pi_j) / \pi_i \pi_j \right] \left[((y_i - y_g)(y_j - y_g)) / \pi_{ij} \right] \right] / N^2 \end{aligned} \quad (13)$$

The confidence interval using a t with v-1 degrees of freedom is given in eq. 9, 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 Table 1, 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 percent cover of the species in each time period. 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. 7 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. 14 in Table 23. An average Euclidean distance (eq. 15, Table 23) 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, distribution of canopy and basal gap 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 distribution of canopy or basal gap sizes and further investigation is required to determine which class intervals increased or decreased 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. 16, Table 23). This coefficient is based on presence/absence of species, and it 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. 7 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 23. Formula for deriving measures of Euclidean distance and similarity.

Euclidean Distance

$$Euc_{jk} = \sqrt{\sum (x_{ij} - x_{ik})^2} \quad (14)$$

where;

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

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

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

NOTE: an attribute could be percent cover or distribution of size classes; 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

$$AEuc_{jk} = \sqrt{Euc_{jk}^2 / n} \quad (15)$$

where;

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

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

n = the number of categories in samples

Sorenson's Similarity Coefficient

$$S_s = 2a / (2a + b + c) \quad (16)$$

where;

S_s = Sorensen's similarity coefficient

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

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

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

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 19) 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 such as 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 19). 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 in-depth 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 it may 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 Table 1 which fluctuate between declines and increases, correlations with climate, 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 (Table 21)
- 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 to aid in explaining trends (or lack of trends) in NCPN monitoring results. ‘Other data’ would include results from other NCPN protocols, 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 17) 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 References

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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 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 5.1 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 trendse.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=	<% increase or decrease per year>
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 Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 20

Revising the Protocol Narrative and SOPs

Version 1.04 (December 2010)

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
1.01	3-26-2008	S. Garman, NCPN Ecologist	Updated MVT	To reflect changes based on 2007 field work	1.02
1.02	9-25-2009	H. Thomas, NCPN Data Manager	Updated MVT	To reflect changes based on 2008 field work, new field methods, and updated NCPN protocol versioning procedures.	1.03
1.03	12-15-2010	H. Thomas, NCPN Data Manager	Updated MVT	To reflect changes based on 2010 field work and incorporate peer review comments	1.04

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. The procedures in this SOP are based on the NCPN Protocol Versioning Guidance Document (NCPN-NPS 2009).

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. Record all changes to a protocol document (Protocol Narrative or SOP) in the document's revision history log, even minor edits like fixing typos or formatting changes. It is not necessary to record the specific edits made, rather just the fact that typos were fixed or formatting changes were made. For minor edits, record the same document version number in the revision history log. For actual protocol changes (e.g., changes in methods, equipment), assign a new version number in the revision history log. Depending on the significance of the changes, it may be okay to combine multiple changes in the same entry in the revision history log. 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, and the reason for the changes along with the new version number (if applicable).
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:\Archive\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. An “x” indicates that an SOP has been retired.

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-Survey Design & Plot Selection	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
1/1/2008	1.00	1.20	1.20	1.00	1.00	1.20	1.20	1.30	1.00	1.10	1.10	1.20	1.20	1.00	1.00	1.00	1.00	1.00	1.10	1.00	1.02	-	1.20
1/1/2009	1.01	1.21	1.21	1.00	1.01	1.22	1.21	1.31	1.01	1.11	1.12	1.21	1.21	1.02	1.01	1.01	1.01	1.01	1.11	1.01	1.03	1.00	x
1/1/2010	1.01	1.22	1.30	1.00	1.02	1.23	1.22	1.31	1.02	1.12	1.14	1.22	1.22	1.04	1.02	1.03	1.01	1.01	1.11	1.01	1.04	1.00	x

References

NCPN-NPS 2009. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

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

Standard Operating Procedure (SOP) # 21

Survey Design and Site Selection

Version 1.00 (September 2009)

Revision History Log:

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

This Standard Operating Procedure (SOP) details the procedures for creating survey designs appropriate for each NCPN park unit and selecting monitoring sites.

1.0 Introduction

This SOP provides general instructions for creating robust survey designs that provide defensible long-term monitoring data and answer management questions to the greatest extent possible. This includes guidelines for the rationale behind selecting target upland monitoring areas, procedures used to define the target population for monitoring, and procedures used to select monitoring locations. Specific survey design and site selection procedures used for each park unit are recorded in a separate document.

2.0 Defining the Upland Resources for Monitoring

Since budget limitations do not allow for monitoring all upland resources in a park unit, priority areas and issues for upland monitoring need to be defined by park resource management staff and NCPN ecologists. The project manager should meet with park resource management staff to discuss the following:

- 1) Park resource management issues (e.g., livestock grazing, social trailing, climate change),
- 2) Vegetation, soil, and/or ecological site types of concern,
- 3) Geographic areas of the park unit of particular concern, and
- 4) Questions and concerns about potential future change of these systems.

These issues should be prioritized so that they can be addressing according to available monitoring resources. The yearly monitoring effort at large parks may be as a great as 2

pay periods of field work for 3 monitoring crews while it may be as little as less than a pay period of work for one monitoring crew at some of the smallest parks. These estimates, along with estimates of the variability of the resource being monitored, should be used to estimate the number of monitoring questions that can be addressed at each park.

The project manager should also introduce park staff to the NCPN Integrated Upland response design during the initial meeting and help them understand the benefits and limitations of using this response design. Management issues should be addressed to the greatest extent possible without losing the quality and robustness of the long-term monitoring effort that I&M standards require. The initial meeting should occur well before the initiation of upland monitoring at a park unit (at least 6 months to 1 year for most parks). Follow up meetings or other forms of communication will be necessary to refine proposed survey designs.

3.0 Accessibility

Before looking at possible target areas for monitoring, accessibility of the park unit is delineated, and inaccessible areas are eliminated from the potential sampling frame. Numerous NCPN park units contain private in-holdings, steep slopes ($\geq 50\%$), and areas that are surrounded by steep slopes (e.g., mesa tops) that are deemed inaccessible for NCPN upland monitoring. In addition, areas only accessible by river travel may be eliminated due to costs and complicated logistics of access.

Accessibility is derived using the NCPN LAM system (Landscape Accessibility Model - <http://science.nature.nps.gov/im/units/ncpn/Tools.cfm>). This model uses roads and trails to determine access to park areas, to derive an estimate of hiking distance to every parcel of the landscape. The model also uses slope and aspect to identify areas deemed too steep to traverse and areas such as mesa tops isolated by steep slopes. Rivers and private property may also be masked out of the model. The result of this model is a spatial data layer delineating inaccessible areas and hiking distances to all accessible areas of the park unit.

4.0 Delineating the Target Population

Defining the target population is a multi-step procedure. The initial emphasis is to determine the ecological site types (SRM 1989, 1995) that correspond to the resource of interest. NCPN preferentially uses ecological sites to delineate target upland monitoring areas because they incorporate soil, geologic, and climate characteristics in addition to the potential vegetation. Depending on the affordable sampling effort, a number of ecological sites are then selected for monitoring, and collectively define the sampled, target population. In park units where recent soil surveys and ecological site descriptions

are not available, alternative procedures are used for delineating target monitoring areas. Procedures used to define the sampled, target population are described below.

4.1 Ecological Site Types

Recent Natural Resources Conservation Service (NRCS) soil survey maps and corresponding Ecological Site Descriptions are used to identify the types of ecological sites which potentially support vegetation of interest. For example, in a park where grasslands have the greatest management concern, all ecological sites that support grasslands would be identified. Based on perceived costs and goals of upland monitoring, either the most spatially extensive or all ecological sites supporting grassland communities are selected for further consideration (Table 1).

Soil map units corresponding to the selected ecological site types are evaluated based on the reported percentages of site types within a soil map unit and the spatial extent of soil map units. Based on this evaluation, ecological sites with small spatial extent may be eliminated from the sampling frame (Table 2). After the initial filtering of inaccessible areas and unsuitable soil map units, the remaining area (example shown in Fig. 1) is included in spatial-data and field-based investigations of ecological site types.

Table 1. Ecological sites supporting grassland communities in accessible areas of Needles and ISKY districts of Canyonlands NP.

Ecosite #	Ecosite Name	Estimated ha of ecosite	% of total land area	% of total herbaceous land area
R035XY118UT	Desert Sandy Loam (Four-wing Saltbush)	2618.0	4.3	19.6
...	...	...	...	...
Total land area (ha) = 61048.19530		Total herbaceous land (ha) = 13377.38670		

Table 2. List of soil map units by selected ecological site. Bold, italicized map units were deleted from consideration due to limited amounts of target ecological sites within the map unit or the limited spatial extent of the map unit.

Vegetation community – target ecological site number & name	Soil map units with $\geq 35\%$ of target ecological site	Soil map units with $< 35\%$ of target ecological site
SHRUBS – 133 Desert Shallow Sandy Loam (blackbrush)	1, 56, 57	11, 20, 40 , 51, 58 , 71, 73, 75 , 76, 80, 99
...	...	...

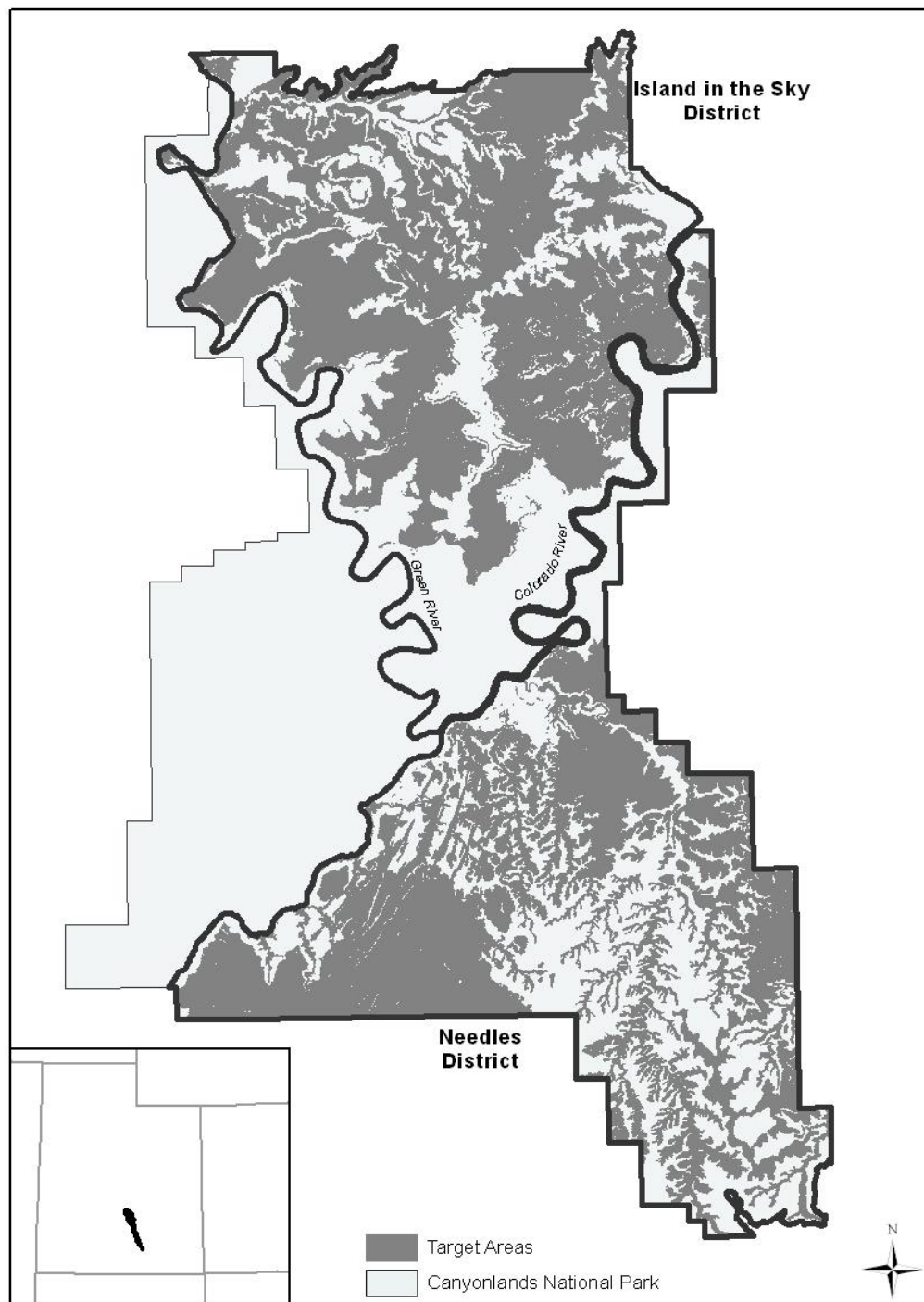


Figure 1. Location of the districts selected for initial Integrated Upland Monitoring in CANY and the resulting portion (target areas) of these districts considered in field investigations of ecological site types.

4.2 Predictive Mapping of Ecological Sites on the Landscape

Soil components which define ecological site types are not explicitly mapped in soil surveys, and depending on the soil survey and the goals of upland monitoring, it may be useful to explicitly map target ecological site types. Similar ecological sites may be mapped together in groupings of ecological site types when they have similar characteristics. Finer mapping of similar ecological sites was found by NCPN to not be a worthwhile exercise, especially when all of the similar ecological sites are deemed as target areas for monitoring.

Advanced methods of predictive mapping may be used to create ecological site maps when you have complete coverage of soil maps and other spatial data layer such as elevation, slope, vegetation, geology, etc. Some possible methods include feature extraction modeling and Classification and Regression Tree (CART) models. Specifics on how to use each method are outlined in Garman et al. (in press) and in the reports documenting upland survey designs for CANY and CARE (located in R:\Archive\Monitoring_Archive\Upland\Reports). Both methods require an extensive field recon effort to determine ecological site types of random points in the potential target sampling frame. The sections below provide an overview of a few possible predictive mapping techniques including alternative methods for dealing with incomplete and old data sets.

4.2.1 Feature Extraction Modeling

Feature extraction modeling can be used for predictive mapping of ecological site types through packages such as Feature Analyst (FA) (VLS 2002). This software program uses information from field recon points and spatial data layers (soil map unit, vegetation map unit, elevation, geology, etc.) to develop rules for where each ecological site occurs on aerial photos. It then uses these rules to characterize the entire area of interest with the output of a predicted map of target ecological sites (Figure 2). After field verification, the program can use new data to “learn” and improve the initial version of the map.

Feature extraction modeling is a good tool for delineating areas that appear distinct on aerial photos. It is not recommended for distinguishing ecological sites with similar species or life form composition. For example, areas dominated by different species of perennial bunchgrasses are not easily distinguished using this method. Feature extraction modeling may also be useful for simply eliminating non-target areas such as rock outcrop from soil map units.

4.2.2 CART

CART uses ecological site and biophysical attributes (soil map unit, vegetation map unit, geology, elevation, percent slope, and slope position) of random locations visited in the field to develop ‘rules’ for classifying the landscape to ecological site. The model with the most heterogeneity in groupings is selected statistically, and decision tree rules are

based on this model. This model is then applied to the landscape to predict areas when each ecological site occurs.

CART models are a good tool when quality spatial data sets are available for the entire area of a park unit.

4.2.3 Other Methods of Determining Target Monitoring Areas

Although feature extraction modeling and CART provide excellent tools to create high-quality ecological site maps, the time and money required to use these methods is high. Other methods may be used to lower costs or to deal with incomplete/poor quality data sets.

For soil surveys that have few ecological site types per soil map unit, you may be able to create an ecological site map based mainly on soil map units. For example, in a park that has sagebrush as a target vegetation type, you can start by creating a map using all soil map units that have a high percentage of sagebrush ecological site predicted (>70%). Soil map units that have 35-70% sagebrush ecological site should also be considered for the map, but you may want visit polygons of these soil map units and eliminate polygons that contain little to no target ecological site area. If a vegetation map of the park unit is available, this may also be used to help identify and eliminate additional non-target ecological site area within the soil map units. Maps should be conservative estimates of ecological site area since it is better to leave in areas and reject specific non-target plots than to eliminate potential target area from the sampling frame.

If recent soil surveys and ecological sites are not available for a park unit, other types of data may be used to delineate target sampling areas. Target sampling areas for survey designs should be delineated using features that are not expected to change over the period of long-term monitoring, such as geology, elevation, and aspect. Target populations should not be delineated using current vegetation maps since vegetation is expected to change over relatively short time periods.

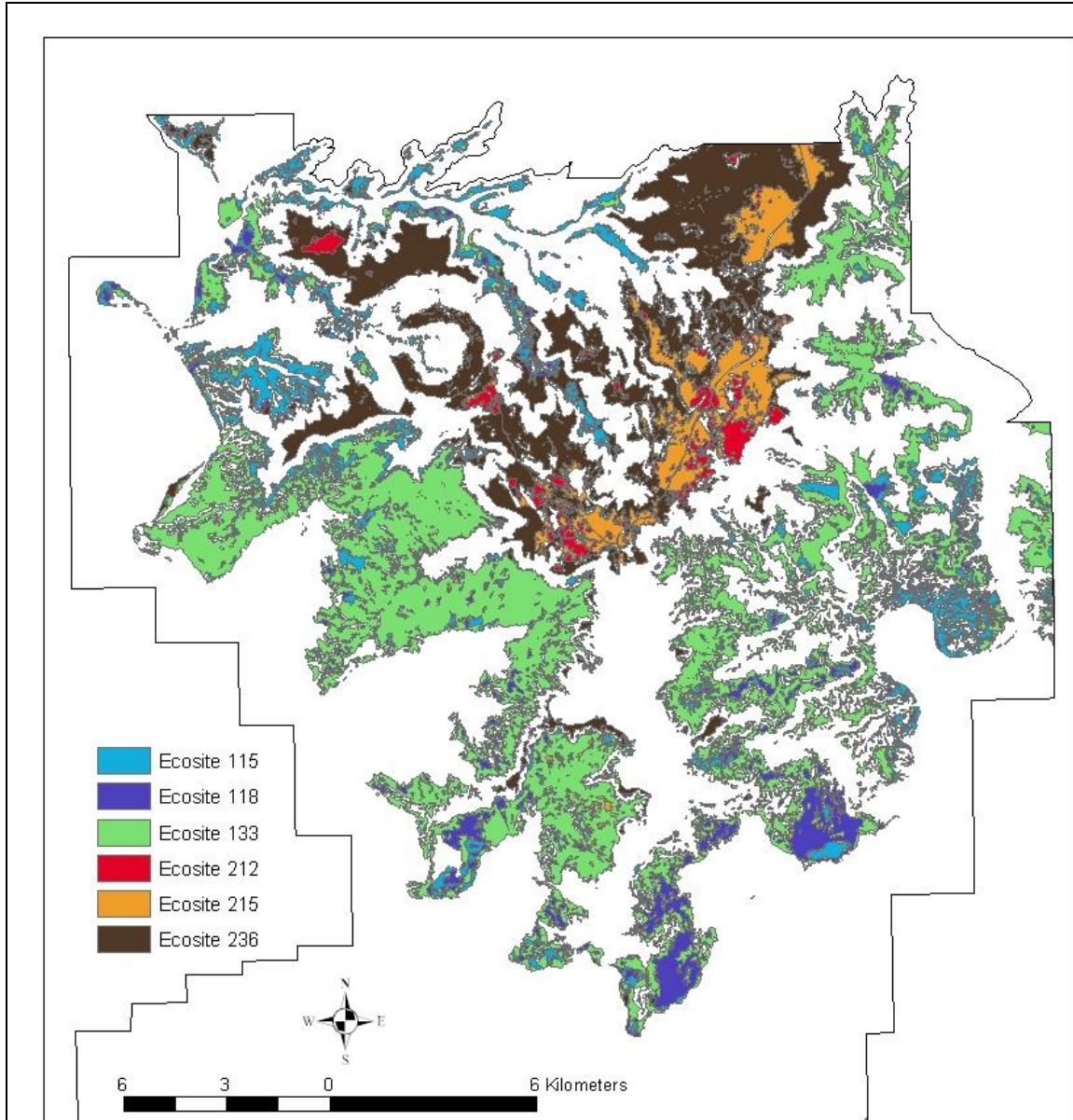


Figure 2. Predicted target ecological sites for the ISKY district of CANY using feature extraction modeling.

4.3 Preparation of the Sampling Frame for Monitoring Site Selection

Obvious non-target areas should be filtered out of the sampling frame. This may include wash bottoms, bodies of water, roads, developed areas in parks, or specific areas that the park would like to exclude from the sampling frame (archeological sites or other areas of special concern).

To avoid selection of sites too close to roads, trails, park boundaries, and site-type boundaries, polygons of predicted site types should also be buffered. The buffer distance depends on the vegetation type to be sampled since different size areas are sampled for different vegetation types (Table 3). Consider using a larger buffer in small parks dissected by numerous roads and trails since it is likely that plots will be selected near these non-target features. Otherwise, you may end up spending a lot of time in the field rejecting plots that are too close to roads, trails, boundary fences, etc.

Table 3. Buffer size by vegetation type.

Vegetation type	Buffer size
Grassland/Shrubland	25-35 m
Forest/Woodland	45-65 m
Oak	10-15 m

5.0 Monitoring Site Selection

After the sampling frame has been finalized, a spatially-balanced random sample of monitoring plots is selected. Sites may be selected over the entire sampling frame and then clipped to areas for stratification or sites may be selected initially by stratum. You will need to think about the overall monitoring goals when deciding which method to use. NCPN uses one of two procedures to select spatially-balanced random sampling plots: Generalized Random Tessellation Stratified (GRTS; Stevens and Olsen 2004) or Reversed Randomized Quadrant Recursive Raster (RRQRR; Theobald et al. 2007). Both methods generate a spatially-balanced random sample based on the requested number of monitoring locations, and sequentially order the selected locations (i.e., points) in an output shape file. Although both methods perform virtually the same task, there are a few advantages and disadvantages to either method. These are listed in the individual sections below.

5.1 Site Selection Methods

5.1.1 GRTS

The R-GRTS version of GRTS operates in the R statistical software environment. The sampling frame is an area shape file that includes all site types. The following section provides basic instructions for running R-GRTS:

- 1) To run R-GTRTS, you need the statistical program R. Download the latest version from <http://cran.r-project.org/>.

- 2) You will also need a couple additional packages to run GRTS. Go to <http://www.epa.gov/NHEERL/arm/analysispages/software.htm> and download sp_0.9-25.zip and spsurvey_2.0.zip. Do not unzip these files.
- 3) Open R and select Packages→Install Package(s). Select a nearby mirror, then select sp and spsurvey, and click OK. This step only needs to be performed once during the initial installation of the R packages.
- 4) Each time you want to run GRTS, you will need to select Packages→Load Package, then select sp and spsurvey. You will also need to go to File→Change Dir... and browse to the location of the sampling frame shape file. If the survey design has multiple ecological sites, make sure that your shape file has unique coding for each ecological site type.
- 5) Create R code for GRTS using the basic design in Table 4 as an example. This script may be edited using any package as long as it is saved as a non-document file (i.e., .R, .txt, etc.). The convention is to use a suffix of .R when saving the file containing the R code, but this is not a requirement. Specific instructions for manipulating the code to your design specifications are provided below:
 - a. Lines beginning with # are simply comment fields, not instructions, so you can include whatever you want.
 - b. Scripts operate on shape files. In this script, replace each place you see “CEBR_frame” with the name of the shape file of your sampling frame.
 - c. Inside the shape file, you need to include codes indicating areas to be considered in the GRTS selection. You can have multiple codes (e.g., different ecological sites or elevation gradients), or a single code. In this example, there is attribute called Gridcode in the CEBR_frame shapefile, and it is set to 1 for areas above the rim and 2 for areas below the rim. In this script, every place you see "Gridcode" you would replace it with the name of the code attribute you used in the shapefile of your sampling frame.
 - d. The following PaneldsgnUN command indicates the selection of 20 points in polygons where Gridcode=1 and 8 points in polygons where Gridcode=2. The number following PanelOne= must be equal to the sum of values specified in caty.n=c(). In this example, we are interested in selecting 20 pts from Gridcode=1 and 8 points from Gridcode=2; thus PanelOne=28 and caty.n=c('1'=20,'2'=8). If we wanted a total of 40 pts, then PanelOne=40, caty.n=c('1'=10,'2'=30) OR caty.n=c('1'=20,'2'=20) OR any other combination as long as the sum of numbers inside caty.n=c() equals 40.

```
PaneldsgnUn <- list(None=list(panel=c(PanelOne=28), seltype='Unequal',  
caty.n=c('1'=20,'2'=8),over=50) )
```

- e. The over=50 part of the PaneldsgnUN command indicates the number of oversample points you would like from GRTS. It will disperse the

oversample points over the entire area of the sampling frame including all stratifications. You can not specify the probability of oversample points. Make sure you have a large enough oversample to account for all possible rejections.

- f. The name of the output shapefile is substituted for “CEBR_sites” in the following section of code:

```
out.shape='CEBR_sites'.
```

- 6) Cut and paste the script into the bottom of the R Console window. As soon as you perform the pasting, the GRTS code is activated. As each line of the GRTS script is executed, it is written to the primary R window. Errors are also written to this window. After you see "Final number of levels: [then a number]", the program is done. You can then look at the resulting point shape file in the directory that you provided to R.

Table 4. Basic script for R-GRTS

```
## Unequal Probability GRTS (and panels) with area shapefile (CEBR upland) ##

# Load sp package
# Load spsurvey package
# Change dir to where shapefiles are located

# Read dbf file
# attribute table from shapefile
att <- read.dbf("CEBR_frame")
#header
head(att)

##### Unequal probability GRTS survey design with panels with oversample

# What is the column that identifies the target population polygons?
levels(att$Gridcode)

# Create design

PaneldsgnUn <- list(None=list(panel=c(PanelOne=28), seltype='Unequal',
                                caty.n=c('1'=20,'2'=8),over=50) )

# run to get random seed
sample(100000000,1)
# or use set.seed for repeatable design
# set.seed(4447864)

Panelsites <- grts (design=PaneldsgnUn,src.frame='shapefile',in.shape='CEBR_frame',
att.frame=att,type.frame='area',mdcaty='Gridcode',DesignID='frpoints',
shapefile=TRUE, prj='CEBR_frame', out.shape='CEBR_sites')

# summarize sites selected
# addmargins( table(Panelsites$mdcaty,Panelsites$panel) )
```

The output from R-GRTS is a shape file which indicates the selected sites and their sequential order. When a site is rejected (due to prediction error, overlap with existing monitoring sites, etc.), the next sequential site is used. The selection probability of sites is provided in the output shape file. However, as sites are rejected the selection probability must be manually re-calculated. Once the final operational survey design is in place this calculation must be performed.

Advantages to using GRTS are that the selection probability of points is calculated for you and that programming language can be used to create complex survey designs with numerous panels. The main disadvantage to using GRTS is that you must initially select an appropriate oversample so that you have enough plots to account for rejection. Adding points after the initial site selection run is not possible in GRTS.

5.1.2 RRQRR

RRQRR operates as a tool within ArcGIS. This tool uses raster files of the sampling frame. The following section provides instruction for running RRQRR:

- 1) Open a new project in ArcMap. Click on Window→ArcToolbox so that the ArcToolbox opens on your screen. Left click on the word ArcToolbox and then right click on AddTool. Go to the directory where RRQRR is stored (usually C:\Temp) and select it. Make sure to use the correct version of RRQRR for the version of ArcGIS installed on the computer. Currently, RRQRR93 is compatible with ArcGIS9.3.
- 2) Add your shape file containing the sampling frame to the project and rasterize to a 5-m grid. A 5-m grid is recommended to ensure complete coverage of the landscape. If you plan to select points separately for each stratification, make sure you include this attribute in your shape file before you rasterize it. This will allow you to modify the raster in Spatial Analyst→Reclassify so that you can select points for each stratification separately. Code the target area for each stratification with a unique positive integer, and code all other areas -9999.
- 3) Move the raster(s) to C:\Temp, then add the raster(s) to your project.
- 4) Click on the tool RRQRR 200712221→Reversed Randomized Quadrat-Recursive Raster (RRQRR) Tools→1. Generate RRQRR Sequence Raster. Select your sampling frame raster under Reference Frame Raster. If you have existing monitoring points that you would like to include in the survey design, direct RRQRR to the shape file containing these points. Click OK.
- 5) The output is a folder in C:\Temp named RRQRR with the year, date, and time attached. Within this folder is a file named rrqrr_ras. Add this to your project.
- 6) Within the RRQRR tool, click on 2. Filter RRQRR Sequence Raster. Select your sampling frame raster under Inclusion Probability Raster. Select rrqrr_ras under RRQRR Sequence Raster. Click OK.

- 7) The output is a folder in C:\Temp named RRQRR_filter with the year, date, and time attached. Within this folder is a file named rrqrr_filter. Add this to your project.
- 8) Within the tool, click on 3. Generate RRQRR Sample Points. Select your sampling frame raster under Inclusion Probability Raster. Select rrqrr_filter under RRQRR Filtered Sequence Raster. Request the number of sample points that you would like from RRQRR. Click OK.
- 9) The output is a folder in C:\Temp named RRQRR_smp with the year, date, and time attached. Within this folder are two files of interest: sample_pts.shp is an ordered list containing the number of sample points you requested, and smpts.shp contains an ordered list of all possible points. Smpts.shp contains your oversample and should be used to continue working down the ordered list of points if you run out of points from sample_pts.

In RRQRR, points should be established following the “order_” attribute. Assign ascending PlotID numbers in this order. When a site is rejected (due to prediction error, overlap with existing monitoring sites, etc.), the next sequential site is used. The selection probability of sites must be calculated manually. Once the final operational survey design is in place, this calculation must be performed. Also, the number of monitoring locations by ecological site must be tracked during plot establishment to ensure a balanced number of locations per ecological site type. In field implementation of monitoring plots, selected sites are rejected if located too close to an established plot.

Advantages to using RRQRR are that it gives you an ordered file of all possible monitoring plots. Therefore, you have an unlimited number of possible monitoring plots in your sampling frame should there be a high number of plot rejections. Another advantage is the option to include a few established monitoring plot locations in your sampling design. This feature could be especially useful if you run out of oversample points in a GRTS run and need to add points to an existing design. The main disadvantage to RRQRR is that it does not calculate selection probabilities, therefore, you must complete these calculations manually.

6.0 Tracking Monitoring Sites

Sequential lists of locations for each of ecological site type (or other stratification) are stored in a shape file. The list indicates acceptance or rejections of plots, reasons for rejection, the date of plot establishment, and other important information related to the survey design (Table 5). The list provides a way to track pre-monitoring evaluation of sites and plot establishment, and for the eventual derivation of selection probabilities.

Table 5. Attributes of upland monitoring plot shape file for each park.

Field	Description
order_	Sequential ordering of plots provided by RRQRR
PlotID	The plot ID number- created manually based on the SiteID in R-GRTS or using the order provided by RRQRR
Ecotype/ecosite	The ecological site type predicted by the map
musym/soilmapu	The NRCS soil map unit number of the plot
grazing	Indicates whether the plot is grazed or ungrazed in designs where this stratification is used
Estab_Date	Month and year when the plot was established
EvalStatus	estab = established; recon = not visited; accept = visited and deemed to be acceptable as a monitoring site; reject = rejected
EvalReason	Describes why a site was rejected and other comments
panel	Panel number assigned to plot once full monitoring design is implemented
X	UTM E (NAD83) of the selected location
Y	UTM N (NAD83) of the selected location
km	Hiking distance to the plot in km
Section	In large parks, this indicates the area of the park where the plot is located.

7.0 Modifications After Pilot Implementation

During the pilot implementation of monitoring, the accuracy of the predictive map should be assessed by visiting as many sites as possible. This effort also doubles as site clearing ahead of the monitoring crew. If a map is found to be overstratified (such as what happened when trying to delineate all of the grassland ecological sites in CANY), then it may be beneficial to combine the sampling frame for all of the similar ecological sites and accept any grassland ecological site that falls within this sampling frame. Other minor modifications to the sampling frame may prove beneficial based on individual circumstances of the sampling design for each park unit.

After 3 years of pilot monitoring, a variance assessment and power analysis is performed on the initial data (SOP #19). These results are used to create a long-term operational sampling design and revisit schedule. After each additional 5 years of monitoring, survey designs are evaluated to make sure they continue to meet the goals of long-term monitoring, and necessary adjustments are made at this time.

8.0 References

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