



Integrated Upland Protocol of the Mojave Desert Network

Volume 2, Standard Operating Procedures

Natural Resource Report NPS/MOJN/NRR—2015/1010.1



ON THE COVER

Larrea tridentata shrubland community, Death Valley National Park
Photograph by: Jean J. Pan, NPS

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Change History

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This table reflects changes to this document. Version numbers will be incremented by one (e.g., Version 1.3 to Version 2.0) each time there is a significant change in the process and/or changes are made that affect the interpretation of the data. Version numbers will be incremented after the decimal (e.g., Version 1.6 to Version 1.7...1.10....1.21) when there are changes to grammar, spelling, or formatting, or minor modifications in the process that do not affect the interpretation of the data.

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Executive Summary

The mission of the National Park Service is “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Natural Resources Challenge, NPS implemented the “Vital Signs Monitoring Program,” a long-term ecological monitoring program that will provide rigorous, scientifically-based information on the status and trends of park ecosystems. With data from this program, park managers will be better able to evaluate complex and challenging resource issues and make sound decisions that result in long-term protection of park ecosystems. Information on park resource conditions will also be useful for park planning, research, education, and public awareness.

In 2000, 270 NPS units with substantial natural resources were organized into 32 inventory and monitoring (I&M) networks based on ecological similarity and geographic proximity as part of the Natural Resources Challenge. The Mojave Desert Network (MOJN) I&M was one of the networks created and includes seven NPS units in California, Nevada, and Arizona. MOJN is comprised of: Death Valley National Park (DEVA), Great Basin National Park (GRBA), Joshua Tree National Park (JOTR), Lake Mead National Recreation Area (LAKE), Manzanar National Historic Site (MANZ), Mojave National Preserve (MOJA), and Grand Canyon-Parashant National Monument (PARA). Collectively, these units encompass over 3.3 million hectares (8.3 million acres), or 9.7%, of the total land area managed by NPS, making MOJN the largest network in terms of area in the lower 48 states.

One of the monitoring protocols for MOJN I&M is the Integrated Upland protocol, which focuses on upland shrub communities and integrates vegetation, soils, and invasive species status and trend (S&T) monitoring. This document describes the standard operating procedures (SOPs) for the MOJN I&M Integrated Upland protocol; that is, the steps required to collect, manage, and disseminate the data representing the status and trend of upland communities in MOJN parks.

The document is intended to be a “living” document that evolves as new information emerges and methodologies are refined. Changes to the SOPs are carefully documented in a revision history log. We anticipate that most changes to this document will occur during the first few cycles of monitoring, when the logistics of field monitoring (e.g., travel time between sites, time needed for on the ground monitoring) is a primary focus.

References:

National Park Service. 1999. Natural resource challenge: the National Park Service’s action plan for preserving natural resources. U. S. Department of the Interior, National Park Service, Washington D.C. Available at <http://www.nature.nps.gov/challenge/challengedoc/NatRes2.pdf> (accessed 9 September 2011).

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Abbreviations

ACC: Access point
BoD: Board of Directors
BSC: Biological Soil Crust
DEVA: Death Valley National Park
DMP: Data Management Plan
DMQA: Data Management Quality Assurance
EC: Electrical Conductivity
FGDC: Federal Geographic Data Committee
GIS: Global Information Systems
GMP: General Management Plan
GPS: Global Positioning System
GRBA: Great Basin National Park
GRTS: Generalized Random Tessellation Stratified
GSA: Government Services Administration
I&M: Inventory and Monitoring
IAR: Investigator Annual Report
IRMA: Integrated Resource Management Applications
IU: Integrated Upland
JHA: Job Hazard Analysis
JOTR: Joshua Tree National Park
LAKE: Lake Mead National Recreation Area
MANZ: Manzanar National Historic Site
MOJA: Mojave National Preserve
MOJN: Mojave Desert Inventory and Monitoring Network
NAD: North American Datum
NCPN: Northern Colorado Plateau Inventory and Monitoring Network
NPS: National Park Service
NRCS: Natural Resources Conservation Service
NRDT: Natural Resources Database Template
NRR: Natural Resources Report
PARA: Grand Canyon-Parashant National Monument
QA/QC: Quality Assurance/Quality Control
REML: Restricted Maximum Likelihood
S&T: status and trends
SE: Standard error
SLR: single lens reflex
SOP: Standard Operating Procedure
TC: Technical Committee
TRKS: Tracks
UNKS: Unidentifiable Shrub Species

Abbreviations (continued)

USGS: United States Geological Survey

UTM: Universal Transverse Mercator

VBA: Visual Basic for Applications

WPTS: Waypoints

Standard Operating Procedure (SOP) # 1: Preparations and Equipment Setup Prior to the Field Season

Version 1.0

Revision History Log:

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

This SOP outlines each of the activities that need to be undertaken to prepare for the field season, including a list of field equipment and tasks that are performed before each field season.

This SOP was adapted from *SOP 1 – Preparations for the Field Season and Equipment Needed* from the Northern Colorado Plateau I&M Network (NCPN) Integrated Upland protocol.

1. Before the Field Season

The field season preparation tasks outlined below should be initiated during the times indicated.

1.1. 3-6 Months Before Field Sampling

The Protocol Lead or Field Lead will need to:

- ✓ Prepare and post position descriptions for seasonal field hires.
- ✓ Request research permits at each park that will be sampled in the coming season via the online NPS internet site <https://irma.nps.gov/rprs/>. If substantial monitoring design changes have been made, update the parks to facilitate the permit request.
- ✓ Compile a list of sites that will be monitored from the GRTS draw or previous field season. Provide the potential list of sites to parks for comment (e.g., accessibility, compliance, etc.) before the first time they are to be visited.
- ✓ Coordinate with the appropriate park staff to submit compliance requests and to ensure proper procedures are followed, particularly since permanent markers are used.
- ✓ Review the entire protocol to become familiar with any changes made from the past field season. Proposed changes to the sampling design, time, and methodology must be discussed with appropriate I&M staff to allow for time to change affected tasks.
- ✓ Work with the Data Manager to make sure that all field forms and databases have been updated from the previous field season and are in good working order.
- ✓ Review and update IU-related SOPs, training, and safety documentation.
- ✓ Check over equipment list (Table 1.1). Repair or order any equipment that needs to be replaced from the previous field season. Order enough consumable supplies for the field season.

Table 1.1. Equipment needed by each crew for IU monitoring.

Item	Quantity needed	Description	Notes
General Equipment - necessary for all SOPs			
GPS with spare set of batteries	2	Garmin GPSMap 76CSx	Main unit and backup
GPS car charger	1		
Digital SLR camera	1		Repeat photos
Extra battery for digital camera	1		
Camera case	1		To carry & protect camera
Inverter	1	Plugs into vehicle	Charge electronic equipment
Permit	2 per vehicle		One on vehicle dashboard, one with crew
Topo Maps	1 per site		
Field Forms	1 set plus 2 complete back-up sets		Per macroplot; See Table 1.2
SOPs and reference table sheets	1		
Clipboard	2	Lightweight with interior storage	
Field notebook	1 per person	Small with water proof paper	Field notes
Pencils	2-3		
Water-proof pens	2-3	Pens with ink that is waterproof	For use in inclement weather
Field forms on Rite in Rain paper	2 complete sets	Waterproof paper	Per macroplot; See Table 1.2; for use if field forms are lost or in inclement weather
Dense bristled brush	2-3		For use to brush off plant material on clothing and equipment
Tablet Computer	1		Data entry, if using electronic data collection device in field
Laptop Computer	1		Digital files and secondary data backup (not carried to macroplot)
Extra battery for Tablet Computer	2		Make sure batteries are fully charged before leaving
External drive (thumb)	1	Rugged, water resistant	Data backup after each macroplot
Car charger for Tablet Computer	1		
Charger for Laptop Computer	1		
Multi-media card reader	1		Card reader for various data cards used in the field
Power (Car battery charger)	1		Used for multiple day camping trips
Safety Equipment - necessary for all SOPs			
First aid kit	1		Minimum 1 kit per crew
Satellite phone	1		Per 2-3 crew members

Table 1.1. Equipment needed by each crew for IU monitoring (continued).

Item	Quantity needed	Description	Notes
Safety Equipment - necessary for all SOPs (continued)			
Satellite phone charger	1		
SPOT Locator/Geotech	1		Per 2-3 crew members
MOJN I&M Backcountry Safety Plan	1		
MOJN I&M Accident Report Logs	1		
MOJN I&M Medical Information Forms	2	Each person carries their filled out form	
2-way radios	1 per person		Within crew and with dispatch communication
Extra radio batteries	min. 3/unit	Lithium ion batteries	each battery is good for ~1 day
Personal Equipment - necessary for all SOPs, provided by field crew members			
Sunscreen			
Sunhat or baseball hat			
Water bottles			4 liters of water per day per person
Raingear (jacket and pants)			
Personal camping equipment			E.g., sleeping bag, pillow
Site Characterization – SOP 6, necessary for first visit only			
Compass	1 per person	With clinometer and declination setting	Site navigation
Clinometer	1	Analog with % and degrees	Measures slope
Laser range finder	1		Can be used to estimate the edges of the macroplot
Mini-key for community types	1	Plant community descriptions	Used to help identify monitored plant community
Macroplot Establishment and Revisits - SOP 7, necessary for all visits unless noted with an E = establishment or R = re-visit			
Compass	1 per person	With declination setting	Set declination, take transect bearings
Clinometer	1	Analog with % and degrees	Measures slope
Pin flags	min. 10	Narrow steel pins with flag top	Mark locations
50-m transect tapes	2	Plastic reel tapes	Set up transects, soil sampling points
100-m transect tapes	4	Plastic reel tapes	Set-up macroplot
Chaining pins	min. 15	Striped metal pins	Secure tapes
Rebar	E – 7 per macroplot R – 2 per macroplot	3/8" diameter cut into 36" lengths	Permanent markers; rebar for revisits are if previous markers were lost
Aluminum tags	E – 7 per macroplot R – 2 per macroplot	1.5" circular brass tags; Write-on rectangular, aluminum tags for revisit	Brass tags pre-stamped with macroplot reference information
Rebar caps	10	Orange, stamped caps	Used to cap top of rebar

Table 1.1. Equipment needed by each crew for IU monitoring (continued).

Item	Quantity needed	Description	Notes
Macroplot Establishment and Revisits - SOP 7, necessary for all visits unless noted with an E = establishment or R = re-visit (continued)			
Sledgehammer	1	4 lb., metal handle	Drive in rebar
Safety glasses	2		For use when working with rebar or stamping tags
Gloves	2 pair	Leather work gloves	For use when using the sledgehammer
Pre-cut wire (8" length)	E – 10 per macroplot R – 2 per macroplot	18-20 gauge	Used to attach tags to rebar
Macroplot Revisit Form/photos	1	Forms from previous visit (SOP 7 and repeat photos) for each macroplot	Helps with macroplot relocation; provides directions to macroplot, UTM's for rebar markers
Vegetation and Surface Cover Point – Intercept Sampling - SOP 8, necessary for all visits			
Pin flags (extra tall)	5	≥48" length	For point intercept
Shrub and target invasive species list for park	1		To help with plant ID and descriptions of target invasive species
Spray bottle with water	1	Holds ~100 ml of water	To help determine whether areas are bare soil or undifferentiated BSC
Hand lens	2	10x or 20x magnification lens	To help with plant identification
Plant identification keys	1		To help with shrub species ID
Basal and Canopy Gaps Sampling – SOP 9, necessary for all visits			
Meter stick or other stiff stick	2		To mark the beginning or end of the canopy or plant base
Invasive Plant and Disturbance Quadrats - SOP 10, necessary for all plots			
Meter stick	2		Used to delineate quadrats
Invasive species list	1		Descriptions of target invasive species
Soil Measurements - SOP 11, necessary for all visits			
Pin flags	min. 12	Narrow steel pins with flag top	Mark soil sampling points
Pocket Penetrometer	1	Equipment used to measure soil compaction	Used to determine soil compaction
Trowel	2	Plastic or metal hand trowel	Used to dig up soil samples
#10 mesh sieve	1	#10 brass sieve	Used to sieve soils to describe soil texture and for soil tests
Sieve pan bottom	1	Brass bottom for sieve	To collect soil from sieve
Sieve pan cover	1	brass cover for sieve	To prevent soil dust from getting into air
HCl 1M (20 ml)	20 ml	Dilute acid	Used for carbonate/effervescence test
Eye dropper bottle	1		Used to contain and drop HCl into soil for effervescence test
Nitrile gloves	1		Used during chemical tests to protect user

Table 1.1. Equipment needed by each crew for IU monitoring (continued).

Item	Quantity needed	Description	Notes
Soil Measurements - SOP 11, necessary for all visits (continued)			
Deionized or distilled water	3 L		For rinsing probes and making soil paste
Wash/spray bottle	2	250 or 500 ml plastic bottle	For rinsing probes and making soil paste
Kimwipes	1 box	Lint-free tissues	Used to wipe pH and EC probes between tests
Spot depression plate	2	Ceramic plate with depressions	Used for carbonate/effervescence test
pH meter	1		Used to measure soil pH
pH standards (4,7,10)	1 each	In 60 ml plastic bottles	Used to moisten electrode or calibrate pH meter
EC meter	1		Used to measure electrical conductivity
EC standard (1413 μ S)	1	In 60 ml plastic bottles	Used to calibrate EC meter
250 ml beaker	24	Graduated plastic beaker	Used to measure soil pH
Stainless steel spatula	24	9" with one flat end and one spoon end	Used to stir soil samples during pH/EC tests
Munsell soil color chart	1	Soil description charts	Used to describe soil color
Glass or plastic vial	3	3-5 ml	Used to determine soil texture
Zip-lock bags	30 per macroplot	Quart size	Used to carry soil samples
Teflon tape	1		Used to seal dropper bottles
Sharpie markers	2	black, fine point	Used for labeling
Repeat Photographs - SOP 13, necessary for all visits			
Whiteboard	1	5 x 7"	Label/description for photo
Whiteboard marker	2-3	Black markers	Used to write on whiteboard
Whiteboard eraser	1		Erase whiteboard
Lens (18-55 mm and/or wide-angles), lens cap, lens filter	1 each	Camera accessories	Wide angle lens may be used for overview photo
8 GB SD card	2	Memory card	Store photos; label each memory card
Tripod	1	Camera tripod	Used to take photos
Tape measure	1	In meters	Used to measure height of camera
Compass	1	With clinometer and declination setting	Take bearing and angle of camera for revisits
Pin flags	5		Used to mark photopoints
Unknown Shrub Species - SOP 14, necessary for all visits			
Blank sticky labels	25	White address labels	To use as plant tags
1 gallon Zip-lock bags	25		To carry plant specimens
Book/plant press	1		To press specimens and avoid crushing
Sharpie markers	2	black, fine point	Used for labeling

1.2. 0-3 Months Before Field Sampling

The Field Lead will need to:

- ✓ Make sure that field crew members have been hired and background checks initiated.
- ✓ Based on park feedback, work with the Protocol Lead and GIS specialist to develop a field schedule for monitored parks, macroplots within parks, and provide the travel schedule to the appropriate parks.
 - For this protocol, it is anticipated that at least one macroplot will be completed per field day, including travel time.
 - Use the following guidelines to develop a field schedule that meets the objectives for the field season, maintains the integrity of the sampling design, and maintains some flexibility for unforeseen events:
 - *Seasonality* - Sampling visits should be scheduled to optimize phenology for the park vegetation. Park units and monitored macroplots should be visited at approximately the same time and in the same order each revisit to maximize repeatability.
 - *Field crew schedule* – At the start and end of the field season, field crews are scheduled for eight hour days, Monday through Friday, to allow for trainings, field preparation, data management, or office work.
 - When in the field, crews typically work eight consecutive 10-hour days, followed by six days off, especially when working in the backcountry.
- ✓ Prepare Protocol Review Certificate and submit to park superintendent or superintendent designee for signature.
- ✓ Provide parks (e.g., resource staff, chief ranger) with the dates that crews will be working in the park, names of field crew members, vehicle descriptions, and approximate locations of monitoring activity (see *MOJN I&M SOP M4 – Safety* for more details).
- ✓ Arrange for and schedule pre-field work meeting with relevant park staff to provide park orientation and to discuss park regulations and park safety regulations; this meeting is generally scheduled on the first day the field crews arrive at the park.
- ✓ Determine lodging options.
 - Contact parks to determine whether park housing will be available.
 - If camping, reserve camping sites or acquire backcountry camping permits.
 - Determine potential car camp and backcountry camp sites
- ✓ Gather and review existing maps for each park. Work with GIS specialist to update maps. If necessary, request additional maps from the GIS Specialist.
- ✓ Prepare site packets for each field site that may be visited, including potential back-ups.
- ✓ Coordinate with the GIS Specialist to reserve Global Positioning System (GPS) units. Load Universal Transverse Mercator (UTM) coordinates onto GPS units using the standardized naming convention for all plots to be sampled.
- ✓ Coordinate with the Data Manager to reserve back-up portable hard drives and field laptops. Field laptops need to be loaded with the database and other relevant information for macroplots or parks.

- Work with Data Manager to update field data management procedures to reflect any changes in equipment
- ✓ Make sure that research permits have been approved.
- ✓ Review and update plant species lists for each park unit, and update them with any new species detected in the previous field season.
- ✓ Organize updated materials and review relevant information for each macroplot including:
 - Revisit field forms* – provides directions to the macroplot, coordinates of monuments, and any other specific information from the previous visit.
 - Trip reports* - from the previous field season. At the end of each field trip, the Field Lead 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.
 - Macroplot species list* - list of species detected during the previous monitoring visit.
 - Repeat photos and notes on camera placement* – provides information on how to locate the repeat photopoint and photo frame.
- ✓ Work with the Protocol Lead to organize and update crew training materials. Arrange for and schedule necessary trainings for crew.
- ✓ Have the field vehicle thoroughly inspected for back country road-worthiness. Make sure that the field vehicle is fully equipped with all necessary safety equipment and all associated equipment (e.g., spare tire, jack, bungee cords, etc.) is in good working order.
- ✓ Review and update the Job Hazard Analysis (JHA) and emergency/park contact lists.
- ✓ Test that all field communication devices (e.g., radio, SPOT, satellite phone) are working, plans have been paid for the duration of the field season, and units are ready for the field season.
- ✓ Update the safety and communications procedures if needed.
- ✓ Work with the park to determine daily and field tour check-in and check-out procedures for the field season at the park.

1.3. Before Heading Out to the Parks

The Field Lead will:

1. Provide field crew and park contacts the procedures that the field crew will use to check in and check out each day and at the beginning and end of each field tour.
2. Make sure that protocol readiness certificate is signed and submitted to Program Manager.
3. Submit a daily backcountry travel plan to appropriate contacts at each park (e.g., dispatch, park designee) and contact the park to let them know the crew's estimated time of arrival and anticipated field schedule. Crews should review the *MOJN I&M SOP M4 - Safety* for specific procedures.
4. Prepare and provide the following documents for each crew:
 - ✓ copies of the protocol (only SOPs and reference table sheets are needed in the field)
 - ✓ permits (e.g., research, backcountry camping)
 - ✓ emergency contact information and procedures

- ✓ shrub species list for each park
- ✓ target invasive species list and field guides
- ✓ adequate copies of all field forms (Table 1.2)
- ✓ relevant flora, keys, and field herbaria

The field crew will:

1. Obtain all equipment and gear needed for field sampling and make sure that everything is in good working order (Tables 1.1 and 1.2). Each crew member will demonstrate that he/she knows how to use each of the communication devices.
2. Make sure that all batteries and rechargeable equipment are fully charged to start field work.
3. Take all mandatory trainings in field skills, procedures, and safety (see *SOP 2 – Training Observers*).
4. Read and understand the MOJN I&M Integrated Upland Protocol, volumes 1 and 2. If there are any questions after the field training, ask the Protocol Lead to clarify before heading to the field.
5. Read the MOJN I&M safety plan, review the JHA and/or GAR with the Field Lead, and sign a copy of the JHA and/or GAR.
6. Demonstrate an understanding of the check-in and check-out procedures at the park to be visited.
7. Make sure to take the appropriate site packets for the field tour.
8. Make sure that they are prepared, have all of their own gear in order, and are ready to go to the field.

Table 1.2. Sets of field forms needed to sample each IU macroplot.

Field Forms	Number
Site Characterization (initial site visit only; <i>SOP 6</i>)	1
Macroplot Establishment (initial site visit only) or Macroplot Revisit (<i>SOP 7</i>)	1
Point-Intercept (<i>SOP 8</i>)	3
Canopy and Basal Gap (<i>SOP 9</i>)	3
Invasive Species Quadrat (<i>SOP 10</i>)	3
Soil Measurements (<i>SOP 11</i>)	1
Site Assessment for Invasive Plant and Target Tree Species (<i>SOP 12</i>)	1
Repeat Photos (<i>SOP 13</i>)	1
Unknown Shrub Species (<i>SOP 14</i>)	10
Unknown Shrub Log (<i>SOP 14</i>)	1
Photo Log	1

Standard Operating Procedure (SOP) # 2: Training Observers

Version 1.0

Revision History Log:

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

This SOP describes the training that MOJN I&M crews must undertake and demonstrate competency in before undertaking monitoring activities. Adequate training is necessary for consistent and accurate data and to ensure that crews return safely from the field.

Parts of this SOP were adapted from *SOP 2 – Training Observers* from the Northern Colorado Plateau I&M Network (NCPN) Integrated Upland protocol. The Job-Hazard Analysis (JHA) was adapted in part from *Appendix C: Job Hazard Analysis for the Klamath Network Vegetation Monitoring Protocol*.

1. Safety Training

All field crew must provide emergency contact information to MOJN I&M, have thoroughly read and understand *MOJN I&M SOP M4 – Safety*, have reviewed the JHA (SOP 2 Appendix A), and have undergone MOJN I&M required trainings, including the National Park Service Operational Leadership training. All field crew are expected to be certified in First Aid and Wilderness First Aid; crew members who have not been certified will undergo training before beginning field work. Travel within parks will often be on backcountry roads and require the use of a 4WD vehicle. Crew members will participate in a 4WD drive training course or evaluation before driving any MOJN I&M vehicles. Moreover, crews must be familiar with federal government regulations for Government Services Administration (GSA) vehicles and defensive driving. Crew members will also be trained in the proper use of communication devices (e.g., radios, satellite phones, SPOT device) and the check-in/check-out procedures for MOJN I&M, dispatch, and designated contacts at each park. Field crew are expected to follow all MOJN I&M and NPS safety procedures, training, and guidelines; any deviations can potentially jeopardize crew safety and can lead to crew member termination.

A detailed list of recommended personal field and camping equipment will be provided to all field crew before they arrive for training. Before entering the field, the Field Lead will check over each crew member's personal gear to make sure that it is adequate for the harsh backcountry conditions of the MOJN parks.

2. Training Observers

MOJN I&M staff will train field crews in all aspects of the monitoring procedure before data collection, including navigating to field sites, setting up macroplots, plant ID, soil measurements, use of the camera, and data management activities. To promote accuracy and consistency in data collection among field crews and field crew members, the Field Lead will calibrate data collectors periodically so that they have comparable field skills and can record data in a consistent format. Periodically throughout the field season, the Field Lead and/or Protocol Lead will conduct field audits on crew members to check that they are performing measurements similarly to other crew members and resolve any discrepancies that are discovered. The Geographic Information Systems (GIS) Specialist will audit any data taken on the Global Positioning System (GPS) units.

The Program Manager or Protocol Lead will provide a program overview to field crew, introducing the I&M program, monitoring program and goals, roles and responsibilities of staff, and park etiquette. The Protocol Lead will provide an overview of upland monitoring sampling design and objectives. The Field Lead will go over administrative responsibilities and policies, including timesheets, travel, work hours, leave policies, and equipment care.

The Protocol Lead and/or Field Lead are the primary instructors for field training. Training materials, itineraries, and field gear must be gathered before training begins. Materials, including the SOPs and equipment lists, should be provided to the field crew before training so they can become familiar with them prior to the actual training.

2.1. Field Navigation – GPS, Compass and Map Training

The GIS Specialist or Field Lead will be the primary instructor for field navigation. Field crews will receive training on traditional navigation techniques, using a map and compass, and using handheld GPS units. Crews must carry topographic maps as a back-up to GPS failure or error. All crew members must demonstrate proficiency in map reading and using a map and compass for field navigation before beginning field work.

Crew members must thoroughly review and understand *MOJN I&M SOP M3 – GPS* and *SOP 4 – Spatial Data Naming Conventions*, as part of GPS training. As part of the training, how to use the GPS unit will be demonstrated, including uploading field sites and waypoints, downloading data, and how to change the battery. Field crew will use the GPS to navigate to pre-determined locations and will be expected to use the appropriate naming conventions to mark their waypoint or tracks.

Field crew will also learn how to manage geospatial data: recording, backup, conversion to useable formats, creation of associated metadata, and quality assurance/quality control (QA/QC) of data. Geospatial locations will be recorded using the GPS, downloaded as raw data in dot text, and backed up daily to an external drive to prevent catastrophic data loss. Spatial data will be converted to feature class/shapefile formats using DNRGarmin (see *MOJN I&M SOP M3 - GPS* for details). Metadata will also be created for each dataset following the instructions described in *MOJN I&M DM SOP M12 - NPS Metadata Tools and Editor* and *MOJN I&M DM SOP M6 - Biological Data*

Profile. QA/QC will be conducted by field crews, with the help of the GIS Specialist, to ensure that the spatial and metadata is accurate and has the correct datum and coordinate system.

2.2. Field Procedures Training

All field SOPs should be thoroughly reviewed prior to field exercises, so that SOPs can be used as references during training. Field crews will be instructed on how to reduce disturbances in the field and monitoring macroplots, particularly to biological soil crust (BSC).

2.2.1. Plant and Invasive Species Identification

Crews are expected to be able to identify plant species using plant keys. Thus, all field crew will participate in plant identification training. Training will include a basic review of plant terminology, how to distinguish plant life forms, annuals vs. perennials, and how to use a dichotomous key. There will be field and office-based (herbarium specimens) identification of plants likely to be observed during the field season, with an emphasis on shrub and target invasive species. How to make collections of unknown shrub species will also be reviewed (see *SOP 14 – Unknown Shrub Species* for details).

2.2.2. Basic Camera Use

Clear and repeatable photos will be critical to monitoring upland communities. In order to acquire quality photos, crews must be able to competently use a digital SLR camera, tripod, and determine the appropriate camera lens for different photos. Crews will be trained in the basic features of the camera, how to navigate the camera menus, when to use which lenses, how to check photos for clarity, how to set-up and maneuver the tripod, and how to download photos. We will also review how to fill out the *Photo Log* and relevant field forms.

2.2.3. Sampling Procedures

Crews will take part in several days of instruction covering all field-based procedures. All field SOPs should be thoroughly reviewed prior to field exercises so the SOPs can be used as references during training. Unless the field crew is experienced with the IU protocol procedures, field trainings will take place on sites in appropriate communities that are not used for monitoring. For each procedure, field crew members will practice sampling techniques with the Protocol Lead and/or Field Lead observing closely. Field crew members will also practice recording observations on paper field forms and the Field Lead will check the field forms for clarity.

The following SOPs will be part of the field exercises:

- **Site Characterization** (SOP 6) – Crews will be trained on what to look for to reject a site for monitoring and how to document when a site is rejected.
- **Macroplot Establishment and Revisit Set-up** (SOP 7) – Macroplot orientation and transect set up is demonstrated and practiced. Close attention must be paid to taking compass bearings, as this will affect the relative placement of transects and edges of the macroplot. Throughout the field season, crew members should periodically check each other's accuracy using the compass and clinometer.

- **Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling (SOP 8)** – Placement of the “point” along the transect and what is considered an intersection with plants and surface cover will be practiced. Identification of the different canopy layers and how to record the data on the field forms will be reviewed. How to identify different soil surface cover and disturbance will be reviewed.
- **Measuring Basal and Canopy Gaps Using Line-Intercept Sampling (SOP 9)** – Identification and measurement of basal and canopy gaps will be demonstrated and practiced. In particular, the minimum gap size and gaps at the beginning and end of the transect will be reviewed.
- **Assessing Invasive Plant and Disturbance Frequency Using Quadrats (SOP 10)** – Placement of quadrats, what constitutes inside/outside of the quadrat, and interspace or canopy will be demonstrated and practiced. How to identify biological soil crust (BSC) and different soil disturbances will be reviewed.
- **Soil Measurements (SOP 11)** – Field crews will be trained to locate and mark sample points, collect soil samples, use of pH and EC meters, and how to determine each of the soil parameters.
- **Site Assessment for Invasive Plant and Target Tree Species (SOP 12)** – How to conduct the patterned walk and estimate the measured parameters on a macroplot scale will be demonstrated and practiced. Identification of target status and trends invasive plant and target tree species will also be reviewed.
- **Repeat Photographs (SOP 13)** – The objective of each of the required photographs will be reviewed. Crews will practice setting up photopoints and taking quality photographs. For revisit photographs, crews will practice using photographs from the last visit to locate the photopoint and previous camera information to find the same camera frame.

2.3. Data Management Procedures

There will be daily, end of tour, and season closeout of data management activities (see *SOP 3 – Daily Field Activities* and *SOP 15 – End of Field Tour and Season Activities*). The Data Manager, GIS Specialist, Protocol Lead and/or Field Lead will train field crew members in the proper procedure for any data management activities that they will be expected to perform in the field or in the office. The appropriate MOJN I&M staff member will review and check data management activities the first few times that the crew members undertake a new activity.

SOP 2 APPENDIX A: Job-Hazard Analysis

JOB HAZARD ANALYSIS	JOB TITLE OR OPERATION: Field work/Backcountry Travel (see <u>Vehicle Operation and Usage JHA</u> for vehicle related hazards)	PAGE <u>1</u> OF <u>6</u>	DATE: December 2013	<u>X</u> NEW ____ REVISED
ORGANIZATION: NPS	EMPLOYEE / OPERATOR: All LOCATION: MOJN I&M parks	SUPERVISOR: MOJN I&M Program Manager DEPARTMENT: MOJN I&M	ANALYSIS BY: MOJN I&M REVIEWED BY:	
REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Refer to relevant protocols and MOJN I&M Safety Plan			APPROVED BY:	
SEQUENCE OF BASIC JOB STEPS	POTENTIAL HAZARDS UNSAFE ACTS OR CONDITIONS	RECOMMENDED ACTION OR PROCEDURE FOR ALL: REPORT ALL INJURIES AND ACCIDENTS TO SUPERVISOR.		
BACKCOUNTRY TRAVEL Refer to Office Order on Backcountry Travel.	- Falling or tripping due to any off-trail travel, wet areas, holes, fences, poor footing, snow and ice, uneven terrain, steep terrain, loose/rolling rocks and heavy pack. - Terrain & environmental hazards associated with work that occurs in mountainous and high altitude terrain during all seasons. - Falls, broken bones, etc. from loose footing crossing over water (e.g., streams, washes, etc.) - Getting separated/lost	- Understand and practice situational awareness & risk management at all times. - Plan ahead & identify necessary PPE for your trip (i.e. Wear proper footwear; ensure protection from environmental conditions such as precipitation, wind, cold, heat; anticipate a full day and even a night out (e.g., appropriate outerwear, sunscreen); consider you may have to care for someone else; anticipate whether you might need a helmet for the trip, etc.). - Guard against overloading yourself with unnecessary equipment. Recognize that in the backcountry and in mountain environments the speed & the ability to travel quickly & efficiently, at times, may equate to safety. Unnecessarily heavy packs <u>may</u> be hazardous to safe travel in rugged terrain. STRIKE THE BALANCE between adequate preparedness and excess. Work with supervisors & other experienced personnel to develop your own needs and the ability to adequately assess and prepare. - Stay out of areas with swift current, especially after heavy snowfall, rain, or spring melt. - Avoid crossing when water levels are higher than knee height or on logs. Step on streambed proper instead of the tops of boulders that may be slippery. Use a stick or pole to secure footing; place it upstream at a slight angle and use pole to test for depth. - Be alert to changes in terrain & weather and make appropriate adjustments to travel plans. - Stay in shape. Know & monitor your personal fitness level & that of others in your group during the trip. Adjust plans accordingly. Carry adequate water and/or a filter. - Have an approved first aid kit on hand and maintain first aid and CPR certifications in case basic first aid in the field is necessary. - Travel and field work should be conducted in crews of two (minimally), with crew members working within shouting distance of each other. All members must travel together or each group must have a means to communicate. Ideally, each member of the crew will have a radio. - Communications are a life link. Carry a radio & spare battery at all times. Know and consult radio coverage maps. Take a satellite phone or SPOT device for the areas not covered by radio. Make sure to follow MOJN I&M check-in/check-out procedures. - File a written backcountry route plan with Dispatch and supervisor at least 24 hours in advance of the trip. If you deviate from this plan, notify dispatch. At key points during your trip (e.g., destination reached, decision-making points such as summits, junctions, saddles), re-contact dispatch & provide a status. Request status checks when traveling through hazardous areas (e.g., when crossing a known or suspected avalanche path).		

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MOJN I&M IU SOP

COMING INTO CONTACT WITH DANGEROUS AND/OR POISONOUS SNAKES, ANIMALS, INSECTS, AND PLANTS	- bites, stings, disease, dismemberment, death - Piercing of skin by spines or poisons of plants.	- Be aware of the dangerous and/or poisonous plants, insects, and animals and avoid coming into contact with them. Give a wide berth to any animals. - Don't leave out materials that may attract animals (e.g., food) and avoid hiking at night. Attend wildlife training. - Ticks: Use insect repellent and check clothing and skin regularly for ticks. Remove any ticks with tweezers within 24 hours, preferably immediately; do not leave the head imbedded - Snakes, spiders: Do not put your feet or hands where you cannot see (e.g., avoid stepping over logs, when you cannot see the other side). If bitten, remove jewelry, lower bitten extremity below heart, cover wound with sterile band while enroute to medical attention. Seek immediate professional medical attention – call/send someone for aid. - Bears: Work in teams of two to deter bear attacks. If you encounter a bear, do not panic-give it as much room as possible. Try to leave the area by backing away slowly – DO NOT RUN. If the bear follows, stop and hold your ground. Wave your arms, make yourself look big, and talk in a normal voice. - Mountain lions: If you see a mountain lion, do not run; you may stimulate its predatory nature. Shout and wave arms to let it know that you are not prey. FIGHT BACK. - Stings: Avoid and be careful around flowering plants that attract bee/wasp pollinators. Be on the watch for scorpions, hives, and nests. - Rabies: If bitten by a wild or domestic animal that is acting strangely, get medical attention and report to local health authorities or animal control officer. Get a rabies shot. - If you know or suspect you are allergic to anything, carry appropriate allergy kits, prescribed by a doctor, for treating anaphylactic shock. Carry and take diphenhydramine (a.k.a. Benadryl), following the label instructions for allergy control. Inform field crew lead and crew members if you suspect you are allergic; this will allow crew members to provide the appropriate treatment in case of emergency. - Wear long sleeves and gloves to minimize skin irritation from poisonous plants and/or sunburn. - Use tweezers or a comb to remove any spines or material embedded in skin. - Do not ingest unknown plants as they may be poisonous. - If bites or piercings lead to an allergic reaction or if bitten by a poisonous animal, stabilize the wound and get medical help as soon as possible. - If you suspect that you have come in contact with a poisonous plant (e.g., poison oak), then change clothing and store contaminated clothing in a bag to avoid spreading the oil to uncontaminated clothing. If the plant rubbed against the skin, wash off potentially affected areas as soon as possible.
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WORKING IN ADVERSE WEATHER	• Adverse weather conditions (e.g., thunderstorms and heavy rain, snow, or extreme heat) • Getting struck by lightning.	• Check weather conditions, schedule outdoor activities accordingly, and bring appropriate field gear. For example, if heat is predicted, then field work may start early and end before the extreme heat of the day. • For thunderstorms, carry a pack or insulating pad if you are not working near a building or vehicle. • If you see or hear a thunderstorm coming, seek shelter and wait for the storm to pass. You are in danger from lightning if you can hear thunder. • If you are caught in a lightning storm, call dispatch to tell them you will be out of radio contact until the lightning storm passes. Call back in after the storm has passed. • If you can't get inside and if you feel your hair stand on end, lightning is about to strike. • Crouch down on your pack or insulating pad on the balls of your feet and keep your feet close together. • Place your hands on your knees and lower your head. • Make yourself the smallest target possible and minimize contact with the ground. • Members of a party should stay separated by at least ten feet. • Stay away from tall things like trees, towers, fences, telephone lines, or power lines. • Stay away from high mountain passes and high open meadows. If caught in these areas rapidly descend to a heavily forested area, however, stay at least 8 feet away from the trunk of the average height tree. • Stay away from metal things that lightning may strike. If there are substantial metal objects that are part of your field gear, you may want to leave them in a separate pile away from anyone. • Stay away from running water. • If there was a torrential downpour and the roads are flooded, then wait until the flood waters recede before driving on the roads. Do not drive through flooded roads as you may not know how deep the water is and you may get stuck in the flood waters. • If someone is struck by lightning or hurt during the storm, call for help on your radio or on the nearest phone; be prepared to give detailed information of the victim's or victims' status, and when and where the accident happened. • Administer First Aid and CPR if certified or instructed to do so. • Take a Backcountry First Aid and CPR Class.
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BACKCOUNTRY MISC.	• Exposure • Heat Stroke • Water borne illnesses • Encountering illegal activities (e.g., irrigation pipes, marijuana plantation, or grow operations) • Heavy lifting • Carrying heavy loads • Altitude sickness • Radio communication not possible	• Be alert to changes in weather. • Take adequate garments for all possible weather conditions. • Carry an approved first aid kit and flashlight. • Drink adequate amounts of water. Know the signs and symptoms and first aid treatments for heat related illness. • Bring adequate water or filter all water. • Work in pairs of larger groups; do not separate if working in areas that have known illegal activities. • Be aware of signs of illegal activity, e.g., irrigation systems, fertilizer, trash, etc. • Check in with supervisor, dispatch, or park staff when leaving vehicle and returning to vehicle. • If people are present at the activity site, do not confront them. Try to disengage yourself from the situation and leave as soon as possible. Report the activity and location of the activity to rangers when you return to your vehicle or when you are a safe distance away. • Carry forms of communication in backpack (not visible) • Get assistance with heavy items. Use proper form and techniques for lifting. • Use backpacks that are appropriate for the amount of equipment to be carried. For heavy loads, packs will ideally have a waist strap. • Pack backpacks with only necessary equipment. • Appropriately pack the backpack and fit the pack properly to the back of the crew member. Wear footwear appropriate for the load carried. • Know and recognize signs of “acute mountain sickness”: headaches; light-headedness; unable to catch your breath; nausea, vomiting. • Practice prevention of altitude sickness by acclimating to high elevations slowly and staying hydrated. • If symptoms progress (i.e., difficulty breathing, chest pain, confusion, decreased consciousness or loss of balance), descend to lower elevations immediately and seek medical attention. • Read the radio use SOP, take radio training, and make sure you understand how to use the radio and the limitations of the radio. • Know which radio frequencies to use and which to monitor. Have a map of the radio repeaters in the park and know their locations. Have a call list ready and understand the call procedure in an emergency. Each crew will have a call number. • Make sure radio is working before you leave the office or field station; carry at least a set of battery backups. Ideally, each member of the field crew will carry a radio. • Use established check-in/out procedures. If in a dead zone, try to check in using an alternative form of communication or try again at a different location. • Monitor battery use and make sure that you will have enough back-up batteries for the trip. Your safety depends on the ability to communicate. • Carry additional/secondary communication devices, such as satellite phones, emergency satellite beacons, or satellite texting devices. Crew must be properly trained in the secondary devices and devices need to be in good working order.
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Backcountry trail conditions, obstacles (e.g., scree and talus, dead and downed trees), and backpacking	• Getting lost • Blisters • Rolled Ankles • Slips/Falls • Wet/Muddy Trails • Wet/Mossy Surfaces • Wet Surfaces • Trench Foot • Rolling/Falling Logs • Rolling/Falling/Shifting Material • Loose Footing • Broken bones	• Use and be trained in navigation techniques using both maps/compass and GPS units. • Bring safety gear (e.g., radio, satellite device); extra clothes, water, food, etc. • Look at notes from crews that previously accessed the field site. • Be aware of the surroundings and look out for potential obstacles and threats to footing. • Wear appropriate footwear (e.g., approach/trail shoes, synthetic/leather hiking boots) that fits properly and is broken in. • Bring extra socks, particularly under damp/wet conditions; change socks throughout the day if they are damp. • Walk carefully, test and secure footing over unstable materials; don't run. • Find the most secure and stable path to the destination; avoid steep slopes, talus slopes, and work your way around obstacles. Take your time ascending and descending areas. • Take breaks as necessary. Exhaustion can lead to slow reaction times and carelessness. • Maintain spacing between crew members to avoid getting hit by equipment or "snap-back" from branches. • Travel as fast as the slowest person in the group.
Being outdoors and far from facilities for long periods of time	• Hyperthermia (Heat exhaustion; heat stroke) • Hypothermia • Sunburn	• Recognize signs: above normal body temps; headaches, nausea, cramping, fainting, increased heart rate, pale and clammy skin, heavy sweating, etc. • Practice prevention of hyperthermia by staying hydrated (e.g., drink 1 liter of water per hour in the summer), wear a broad brimmed hat, and take rest stops in shade. • Consult First Aid book for treatment but generally get the victim to cooler conditions. NOTE: HEAT STROKE IS A LIFE THREATENING CONDITION. • Recognize the signs of hypothermia: Shivering; Numbness; Drowsiness; Muscle Weakness; Dizziness; Nausea; Unconsciousness; Low, weak pulse; Large pupils. • Prevent hypothermia by staying dry; wearing appropriate clothing, wearing layers and shedding layers as needed (don't overheat as sweat can cause hypothermia). Know the weather forecast and plan accordingly. Stay hydrated, cover head with warm clothing, and stay active. • Be aware of the role that wind-chill can play in hypothermia; under certain conditions, hypothermia can occur without any rain or being wet. • Wear protective clothing and use sunscreen to prevent sunburn.
Carrying and using chemicals	• Chemical spills, chemical contact with skin, membranes, eyes, etc.	• Review the MSDS for all chemicals required for procedures. Be aware of the dangers of each chemical and how best to store the chemical in the office and field. Be familiar with how to clean-up if there is a spill. • Carry the least amount of chemical necessary for the procedure. Use chemical-safe containers (this may vary by the chemical) to transport the chemicals. Make sure that all chemicals are sealed during transport and away from other chemicals or materials that they may interact with if there is a spill. • Use gloves or other protective gear to handle the chemical, when necessary. Wear protective eye wear (glasses or sunglasses will suffice in most cases). • Follow the specified procedure for how to dispose of the chemical or how to deal with chemical waste in the field. • If skin or eye contact is made, flush with water immediately and for 15 minutes, if possible. Do not rub or wash.

Emergency Evacuation Instructions	
Reference the MOJN I&M Safety Plan.	
JHA and Emergency Evacuation Procedures Acknowledgement	
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DIVISION CHIEF'S SIGNATURE	DATE:

JOB HAZARD ANALYSIS	JOB TITLE OR OPERATION: Vehicle Operation and Usage	PAGE <u>1</u> OF <u>3</u>	DATE: December 2013	<u>X</u> NEW ____ REVISED
	EMPLOYEE / OPERATOR: All	SUPERVISOR: MOJN I&M Program Manager	ANALYSIS BY: MOJN I&M	
ORGANIZATION: NPS	LOCATION: MOJN I&M parks	DEPARTMENT: MOJN I&M	REVIEWED BY:	
REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Refer to relevant protocols and MOJN I&M Safety Plan			APPROVED BY:	
SEQUENCE OF BASIC JOB STEPS	POTENTIAL HAZARDS UNSAFE ACTS OR CONDITIONS	RECOMMENDED ACTION OR PROCEDURE FOR ALL: REPORT ALL INJURIES AND ACCIDENTS TO SUPERVISOR.		
Starting vehicle, basic operation	- Lights not functioning, visibility impaired - Reduced/no visibility - Brakes non-functional - Lack of traction; low tire pressure - Spare tire not in vehicle or deflated. - Low fluid levels - Low gas	BEFORE DRIVING (drivers need to check vehicle before trip and REPORT/FIX any vehicles at the end of the trip): - Test headlights, turn signals, brake lights before leaving site - Check windshield wipers, clean windshields - Check placement of side and rear-view mirrors - Test brakes and listen for any abnormal noises when vehicle is in motion - Check tires for adequate tread and test for tire pressure in all four tires - Check status of spare; ensure that jack, properly sized lug wrench, and all necessary tools are present in vehicle; 2 spare off-road tires are needed for travel in PARA - Check fluid levels; bring extra water to fill vehicle radiator in case of engine overheating - Check gas; make sure that you have a full tank before beginning any trip. Carry spare gas in metal gas cans on long trips in the backcountry and when away from gas stations.		
Driving in reverse	- Hitting objects (e.g., vehicles, embankments, wildlife) and people - Bodily injury (e.g., whiplash)	- Check area behind vehicle prior to reversing from the site - Use a person outside the vehicle (other crew member) check for objects and obstructions and to help direct the driver safely out of the site - Avoid parking in areas that have obstructions, in areas with drop-offs, or have uneven terrain		
Transporting gear and heavy equipment (including trailers)	- Gear flying around, hitting driver and passenger in accident - Damage to gear during turns or stops - Trailer is unstable, falls over, detaches from vehicle	- Ensure that gear is adequately stowed; use protective containers when possible - Use rope/cords to secure all gear within the vehicle, trunk, or bed of a pick-up - Reduce speed of vehicles before turns and stops; reduce speed on backcountry roads to avoid excessive shifting of gear - Receive proper training for vehicles and trailers (e.g., 4WD training, proper trailer attachment). Always check vehicle or trailer to ensure that they are securely attached and in good working order before each use		

Passenger/driver safety	• Distracted driving • Driving on narrow, single lane roads with bumpy or “washboard” surfaces • Driving with limited visibility, as in heavy rain, fog, or dust • Fatigue driving • Road obstacles (e.g., animals on the road)	• Follow GSA regulations about acceptable use of GSA vehicles (e.g., no cell phones while driving) • All persons in the vehicle must wear seatbelts while in the vehicle • Stay focused on driving and practice safe and defensive driving habits • Obey traffic laws (e.g., stay within the speed limit) • The driver must not text, talk on cell phones, or do anything else that will distract or take one hand off the wheel. • Use turn signals/indicators • Plan the route to where you are going before starting any trip and be familiar with the route; the passenger will be the navigator • Use headlights, even during day time driving. • Only government employees or designated volunteers may ride in a government vehicle; do not pick up hitch hikers • Be prepared for a breakdown; carry all of the MOJN I&M mandatory vehicle equipment (see checklist) and be prepared for any adverse conditions • Carry an approved first aid kit and flashlight • Maintain a safe speed for the conditions (this may be below the legal limit) • Stay to the right, especially on curves, and be aware for oncoming traffic • If turning around, “face the danger,” in other words, turn towards a steep slope, instead of backing into a steep slope cliff • If necessary, wait for hazard (e.g., storm, fog) to pass • Drive with lights on. In some conditions, low lights may penetrate better than brights • Keep informed of the weather (see radio SOP) • Be aware of signs of fatigue. Pull over and catnap if necessary, eat a snack, or have a partner drive. If in doubt, do not drive • Leave an adequate following distance between vehicles to allow for enough reaction time to avoid sudden obstacles; do not tailgate • If excess wind (tree top swaying, twigs falling) consider postponing trip • Do not drive through flooded areas; the water depth may cause a stalled engine • Avoid wet clay roads as much as possible • Get out and move rocks in the road as necessary. If large amounts of rock fall or trees, report to the park staff. • If you hit rocks, stop and check tire conditions (wear, sidewall, and inflation) for damage; also check the undercarriage of the vehicle (e.g., transfer case) for any damage • If obstacle is an animal, slow down! Be aware of high animal traffic areas and drive appropriately. It is better to “ride out” an impact than suddenly swerve. This is true for animals of all sizes, from squirrels to cattle.
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Using 4 wheel drive	• Not knowing how to engage in 4WD or when to use 4WD lo vs. hi, leading to getting stuck in the field • Unsafe driving procedures due to perceived safety of 4 wheel drive • Using 4WD improperly (e.g., forgetting to disengage 4WD) leading to vehicle failure	• Take 4WD training and safety course to understand proper procedure for when and how to engage and disengage 4WD; engage 4WD when off of paved roads and disengage 4WD on paved roads • Practice 4WD driving in a controlled setting to understand the limitations of the vehicle and 4WD (e.g., reduced turning radius) • Drive slowly and carefully, even with 4WD; stay focused on driving and avoid distractions; 4WD is only as good as the driver • If a road is questionable, get out of the vehicle and scout the road before proceeding. If the road is judged unsafe, then do not proceed; look for alternative routes or do not visit the site • Make sure that the field vehicle is adequately outfitted for backcountry travel. MOJN I&M will have a checklist of mandatory vehicle equipment.
Working/Parking on or near a roadside	• Being hit by a car • Running into objects, parking too far off the road, rolling vehicle • Vehicle getting stuck	• Stay off of the road as much as possible; use pullouts or secondary road for parking, when possible • Be aware of the traffic when getting in and out of vehicle; wait for traffic to pass before getting in/out of vehicle • Walk on the side of the road facing traffic and stay as far from the road as possible • When finding a place to park, find a stable surface and consider what the condition of the spot will be under adverse conditions (e.g., rain, in the dark, etc.); do not park in a ditch or in areas that are likely to become flooded • Park on a flat surface with all 4 wheels on a stable surface • Don't park on a blind corner or a solid striped road area • Set parking break

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DIVISION CHIEF'S SIGNATURE		DATE:

JOB HAZARD ANALYSIS	JOB TITLE OR OPERATION: Boat Usage and Travel to Field Sites	PAGE <u>1</u> OF <u>2</u>	DATE: January 2014	<u> X </u> NEW ____ REVISED
	EMPLOYEE / OPERATOR: All	SUPERVISOR: MOJN I&M Program Manager	ANALYSIS BY: MOJN I&M	
ORGANIZATION: NPS	LOCATION: MOJN I&M parks	DEPARTMENT: MOJN I&M	REVIEWED BY:	
REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: A MOCC certified boat operator will operate the vessel during all trips. Require personal protective equipment: personal flotation device (PFD), non-slip foot wear, clothing for all possible weather conditions, food, water, and camping gear. Crews will carry: park radio, GPS unit, SPOT/GeoPro satellite device, and satellite phone. Also refer to relevant protocols and MOJN I&M Safety Plan			APPROVED BY:	
SEQUENCE OF BASIC JOB STEPS	POTENTIAL HAZARDS UNSAFE ACTS OR CONDITIONS	RECOMMENDED ACTION OR PROCEDURE FOR ALL: REPORT ALL INJURIES AND ACCIDENTS TO SUPERVISOR.		
Loading vessel with field equipment and crew member's personal gear	- Slips, trips and falls - Back injury - Crew members or gear falling into water	- Wear proper footwear to avoid skidding on wet surfaces - Use proper lifting technique. Ask for assistance and use team-lifting when loading large, heavy pieces of equipment - PFDs must be worn at all times when in or around the vessel. Be aware of your footing while boarding the vessel. Remain aware of the location of other crew members to avoid colliding with them. Secure all equipment in the storage hatches of the boat or use tie-downs if the equipment must be stored on the deck of the boat.		
Reverse out of the slip	Collision with other boats, divers, submerged rocks, or other hazards in the water	At least one crew member will be designated as a spotter to assist the driver with backing out of the slip. All crew members will remain aware of their surroundings and communicate hazards to the boat operator.		
Travel in the boat to the site	- Loose objects in the boat becoming projectiles - Crew members falling overboard - Mechanical failure or boat running out of fuel - Capsizing of vessel - Drowning - Hazardous weather	- Secure all objects before starting the boat - All crew members will be seated on the boat. No one will make trips back and forth across the boat while it is underway. - The boat operator will perform a thorough vessel inspection before embarking, including checking fluids and fuel level - The boat operator will perform a thorough vessel inspection before departure. Crew members will contact dispatch prior to leaving the marina with the estimated time of arrival at the intended destination. - Everyone on board the boat will wear a properly fitted PFD at all times - A weather forecast for the day of the trip and a seven day forecast will be checked prior to leaving. If there is a likelihood of hazardous weather, the boat trip will be postponed. If weather conditions start to build during the boat trip, the boat operator will use their judgment to determine if the trip can be continued or if the boat should return to safe harbor.		

Navigate to site and moor boat Camp overnight on the beach	• Distraction of boat operator • Collision with submerged objects	• Navigation to the site will be performed by a designated navigator to avoid distracting the driver from their task. • A spotter will assist the driver in identifying submerged rocks or other hazards.
	• Running out of food/water • Hazardous weather • Lightning • Changes in water level • Encountering potentially hostile visitors	• Crew members will be prepared with enough food and water for three days in the event that a boat operator is unable to pick them up at the designated time. • Necessary gear such as tents and sleeping bags will be packed just in case. Crews will be prepared with clothing for all possible weather conditions. • If stuck outside during lightning, crouch down on your pack or insulating pad on the balls of your feet and keep your feet close together, place your hands on your knees and lower your head. Spread group out at least 10 feet from one another. Stay away from tall and solitary objects such as trees, cliffs, towers, fences, telephone lines, or power lines. • Water level remains fairly constant on a day-to-day basis at Lake Mead, however, it is a good practice to keep all gear above the water line in the event of large waves or a sudden change in water elevation. • Do not engage in conversation with potentially hostile visitors. If you perceive a threat, contact dispatch immediately. Move further down the beach if possible to avoid contact. Stay together in a group. Do not go anywhere alone with the visitor.

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DIVISION CHIEF'S SIGNATURE	DATE:

Standard Operating Procedure (SOP) # 3: Daily Field Activities

Version 1.0

Revision History Log:

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

This SOP outlines the procedure that crews must undertake before heading into the field and upon returning to base each day. Using this list will ensure that crews will have all of the necessary equipment and materials for monitoring activities and that data are downloaded daily. Crews are expected to check in with the MOJN I&M office daily by cell phone or satellite device. Activities associated with moving and setting-up of campsites are not included in this SOP.

1. Before Leaving Base Each Morning

- ✓ Make sure that all equipment on the equipment checklist (see Table 1.1 in *MOJN I&M IU SOP 1 - Preparations and Equipment Setup Prior to the Field Season*) is in good working order and available for use*
- ✓ Check vehicle to make sure that it is in good working order (e.g., tires, fluids)
 - if gas tank is not full, consider whether a fill-up is needed that day and make appropriate plans
 - always fill-up at the last available location before entering a park, particularly when entering the back country
- ✓ Refill or replace any consumables used the previous field day*
- ✓ Pack backpacks with needed field equipment (e.g., clipboard/pens, IU SOPs, park permit, camera, GPS units, soil meters), checking that all equipment is in working order*
- ✓ **Review information in the site packet for the day's planned site**
 - review maps for how to get to the current day's field sites and to understand the terrain around the field site*
 - make sure there are the required sets of blank field forms for each SOP (see Table 1.2); in case of rain, carry an additional required set of field forms printed on rite-in-the-rain paper in each site packet*
 - for site revisits, available macroplot location information and photographs from previous visit are in site packet
- ✓ Unplug any electronic equipment that was charging overnight and check that batteries on the unit and any needed spare batteries are fully charged for the day's field activities

- ✓ Make sure that the Universal Transverse Mercator (UTM) coordinates for the current day's field sites are entered into the Global Positioning System (GPS) unit and available in the site packet
- ✓ Make sure to prepare adequate water and food for the day and that all personal gear is packed
- ✓ Determine if there is enough water and gas available for the next day's work; plan to make stops for water or gas at the end of the day, if necessary

*activities that can be done the evening before

2. Before Leaving the Vehicle for Field Activities

- ✓ Park in a secure location
- ✓ Gather field and personal materials that are needed for the field
- ✓ Tailgate talk to discuss daily activities, any considerations, safety concerns for the day, task assignments, etc.
- ✓ Calibrate GPS
- ✓ Assign vehicle parking location a waypoint
- ✓ Secure vehicle keys in a previously agreed upon location
- ✓ Check that all electronic equipment is accounted for, functioning properly, enough spare batteries are available, and equipment is properly stored for travel to macroplot
- ✓ Check-in with MOJN I&M office using satellite device (follow *MOJN I&M SOP M4 – Safety* and park staff guidance for check-in procedures during the day)

3. After Returning to Vehicle from Field Activities

- ✓ Check-in with MOJN I&M office using satellite device
- ✓ Check that all completed field forms are accounted for and placed in the proper storage container
- ✓ Check that all equipment taken into the field is accounted for and turned off
- ✓ Retrieve vehicle keys from agreed upon location.

4. After Returning to Base

- ✓ Check-in with MOJN I&M office using satellite device
- ✓ Check field equipment, determine if any items have been lost or damaged, and replace with any available spares (crews must keep a list of all lost and damaged equipment)
- ✓ Check vehicle for any damage from the current day's travel
- ✓ Double-check all field forms as part of field QA/QC to make sure that all data are legible and all fields have been completed correctly
- ✓ Organize field forms by SOP numerical order and double-check that all field forms are accounted for
 - o Store field forms in designated location
- ✓ Perform data management activities, including downloading UTM coordinates from the GPS, digital photographs from the camera, and backing up all of the day's digital data

- Backup all photos taken onto field laptop and external thumb drive. Do NOT delete backed up photos from camera
 - Backup GPS data onto field laptop and external thumb drive. Do NOT delete backed up data from GPS units
- ✓ Recharge equipment and batteries that were used during the day
- ✓ Store electronic equipment in a secure, cool, dry, location
- ✓ Do a quick decontamination of plant materials (e.g., tissues, seeds) from field clothing, equipment, and vehicle, particularly after visiting areas where invasive species are common
- ✓ Organize any collected specimens of unknown shrubs
 - Verify the ID of any specimens that are you are unsure of or key out specimen after returning to the office
- ✓ As a crew, review site packet information for the next day's site and how to navigate to the site

Standard Operating Procedure (SOP) # 4: Spatial Data Naming Conventions

Version 1.0

Revision History Log:

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

This SOP describes the naming conventions for spatial data and associated geospatial files for the IU protocol. This SOP pertains to three types of data: 1) field locations saved within the Garmin GPSMAP 76CSX receiver including, waypoints and tracks, 2) raw data files saved as backup versions during field work and downloaded through DNRGarmin (dot text files), and 3) shapefiles such as point files converted from proprietary Garmin waypoints and tracks for use in ESRI Global Information Systems (GIS) applications.

This SOP was adapted in part from *SOP 3 – Using Global Positioning System (GPS) Units* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol. *MOJN I&M SOP M3 – GPS* and *MOJN I&M SOP M1 – Incidental Observations of Incipient Invasive Species* should be reviewed before this SOP.

1. Naming Conventions for Field Data

The following information was considered when generating file names for waypoints and tracks:

1. The Garmin GPSMAP 76CSX has a **14 character limit**, so all names must be less than 14 characters. Succinct names and single alpha characters were used whenever possible to represent groups of features.
2. Since the GPS receiver records the time and date of the waypoint, the date and time was not used in file names.

If there is more than one similar feature taken for a macroplot, sequential numbers must be used in the waypoint or track name.

1.1. Waypoints and Tracks

Waypoints and tracks are Garmin brand proprietary files that will be saved in the Garmin GPSMAP 76CSX during monitoring activities. The file naming conventions to be used for waypoint and tracks data from the IU protocol are described in detail below. Definitions of each element of the naming convention are in Tables 4.1-4.2.

1.1.1. IU Protocol Related Waypoints and Tracks

- a. Macroplot Location – The original macroplot location (to the origin of transect 1) UTM (Universal Transverse Mercator) coordinates will be provided by MOJN I&M on the GPS units. The name of the original macroplot location will be the plotID (below). If the macroplot location needs to be shifted, the new macroplot waypoint will be recorded under the transect permanent marker waypoint for the origin of transect 1.

Name: *PlotID#*

- b. Macroplot Corner Permanent Marker - This waypoint feature records the location of the permanent marker for the macroplot (generally at the corner of the macroplot closest to the origin of Transect 1).

Name: *PlotIDPERM##*

- c. Transect Permanent Marker - There are three 50 meter transects per macroplot. The “ends” (“O”rigin at 0 m and “E”nd at the 50 m) of each transect will be marked with a permanent marker. The location of each permanent marker needs to be saved as a waypoint.

Name: *PlotIDT#O*

Name: *PlotIDT#E*

- d. Soil Erosion Overview Photo - A photopoint will be established to qualitatively monitor soil erosion across the macroplot. Although the location will not be permanently marked, a waypoint is needed to help future crews relocate the photopoint.

Name: *PlotIDPS##*

- e. Vehicle Location - This waypoint marks the location where the vehicle was parked for each field site and can be used to help with navigation back to the vehicle from the field site.

Name *PlotIDCAR##*

- f. Unique Access Points - There is the potential that there will be specific unique access points that crews must use to gain access to a site because bluffs or other features restrict access. If this occurs, then the unique access point should be recorded as a waypoint and an image taken of the access point and recorded on the *Photolog*.

Name *PlotIDACCNNN*

- g. Archaeological Artifacts/Sites - This waypoint marks the location of archaeological artifacts or sites on potential macroplot sites. These cultural resources may cause site rejection or shifting of macroplots. These waypoints will be provided to the cultural resources staff at parks.

Name *PlotIDARCHNNN*

Table 4.1. Elements of the field data naming convention for protocol-related waypoints.

PlotID_FeatureType_##			
Element	Description	Acceptable variables with definitions	
PlotID	Seven character unique name assigned to each macroplot, containing four alpha character park acronym followed by a three digit number	Provided by Data Manager and Protocol Lead	
FeatureType	Element used to describe the feature represented by the waypoint. Dependent on the type of feature being collected	P CAR PERM PS T#O T#E ACC ARCH	Photopoint Vehicle location Permanent marker Photopoint for Soil Transect # Begin (0 m) Transect # End (50 m) Unique access point for macroplot Archaeological artifacts/sites
NNN	Element used to describe the image number from the camera	001 – 999	Image camera number automatically assigned in camera
#	Sequential number for similarly named waypoints. Number of symbols indicates the minimum number of digits required, start with zero before digits if necessary	01-99	Two digits based on the potential of expected occurrences of similarly named waypoints

- h. Routes to or from Macroplot - This is a track feature that records the route *to* (T) or *back* (B) from the macroplot.

Name: *PlotIDRT##*
PlotIDRB##

Table 4.2. Elements of the field data naming convention for protocol-related tracks.

PlotID_FeatureType_#			
Element	Description	Acceptable variables with definitions	
PlotID	Seven character unique name assigned to each macroplot, containing four alpha character park acronym followed by a three digit number	Provided by Data Manager and Protocol Lead	
FeatureType	Element used to describe the feature represented by the track: This will always be a Route	RT RB	Route to macroplot Route back from macroplot
#	Sequential number for similarly named waypoints or tracks. Number of symbols indicates the minimum number of digits required, start with zero before digits if necessary	01 – 99	Two digits based on the potential of expected occurrences of similarly named waypoints

1.1.2. Non-macroplot Related Waypoints

- a. Invasive Species Locations - This waypoint is for incidental occurrences of individual invasive species infestations or an invasive plant population. Lists of targeted species are provided for each park. File naming conventions are provided in Table 4.3.

Name: *AAAAAA##*

- b. Archaeological Artifacts Locations - This waypoint file is for incidental occurrences of archaeological artifacts or sites found along the route to/from macroplot locations. These waypoints will be provided to the cultural resources staff at parks. File naming conventions are provided in Table 4.3.

Name: *ARCH##*

Table 4.3. Elements of field data naming conventions for non-macroplot related waypoints.

FeatureType_##			
Element	Description	Acceptable variables with definitions	
FeatureType	Element used to describe the feature represented by the waypoint; dependent on the type of feature being collected. Write down description of feature in field notes and turn in with GPS data	AAAAAA	Four to six letter USDA Plants database acronym for invasive plant species. Depending on the plant code, some characters may be blank.
		ARCH	Archaeological artifacts/sites
##	Sequential number for similarly named waypoints or tracks. Number of symbols indicates the minimum number of digits required; start with zero before digits if necessary	01 - 99	Two digits based on the potential of expected occurrences of similarly named waypoints

1.2. Downloaded Raw Data

Raw data downloads are required daily for project data, both for sound data management and safe storage, as well as out of necessity because the Garmin GPSMAP 76CSx has data storage limits. Raw data will be downloaded by file type (Waypoints and Tracks) from the GPS unit. The raw data will be downloaded from Garmin GPS units using DNRGarmin software to dot text (.txt) format datasets. Data will need to be downloaded prior to conversion to shapefile format. Unlike the GPS waypoint and track file names, raw data naming conventions will include the date of download to dot text files in the file name (Table 4.4). File naming conventions are provided below and in Table 4.4.

- a. Raw Data for waypoints will be named using the following convention:

Name: *PPPP_WPTS_YYYYMMDD*

- b. Raw Data for tracks will be named using the following convention:

Name: *PPPP_TRKS_YYYYMMDD*

Table 4.4. Elements of the naming convention for protocol-related raw data files downloaded from the Garmin GPS.

PPPP_DataType_Date			
Element	Description	Acceptable variables with definitions	
PPPP	Four character acronym for park	DEVA	Death Valley
		GRBA	Great Basin
		JOTR	Joshua Tree
		LAKE	Lake Mead
		MANZ	Manzanar
		MOJA	Mojave
		PARA	Grand Canyon-Parashant
DataType	Element used to describe the type of data represented by the file; dependent on the type of feature being collected	TRKS	Tracks - linear features
		WPTS	Waypoints - Point features
Date	Element used to represent the date that the data were downloaded; 4 numeric characters for the year followed by 2 numeric characters for the month, and ending with 2 numeric characters representing the day	YYYYMMDD	Year Month Day

2. Shapefiles for Use in GIS Applications

The general types of shapefiles that can be generated from data collected for the IU protocol are macroplot-specific shapefiles and incidental invasive species shapefiles. Having separate shapefiles for different data types will allow for easier data management and greater flexibility for ease of data distribution. Macroplot-specific shapefiles include most points associated with the study macroplot, including photopoints and all points representing routes to or from the macroplot from the car or staging area. Incidental invasives species shapefiles include all point locations of incidental observations of incipient invasive species made outside of the macroplot. The date of download will be used when naming the feature classes. File naming conventions for macroplot-specific shapefiles are provided in Table 4.5 and incidental invasive species shapefiles in Table 4.6.

2.1. Macroplot Specific Shapefiles

- Data points associated with the macroplot are saved as a point shapefile. This shapefile should include the Macroplot Corner Permanent Marker and all Transect Start and End locations.

Name *PlotID_All_YYYYMMDD*

- All photopoint locations for a macroplot, such as the Soil Erosion Photopoint, are saved as a point shapefile.

Name *PlotID_Photos_YYYYMMDD*

- All routes to or from each macroplot are saved as a point shapefile. Each shapefile should contain routes for only one macroplot and the associated track that was recorded on the GPS unit should be saved as a point feature when downloading through DNRGarmin.

Name *PlotID_Routes_YYYYMMDD*

Table 4.5. Elements part of the naming convention for macroplot specific shapefiles.

PlotID_DataType_Date			
Element	Description	Acceptable variables with definitions	
PlotID	Seven character unique name assigned to each macroplot, containing four alpha character park acronym followed by a three digit number	Provided by Data Manager and Protocol Lead	
DataType	Element used to describe the type of data represented by the file; dependent on the type of feature being collected	All Photos Routes	All protocol specific points Photopoints Routes taken into or out of Macroplot
Date	Element used to represent the date that the data were downloaded; 4 numeric characters for the year followed by 2 numeric characters for the month, and ending with 2 numeric characters representing the day	YYYYMMDD	Year Month Day

2.2. Non-macroplot Related Shapefiles

- a. The spatial occurrences of incidental invasive species for each field sampling tour will be saved as a point shapefile. Because the waypoint name will be recorded in the attribute table, the name of this shapefile can be more general.

Name *Park_Invasives_YYYYMMDD*

- b. The spatial occurrences of archaeological artifacts/sites for each field sampling tour will be saved as a point shapefile. Because the waypoint name will be recorded in the attribute table, the name of this shapefile can be more general.

Name *Park_Arch_YYYYMMDD*

Table 4.6. Elements part of the file naming convention for non-macroplot related shapefiles.

Park_Invasives_Date			
Element	Description	Acceptable variables with definitions	
PPPP	Four character acronym for park	DEVA GRBA JOTR LAKE MANZ MOJA PARA	Death Valley Great Basin Joshua Tree Lake Mead Manzanar Mojave Grand Canyon-Parashant
DataType	Element used to describe the type of data represented by the file; dependent on the type of feature being collected	Invasive Arch	Invasive Species recorded as Incidental Observations of Incipient Invasive Species Archaeological artifacts/sites found in park that are not associated with macroplot
Date	Element used to represent the date that the data were downloaded; 4 numeric characters for the year followed by 2 numeric characters for the month, and ending with 2 numeric characters representing the day	YYYYMMDD	Year Month Day

Standard Operating Procedure (SOP) # 5: Crust-Friendly Field Procedures

Version 1.0

Revision History Log:

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

Biological Soil Crust (BSC) is an important component of arid and semi-arid ecosystems, as it plays a critical role in nitrogen fixation and in soil stability. BSC can range from cryptic cyanobacteria to the more distinctive moss/lichen crusts (see *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point Intercept Sampling*). BSC is easily destroyed through trampling, and its' recovery, particularly crust thickness, can be extremely slow

(<http://www.soilcrust.org/crust101.htm>). Thus, reducing BSC destruction is critical. MOJN I&M monitoring efforts must minimize 'crust busting' in order to: 1) limit destruction of this important park resource, and 2) reduce monitoring impacts on the validity of the monitoring data. That is, disturbances from obtaining monitoring data from plots, such as 'crust busting', can affect the dynamics of the macroplot, introducing bias and possibly providing a false representation of 'natural' system dynamics, which is what the described monitoring is intended to document.

This SOP was adapted from *SOP 4 – Crust-friendly procedures* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol (which was adapted from protocols used by USGS researchers working in the Colorado Plateau) and describes general procedures for minimizing BSC and soil disturbance during monitoring. All crew members must learn and follow the procedures below when visiting monitoring sites.

1. Walking To a Monitoring Macroplot

Footprints last a long time in desert systems. Walking the same route from a road or trail to a monitoring macroplot can quickly create the appearance of an 'established', or 'social', trail. Park visitors tend to gravitate to such trails and, over time, the macroplot access route can become heavily trampled. Additionally, such trails increase the chance of unwanted macroplot disturbance by visitors. Crews need to follow the following procedures walking to and from a macroplot:

1. Select a route that maximizes the use of bedrock, washes, and other large rocks that can be used as stepping stones. Tracks in washes should be erased during the next rain storm. Avoid stepping on crust, no matter how developed it is.
2. 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).

2. Walking In a Monitoring Macroplot

Site evaluation, site establishment, and measurement procedures require crew members to restrict their impact to specific areas on a macroplot. Crews need to follow the following procedures when walking in or around a macroplot:

1. Select a pathway that optimizes stepping on rock or in washes.
2. If you must step in areas with crust, leave only one set of footprints by walking in existing footprints.
3. 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.
4. Place packs, equipment, or anything that needs to be set down on bedrock or in a wash *outside* of the monitoring macroplot.
5. If these options do not exist, minimize disturbance as much as possible and use previously disturbed areas *outside* of the monitoring macroplot during revisits.
6. To minimize the number of people trampling inside a macroplot, avoid huddling with other crew members to look at the Global Positioning System (GPS) unit, unknown plant species, etc.
7. Stand outside of the macroplot when taking any breaks. Have the recorder sit by the packs and use a radio to communicate with the observer in plots with well-developed crusts.
8. Minimize unnecessary trips across plots by carrying water bottles and other necessities with you.
9. In areas with well-developed crusts and very shallow soils, use shorter pieces of rebar (no less than 9 inches) to mark transect ends.
If that is not possible, then use rocks (if available) to hold standard lengths of rebar in place.

3. Macroplot Revisits

If soil disturbance from previous visits is still visible and extreme, record the location of the soil disturbance on the macroplot diagram form in *SOP 12 – Site Assessment for Invasive Plant and Target Tree Species*, photograph the disturbance (if possible, without walking onto the macroplot), and immediately report the disturbance to the Protocol Lead.

Do not re-measure the macroplot; the macroplot 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 transects are not considered an extreme disturbance.

Standard Operating Procedure (SOP) # 6: Site Characterization

Version 1.0

Revision History Log:

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

This SOP provides instructions for characterizing potential field sites to determine whether a long-term monitoring macroplot can be established on a site. This SOP is used only during the initial visit to a potential site. Some sites will be eliminated prior to field implementation due to safety or accessibility concerns, cultural resources, or through office reconnaissance of relevant site characteristics (as described in section 2. *Sampling Design* in Volume 1: Protocol Narrative). While every effort will be made to pre-survey sites in the office, some site characteristics cannot be seen without field visitation and some sites cannot be eliminated until site visitation.

This SOP was adapted in part from *SOP 5 – Site Characterization* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol. *SOP 5 - Crust-Friendly Field Procedures* and *MOJN I&M SOP M3 – GPS* should be reviewed before site characterization.

1. Locating Field Sites and Estimating the Macroplot Area

A list of field site locations for each park, with Universal Transverse Mercator (UTM) coordinates loaded onto Global Positioning System (GPS) units, will be provided to field crews. This list will contain the master macroplot numbers for each site. However, the site coordinates have not been included in this protocol because the current lists are tentative and subject to field verification. Sites should be visited in the order provided in order to maintain the integrity of the sampling design.

The primary approach to estimate the macroplot edge is to lay out transect tapes, which will be needed to help with macroplot establishment. However, if the site is steep, a laser range finder may be used to roughly estimate the macroplot edges in order to determine whether the site is suitable for monitoring.

1. Locate the pre-determined UTM coordinates that designate the origin of transect 1 of the macroplot using a GPS unit and topographic map.
Approach from downslope to avoid trampling the sampling area.
2. Place a pin flag on the ground to mark the origin of transect 1.

3. Standing at the pin flag, determine which direction would be downslope for the macroplot. *If there is no obvious slope, the nearest drainage will mark the downslope side of the macroplot.*

Keep in mind that you are standing at the origin of transect 1 and it should be the most upslope transect of the macroplot and run relatively perpendicular to the direction of the slope (see *Figure 7.1 in SOP 7 - Macroplot Establishment and Revisit Set-Up*).

Downslope should be representative of the macroplot as a whole (not just the transect origin) and may require examination of the site from areas closer to what would be the center of the macroplot.

4. Once downslope has been determined, take a compass bearing for the downslope direction. Use this compass bearing to help with estimating the edges of the macroplot (Figure 6.1). To read the compass, crew member A will level the compass and close one eye to read the compass. If necessary, crew member B can serve as a reference point for crew member A by standing 75 m downslope of crew member A.

It is very important to have the compass level and to keep metal objects (i.e., rings, watches, chaining pins, transect tape ends) away from it to get an accurate reading.

5. Crew member A will stand on the downslope side of the pin flag, hold the reel end of a 100 m transect tape, and direct crew member B, who has the free end of the tape and four pin flags and chaining pins (take extra chaining pins to secure the tape on windy days), to go in the downslope direction for 75 m (Figure 6.1). The line should be taut and as close to the ground as possible to avoid curvature in the line. If all shrubs are of similar height, the tape can be strung overtop the shrubs in order to keep the tape straight.
6. When crew member B reaches 75 m, he/she should take a compass bearing back to crew member A to check that the tape was pulled in the correct bearing (bearing is 180° from crew member A's bearing). When the tape is in the correct bearing, crew member B will use a pin flag and chaining pin to secure the transect tape at the 75 m point. As crew member B heads back to crew member A, he/she will *place a pin flag every 25 m* to help with visualization of the tape (chaining pins can be placed as needed).
7. Crew member A will face the pin flag in the upslope direction. Holding the 75 m mark of the transect tape, crew member A will direct crew member B (carrying one pin flag and one chaining pin) to take the free end of the tape 25 m upslope. Crew member B will double-check that the transect tape is in the correct compass bearing and pulled in-line with the rest of the tape from the free end of the transect tape before using a pin flag and chaining pin to secure the tape.
8. Repeat steps 5-7 to establish a line perpendicular (90°) to the first tape (Figure 6.1, black dotted lines).

If crew member A is facing the pin flag for the origin of transect 1 and upslope, then start by having crew member B take the free end of the tape (with a pin flag and chaining pin) and heading 25 m to the *left* of the pin flag. By pulling the tape in this order, the transect origin

will have a smaller number than the transect end (this will help with macroplot establishment later on).

9. The crew will set up two additional transect tapes at the 75 m points on the established tapes, following steps 5-8 (Figure 6.1, gray dotted lines). Thus, there will be two pin flags marking the edge of each macroplot.

To reduce trampling, examine the areas traversed when estimating the edges of the macroplot for criteria (see section 2.1 *Criteria*) that would cause the macroplot to be rejected or shifted.

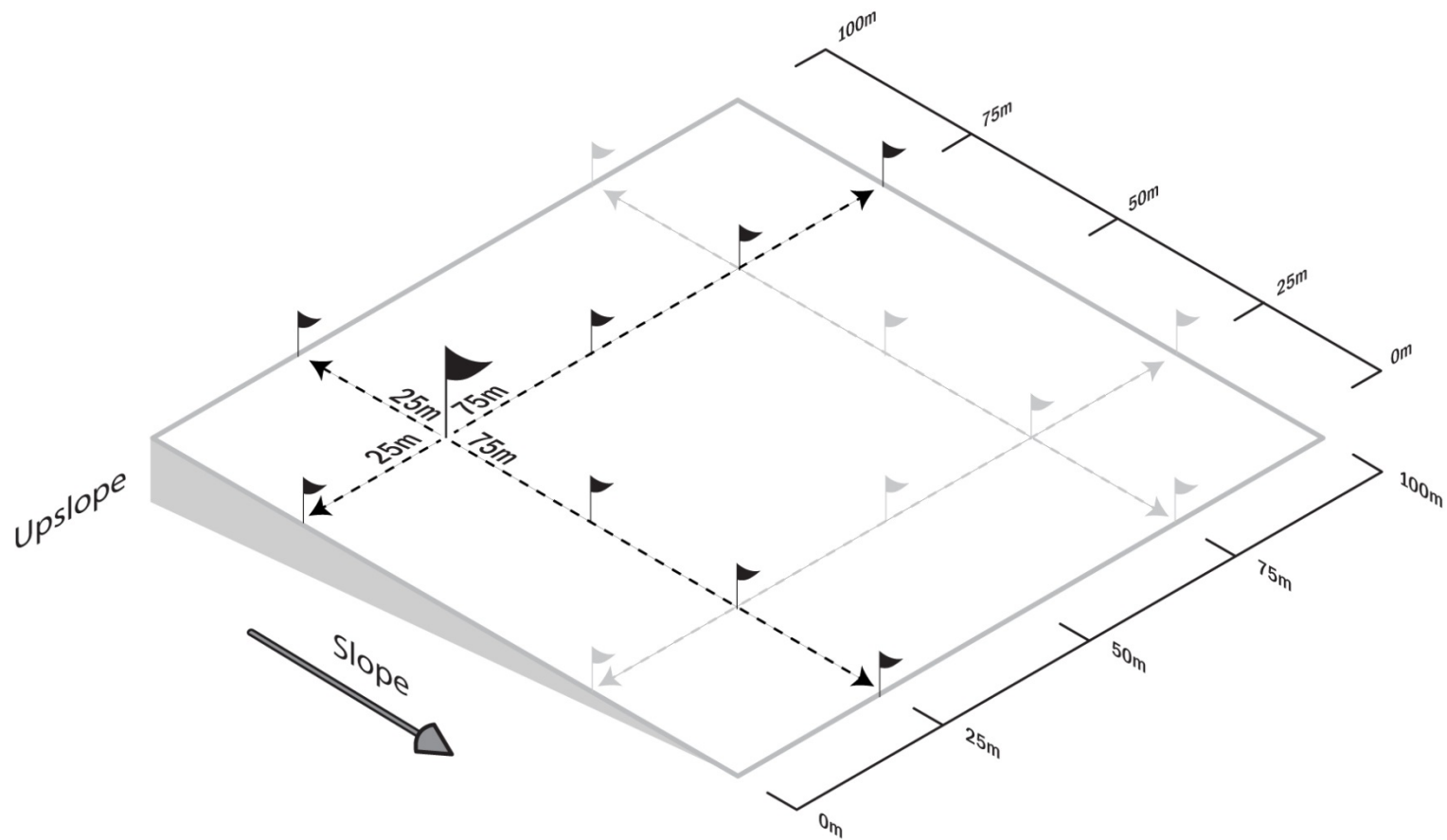


Figure 6.1. Example of how to estimate the potential 100 x 100 m macroplot. The large black flag marks the origin of transect 1. The black dotted arrows represent the distances to measure from the origin of transect 1 to estimate the edges of the macroplot (steps 2-8). The dark gray dotted lines represent the two additional transect tapes that need to be established to estimate the macroplot edges (step 9).

2. Assessing the Suitability of a Field Site for Monitoring

Sites will be assessed based on macroplot locality, disturbance, and existing vegetation to determine whether they are acceptable for long-term monitoring. Sites that are not acceptable will be rejected and dropped from the sampling frame (i.e., sample error). Do not deviate from the UTM coordinates given for the macroplot (except within the parameters described in section 2.1.3. *Shifting the Macroplot*).

2.1. Criteria

For each field site, fill out relevant information at the top of the *Site Characterization Field Form* (SOP 6 Appendix A). Fill in the fields relevant for site “accept” or “reject”. If field sites are rejected, then proceed to section 2.2 *Rejected Sites*. If field sites are acceptable, then proceed to section 2.3 *Accepted Sites*. If field sites need to be shifted (see sections 2.1.2 *Criteria for Shifting Macroplots* and 2.1.3 *Shifting the Macroplot*), then attempt to shift before determining whether the site should be accepted or rejected; crews should only attempt to shift sites for those sites that meet the criteria described in section 2.1.2 *Criteria for Shifting Macroplots*.

Field crew will walk the estimated macroplot area looking for any of the criteria listed under section 2.1.1 *Criteria for Rejecting Macroplots* and 2.1.2 *Criteria for Shifting Macroplots*. Depending on the number of field crew members, the estimated macroplot area should be divided into sections so that one field crew member searches each section. For example, the macroplot can be divided into quadrants if there are four crew members. To reduce trampling, field crew should also be scouting the field site for the criteria in this section as they are estimating the edges of the macroplot.

2.1.1. Criteria for Rejecting Macroplots

Field sites can be rejected for any of the reasons below. For rejected sites, circle “Reject” for “Site Status”, the criteria(on) causing the rejection under “Rejected Site”, and proceed to section 2.2 *Rejected Sites*.

Site accessibility

- Site was inaccessible
 - routes to site are blocked off or washed away, and alternative routes unavailable
 - no permission to cross private roads/lands to access sites
 - site on the side of a cliff
 - presence of illegal activities, such as drug production/growing

Macroplot Locality

- the macroplot will extend beyond the park boundary or into non-park inholdings
- site for macroplot is $>35^\circ$ (70%) slope
- bedrock, large boulders (>0.25 m), rock outcrops, or playa are present on more than 30% of the area sampled by transects, leading to a *continuous* 30% of transects devoid of vegetation
- discernible cultural resources are within the macroplot

Disturbances (affecting >10% of the macroplot area)

- site has recently experienced a major disturbance that had large effects on topography or vegetation, such as uprooting, burial, or mortality of plants
 - fire <5 years old
 - flood
 - windstorm
 - hailstorm
 - ORV use
 - construction
 - other
- Excessive soil compaction leading to denudation or water impermeability

Vegetation

- observed vegetation does not reasonably match expected vegetation (e.g., Joshua tree – blackbrush community is actually a pinyon pine – Juniper community)
- Vegetation is dynamic and will fluctuate with local environmental conditions (microclimate, precipitation, land use, slope, aspect, elevation, time since last disturbance, other). If the observed vegetation is within the range of community fluctuation, then the site should not be rejected. Use mini-keys for communities and refer to community descriptions for comparisons (SOP 6 Appendix B).
- mixture of vegetative communities is present on the macroplot and the target community is <80% of the macroplot
- obligate riparian species are present within the macroplot, indicating a riparian community
- incipient invasive species (invasive species that are in the colonization or establishment phase of invasion, i.e., not fully established or widespread), particularly species targeted for active management, are present on the macroplot

2.1.2. Criteria for Shifting Macroplots

Under the criteria described below, field crews can try to shift macroplots (see section 2.1.3 *Shifting the Macroplot*) away from obstructions or disturbances. If the crew is able to successfully shift the macroplot, then they will circle “Accept” for “Site Status”, circle the criterion causing the shifting under “Shifted Site”, describe the distance, compass bearing relative to the original UTM (transect 1 origin), and any other pertinent notes on how the macroplot was shifted in the “Notes” section of the *Site Characterization Field Form* (SOP 6 Appendix A), and proceed to section 2.3 *Accepted Sites*.

If the crew cannot successfully shift the macroplot, then they will circle “Reject” for “Site Status”, circle the criteria that caused the attempt to shift under “Shifted Site”, and proceed to section 2.2 *Rejected Sites*. Under the “Notes” section on the *Site Characterization Field Form*, describe the attempts to shift the macroplot and why it was not possible.

Macroplot Locality

- macroplot will span multiple terrain types (wash bottom, mountain top, ridges, valley, hillside) or slopes (saddle between hills)
 - wash bottoms: >0.2 m wide and sides forming the wash >10° slope

- o ridges: >3 m tall and slopes >10°
- macroplot will include part of paved/unpaved roads
- any of the macroplot area spans safety hazards
 - o cliff
 - o deep ravines

Disturbances

- localized man-made disturbances present: established human trails, drinkers, guzzlers, and other man-made and maintained water sources, and backcountry RV/campsites (particularly in DEVA, LAKE, PARA)
- larger-scale man-made disturbances present: communication tower, water tower, buildings, weather stations/gauges, cable, gas, power, irrigation lines, fences, campgrounds, pipelines, railroads, backcountry bathrooms, old construction sites, abandoned mines, illegal dumping grounds, and other man-made structures
- natural disturbances present from animal trails, use by burros as an excrement area, animal wallows, animal trampling and/or grazing has led to site denudation or extreme soil compaction

2.1.3. Shifting the Macroplot

Under the criteria described in section 2.1.2 *Criteria for Shifting Macroplots*, the macroplot can be shifted **no more than in a 100 m radius from the original transect 1 origin location** indicated by the GPS unit. One hundred meters is reasonable given the combined errors resulting from the spatial data layers (e.g., slope, landcover), interpreting the imagery for office reconnaissance, and GPS error in the field at the MOJN parks. From office reconnaissance, 100 m buffers should be established from the edge of disturbances that are available as part of spatial data sets or can be seen in imagery (but see GRBA, MANZ, PARA), such as, campgrounds, power lines, gas lines, communication lines, communication towers, railroads, mines, backcountry restrooms.

Macroplots should be shifted in a manner to retain as much of the area that would have originally been part of the macroplot and/or in the direction that is the shortest distance from the edge of the object/disturbance that is to be excluded from the macroplot (Figure 6.2). If there is a choice for which direction to move the macroplot, move the macroplot in the direction that captures the most area from the original macroplot location. For example, if the origin of transect 1 lands in a saddle and 10% of the macroplot is on one side of the saddle, 30% on the other side, then the macroplot should be shifted in the direction where 30% of the macroplot would be captured (Figure 6.2a).

At all parks, if the macroplot covers different terrain types (as described in 2.1.2 *Criteria for Shifting Macroplots*) or goes across multiple slopes, then the macroplot should be shifted so that the macroplot includes **only one terrain type or slope** (Figure 6.2b). This may not be possible if the general terrain of the area is narrow, steep-sided ridges between dry washes. If it is not possible to have only 1 terrain type in the macroplot, at the very least, the **three 50 m transects should span a**

single terrain type. It is acceptable for the edges of the macroplot to be slightly in a different terrain type, such as wash or ridge.

Be objective in shifting macroplots using the procedure described above; do not shift sites to a particular area based on a perception of the “best” site. If it is possible to shift in any direction and equally fulfill the parameters described above, all else being equal, then shift the plot to the *right* of the transect 1 origin when facing the pin flag and upslope.

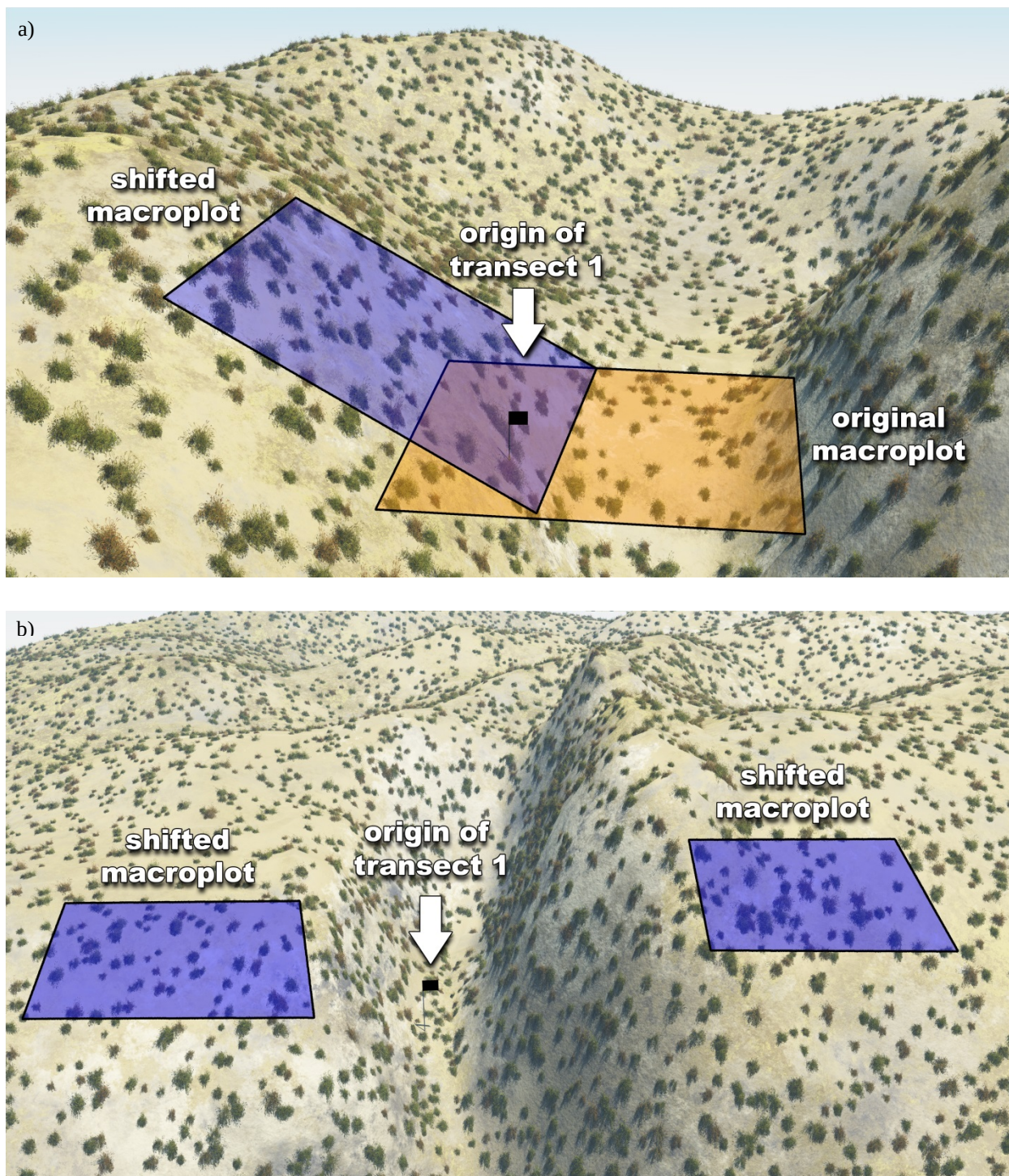


Figure 6.2. Examples of how to shift macroplot placement to have one terrain type or slope. a) shifting the macroplot in the direction that captures the most area from the original macroplot location. b) shifting the macroplot to capture one slope or terrain type. The black flag represents the original location of the origin of transect 1. The blue square represents the new location of the macroplot. The orange square represents the placement of the original macroplot.

In addition to the criteria that apply to all parks (above), there is also park-specific guidance for shifting macroplots based on park recommendations on particular issues or special conditions. For example, neither GRBA, MANZ, or PARA could follow the guidelines for road buffers at the other parks. GRBA has a very limited spatial distribution of the monitored community, so the area that could be monitored would be further reduced with a substantial buffer around roads. Furthermore, their roads experience fairly low use. All areas in MANZ are close to roads. The roads at PARA tend to wash out and are not always in the same area or of the same width after they are cleared out.

Park-specific Macroplot Shifting Guidance

At **DEVA**, **JOTR**, **LAKE**, and **MOJA**:

- Roads: if a macroplot would include an active road (paved/unpaved), the macroplot should be shifted so that the edge of the macroplot is ~9 m (30 ft) from the center line of unpaved roads and ~32 m (100 ft) from the centerline of paved roads, which is based on cherry stem distances for roads in wilderness areas.
- Safety hazards: Move macroplot edge 25 m from hazard. Under the notes, provide detailed information about where the hazard is located so that future crews do not stumble into the hazard.
- Localized man-made disturbances: Move macroplot to one side of trail or so that the edge of macroplot is just outside of any disturbance associated with any structures, following the guidance provided above.
- Larger-scale man-made disturbances: Move macroplot edge 100 m from edge of disturbance.
 - Fences: edge of macroplot should be 32 m (100 ft) from the edge of any disturbance associated with the fences.
- Natural disturbances: Move macroplot so that edge of macroplot is just outside of any disturbance, following guidance provided above.
 - DEVA: move macroplots only if disturbance is greater than 10% of the overall macroplot area
 - JOTR: include animal trails in macroplot

GRBA:

- Roads: The macroplot should be shifted so that the edge of the macroplot is 30 m (~98 ft) from the center line of any active paved/unpaved road.
- Localized man-made disturbances: Move macroplot to one side of trail or low use/abandoned unpaved road, so that edge of macroplot is just outside of any disturbance associated with the trail/road, following guidance provided above.
- Larger-scale man-made disturbances: Move macroplot so that edge of macroplot is 30 m away from any disturbance associated with the structure, following guidance provided above.
- Animal made disturbances can be included in macroplots.

MANZ: Move edge of macroplot just outside of any disturbance/structures, following the guidance provided above.

PARA: For any of the circumstances described under “DEVA, JOTR, LAKE, and MOJA”, there will be a 50 m (~164 ft) buffer from the edge of the macroplot to the disturbance, given the known year to year variation for different disturbances. For roads, the 50 m buffer will be from the centerline of any road, because roads have a high probability of washing out during the rainy season.

2.2. Rejected Sites

If a site is rejected, record the following on the *Site Characterization Field Form* (SOP 6 Appendix A):

1. Circle “Reject” under site status.
2. Circle the appropriate criteria under “Rejected Site Criteria” *or* “Shifted Site Criteria” and provide a detailed explanation of why the site was rejected, if needed.
If the site was rejected outright during evaluation (that is, no shift was attempted), only criteria under “Rejected Site Criteria” should be selected.
For sites where shifts were attempted but the site was rejected, provide a detailed explanation. Do not circle rejection criteria under “Rejected Site Criteria”.
3. Take photos of the site, specifically showing why the site was rejected.
 - a. The **FIRST** photo for each site should be of a photoboard.
Fill in the following information on the photoboard using a black marker:
Rejected site
Park code – Use the standard 4-letter code to indicate the park unit.
Macroplot Nbr – A pre-assigned, unique number provided for each site.
Date - Use the format mm/dd/yyyy
 - b. From approximately the center of the macroplot, face north and take a picture of what would have been the north part of the macroplot.
 - c. Proceed *clockwise*, taking pictures of each of the remaining cardinal directions.
 - d. If the four cardinal direction photos do not adequately show the criteria for site elimination, take additional photos of the site.
 - e. Record the photo file numbers on the “*Site Characterization Field Form*” and include a brief description of each photo under the “Comments” field.
 - f. To find the photo file name, playback the image. The file number (e.g., DSC_0001) should be below the image during playback. Record only the number after the “_” of the file number on the field form.
4. Remove the pin flag and head to the next site on the list of potential field sites.

2.3. Accepted Sites

If a site is considered acceptable, then circle “Accept” under site status on the *Site Characterization Field Form*. Then proceed to *SOP 7 – Macroplot Establishment and Revisit Set-up*.

SOP 6 APPENDIX A: Site Characterization Field Form

Integrated Uplands - VGS
SOP 6 - Site Characterization Field Form

Date: ____/____/____ (MM/DD/YY)

Park code:

Macroplot Nbr:

Observer: _____

Recorder: _____

Others: _____

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Criteria for Rejection (circle rejection criteria)

Site is Inaccessible

routes to site blocked

Macroplot Locality

plot extends past park
boundary or into inholdings

Disturbances (>10% plot area) Vegetation

recent major disturbance
(describe in Notes)

) Vegetation

vegetation mis-match

no permission to cross private land

slope > 35 degrees

excessive soil compaction

target community <80% of
macroplot

presence of illegal activities

>30% transects bedrock, large boulders, outcrops, playa

obligate riparian species
present

illegal activities present

cultural resources

park-managed incipient
invasive species present

Criteria for Shifting (circle criteria for shifting)

Locality

multi-terrain types
paved/unpaved roads
safety hazards (describe in
Notes)

Disturbances (provide specific description in Notes)

localized man-made:

human trails
drinkers, guzzlers, maintained
water sources
backcountry RV/campsites

larger-scale man-made:

communication tower
water tower

buildings

old construction sites
abandoned mines

illegal dumping grounds

other

weather stations/gauges
cables, gas, power, irrigation
lines

other

natural:

- animal trails
- excrement area
- animal wallows
- animal trampling/grazing
- other

- fences
- campgrounds
- pipelines
- railroads
- backcountry bathrooms

Notes (Describe why and how site was shifted):

Integrated Uplands - VGS
SOP 6 - Site Characterization Field Form

Date: ____/____/____ (MM/DD/YY)

Park code: _____ Macroplot Nbr: _____

Page 2 of 2

Observer: _____

Recorder: _____ Others: _____

Camera Nbr: _____

Site Status (circle one): **Accept** / **Reject** (provide photos and description of why rejected)

Photo #:	Direction:	Comments
	Photoboard	
	North	
	East	
	South	
	West	
	Extra	
	Extra	
	Extra	

Notes (describe why site was rejected):

SOP 6 APPENDIX B: Plant Community Mini-key and Descriptions

Mini-key and detailed descriptions used to determine whether the plant community on the macroplot is the one targeted for monitoring.

Alliance Key

(adapted from Thomas, K., Keeler-Wolf, T., Franklin, J., and Stine, P. 2004. Mojave Desert Ecosystem Program: Central Mojave Vegetation Database. USGS Western Ecological Research Center & Southwest Biological Science Center Final Report.)

IIA Tree species are present. Trees are defined as woody perennials that are regularly >3 m in height; including shrub species often taller than 3 m such as *Chilopsis linearis*, *Cercocarpus ledifolius*, *Yucca brevifolia*, *Tamarix spp.* and *Juniperus osteosperma* or *californica*. The tree layer is visibly uniform in the stand although it may be low in cover. Go to II.2.

II.2 *Yucca brevifolia*, *Pinus monophylla*, *Juniperus californica*, and/or *Juniperus osteosperma* $\geq 1\%$ cover. Go to 250A.

II.3 Go to IIIA.

IIB Tree species not present. Go to IIIA.

IIIA Perennial herbaceous vegetation present ($\geq 2\%$ cover), and woody shrubs generally $< 2\%$ cover; stop; this is not the target community.

IIB Shrubs present ($\geq 2\%$); go to 400A.

TREE DOMINATED ALLIANCES (for GRBA, JOTR, MOJA, PARA)

250A *Yucca brevifolia* $\geq 1\%$ cover, *Juniperus spp.* and/or *Pinus spp.* may be present but low in % cover. Dominant understory species are shrub species such as *Coleogyne ramosissima*, *Opuntia ramosissima* or the perennial grass *Pleuraphis rigida*. Common in shallow upland soils throughout the Mojave Desert, ***Yucca brevifolia* Wooded Shrubland Alliance**.

250B Go to 251A.

251A *Juniperus californica*, *Juniperus osteosperma* and/or *Pinus monophylla* $\geq 1\%$ cover. *Yucca brevifolia* absent. Go to **Sagebrush steppe shrubland** community description to determine whether target community for GRBA, PARA.

SHRUB CHARACTERIZED ALLIANCES

400A Either *Hymenoclea salsola*, *Bebbia juncea*, *Eriogonum fasciculatum*, *Salazaria mexicana*, or *Senna armata*, are $> 1\%$. Other shrubs, if present, are each less than half of the above species with the exceptions of *Hyptis emoryi* or *Salvia dorrii*, which may have higher cover. **Stop; not community of interest.**

400B *Yucca schidigera* $\geq 2\%$ cover. Understory dominant species is a shrub. **Stop; not community of interest.**

400C Creosote Bush <1% cover. **Stop; not community of interest.**

400D No shrub with cover greater than *Larrea tridentata*, with the following exceptions: *Ambrosia dumosa*, *Encelia farinosa*, *Krameria* spp. *Bebbia juncea*, *Ericameria teretifolia* or *Acamptopappus spherocephalus*. *Ephedra nevadensis* or *Opuntia acanthocarpa* may have higher cover, but no more than three times. Go to 401.1 (these are all *Larrea* communities).

401.1 *Ambrosia dumosa* present ($\geq 1\%$ cover) and is codominant with *Larrea tridentata*.

Ambrosia dumosa may have higher cover than *Larrea tridentata*. If *Encelia farinosa* is codominant with *Larrea tridentata*, go to 401.2. Widespread on all but the hottest and most rocky, sandy or most alkaline areas of the low Mojave Desert. ***Larrea tridentata*-*Ambrosia dumosa* Shrubland Alliance.**

401.2 *Encelia farinosa* present ($\geq 1\%$ cover) and is codominant with *Larrea tridentata*,

Encelia farinosa may have higher cover than *Larrea tridentata*. *Ambrosia dumosa* may be present but is not codominant. Widespread on hot (southerly exposure) mountain slopes and upper bajadas. ***Larrea tridentata*-*Encelia farinosa* Shrubland Alliance.**

401.3 Associate shrubs other than *Ambrosia dumosa* or *Encelia farinosa* may be present or absent; if *Ambrosia dumosa* is present, its cover is <3 times *Larrea tridentata*. Except for shrubs listed above, associate shrub cover is less than *Larrea tridentata*. ***Larrea tridentata* Shrubland Alliance.**

Shrub Community Descriptions

*keep sites with communities that might be considered “close” to the provided descriptions. In many instances, “dominant” is considered to be 30-60% of the total vegetation cover.

Creosote bush (*Larrea tridentata*) mixed shrubland (DEVA) - Shrubs usually 0.5 to 2-m tall (may occasionally be up to 5 m), generally forming >25% canopy cover; at minimum, shrubs are $\geq 2\%$ cover. *Larrea tridentata* will generally have the greatest cover though in some stands *Ambrosia dumosa*, *Encelia farinosa*, *Krameria* spp. *Bebbia juncea*, *Ericameria teretifolia*, or *Acamptopappus spherocephalus* may have greater absolute cover. Associate shrub species, particularly *A. dumosa* and *E. farinosa*, may be >1% cover, but *L. tridentata* will be at least 1% cover. *Ephedra nevadensis* or *Opuntia acanthocarpa* may have higher cover, but usually no more than three times the cover of *L. tridentata*. Emergent *Yucca brevifolia* may also be present.

Joshua tree woodlands (JOTR) – There are 4 main associations that we will be working in. Any of these associations can be considered to be Joshua tree woodland but we will need to note if any association appears to be designated incorrectly by the vegetation map (e.g., if a selected site is indicated as *Yucca brevifolia* / *Coleogyne ramosissima* but does not fit the description but fits the description of *Yucca brevifolia* / *Larrea tridentata* better, then we will need to evaluate and/or reclassify).

***Yucca brevifolia* / *Coleogyne ramosissima* Woodland Association** – Vegetation is characterized by having a tree/tall stratum with a shrub stratum that is equal or greater in cover than the tall stratum. Cover for the tall stratum ranges from 1-10% cover with the *Y. brevifolia* being the dominant species in this stratum. The medium/shrub stratum ranges from 8-20% cover, with *C.*

ramosissima as the dominant species in this stratum. *Juniperus californica* may be found in this community but *Y. brevifolia* will be clearly dominant.

***Yucca brevifolia* – *Juniperus californica* / *Ephedra nevadensis* Woodland Association** - Open shrubland vegetation, generally characterized by having greater shrub/medium stratum cover than tree/tall stratum cover. Cover for the tall stratum ranges from 0-5% cover, with both *Juniperus californica* and *Yucca brevifolia* dominating this stratum; there may be no tall stratum if the height of both of these species places them in the medium stratum. The medium/shrub stratum ranges from 4-42% cover and includes *Ephedra nevadensis*, *Eriogonum fasciculatum*, and *Cylindropuntia echinocarpa*. *Ephedra nevadensis* is found most frequently in this association but may not be dominant in terms of % cover. *Coleogyne ramosissima* may also be found in this community.

***Yucca brevifolia* / *Larrea tridentata* – *Yucca schidigera* / *Pleuraphis rigida* Woodland Association** - Open woodland vegetation, generally characterized by having much greater shrub/medium stratum cover than tree/tall stratum cover. Cover for the tall stratum ranges from 0-2%, with *Y. brevifolia* as the dominant species; if *Y. brevifolia* is present but not part of the tall stratum, then the tall stratum cover may be 0%. The medium/shrub stratum ranges from 12-40% cover and a number of shrub species can be found in this stratum. *Bromus rubens* is the dominant species in the herb layer, when it is present (0-48% herb/low stratum cover). *Pleuraphis rigida* is a characteristic species of this association. *Juniperus californica* may be found in this community but *Y. brevifolia* will be clearly dominant.

***Yucca brevifolia* / *Pleuraphis rigida* Woodland Association** - Open woodland vegetation, generally characterized by an open tree/tall stratum often emergent over a shrub/medium stratum species. Cover for the tall stratum ranges from 0-6% and is dominated by *Y. brevifolia*; if *Y. brevifolia* is present but not part of the tall stratum, then the tall stratum cover may be 0%. The medium/shrub stratum ranges from 2-29% cover, with a variety of species making up this stratum, the three most frequent are *Ambrosia salsola*, *Cylindropuntia echinocarpa*, and *Salazaria mexicana*. *Pleuraphis rigida* and *Bromus rubens* are dominant in the herb/low stratum, which has 2-18% cover.

Creosote bush (*Larrea tridentata*) -white bursage shrubland (*Ambrosia dumosa*) (LAKE) - Shrubs usually 0.5 to 2-m tall, generally forming >25% canopy cover; at minimum, shrubs are ≥2% cover. *Larrea tridentata* and *Ambrosia dumosa* are the dominant or co-dominant shrubs in the canopy, both of which have ≥1% cover; *A. dumosa* may have higher cover than *Larrea tridentata*. The following shrubs may have greater cover than either *L. tridentata* or *A. dumosa* but no more than three times either species' cover: *Krameria* spp., *Bebbia juncea*, *Ericameria teretifolia*, *Acamptopappus spherocephalus*, *Ephedra nevadensis*, or *Opuntia acanthocarpa*.

Rabbitbrush (*Ericameria nauseosa*) Shrubland Alliance (MANZ) – Shrub-dominated vegetation, where total shrub cover generally ranges from 10-40%. *Ericameria nauseosa* or *Atriplex canescens* is dominant, or both species are codominant. *E. nauseosa* will be present as a component of the shrub

cover when it is not dominant. Scattered individuals of *Atriplex polycarpa* and *Artemisia tridentata* ssp. *tridentata* occur within the stand.

Joshua tree wooded shrubland alliance (MOJA) – Shrubs or tree dominated vegetation, usually 0.5 to 5-m tall, generally forming >25% canopy cover. *Yucca brevifolia* is $\geq 1\%$ cover. Dominant understory species are shrub species such as *Coleogyne ramosissima*, *Opuntia ramosissima* or the perennial grass *Pleuraphis rigida*.

Sagebrush steppe shrubland (GRBA, PARA) – Tall and short shrub-dominated vegetation, where shrubs are >5% of the total vegetative cover. *Artemisia* species (e.g., *A. arbuscula*, *A. nova*, *A. tridentata*) are generally the dominant shrubs in the community or >40% of the total shrub cover. Scattered trees may be present in this community.

Standard Operating Procedure (SOP) # 7: Macroplot Establishment and Revisit Set-Up

Version 1.0

Revision History Log:

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

This SOP provides instructions for establishing permanent monitoring macroplots in shrubland communities and for setting up the macroplots during revisits. Procedures are described assuming there is a two person field crew, with crew members indicated as either 'A' or 'B'.

This SOP was adapted from *SOP 6 – Macroplot Establishment and Revisit Set-up* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol (which was based on Herrick et al. (2005)). *MOJN I&M SOP M3 – GPS* and *SOP 5 - Crust-Friendly Field Procedures* should be reviewed before macroplot establishment. *SOP 6 – Site Characterization* should be completed before starting this SOP.

1. Transect Establishment Procedures

1.1. Navigate to the Origin of Transect 1 (see Figure 7.1)*

*if *SOP 6 – Site Characterization* has been conducted immediately prior to this SOP, then skip this section.

1. Use a Global Positioning System (GPS) unit, topographic map, and pre-determined Universal Transverse Mercator (UTM) coordinates to locate the origin of transect 1 in the macroplot. Approach from downslope to avoid trampling the sampling area. If there is no obvious slope, the nearest drainage will mark the downslope side of the macroplot.
2. Place a pin flag at the origin of transect 1.

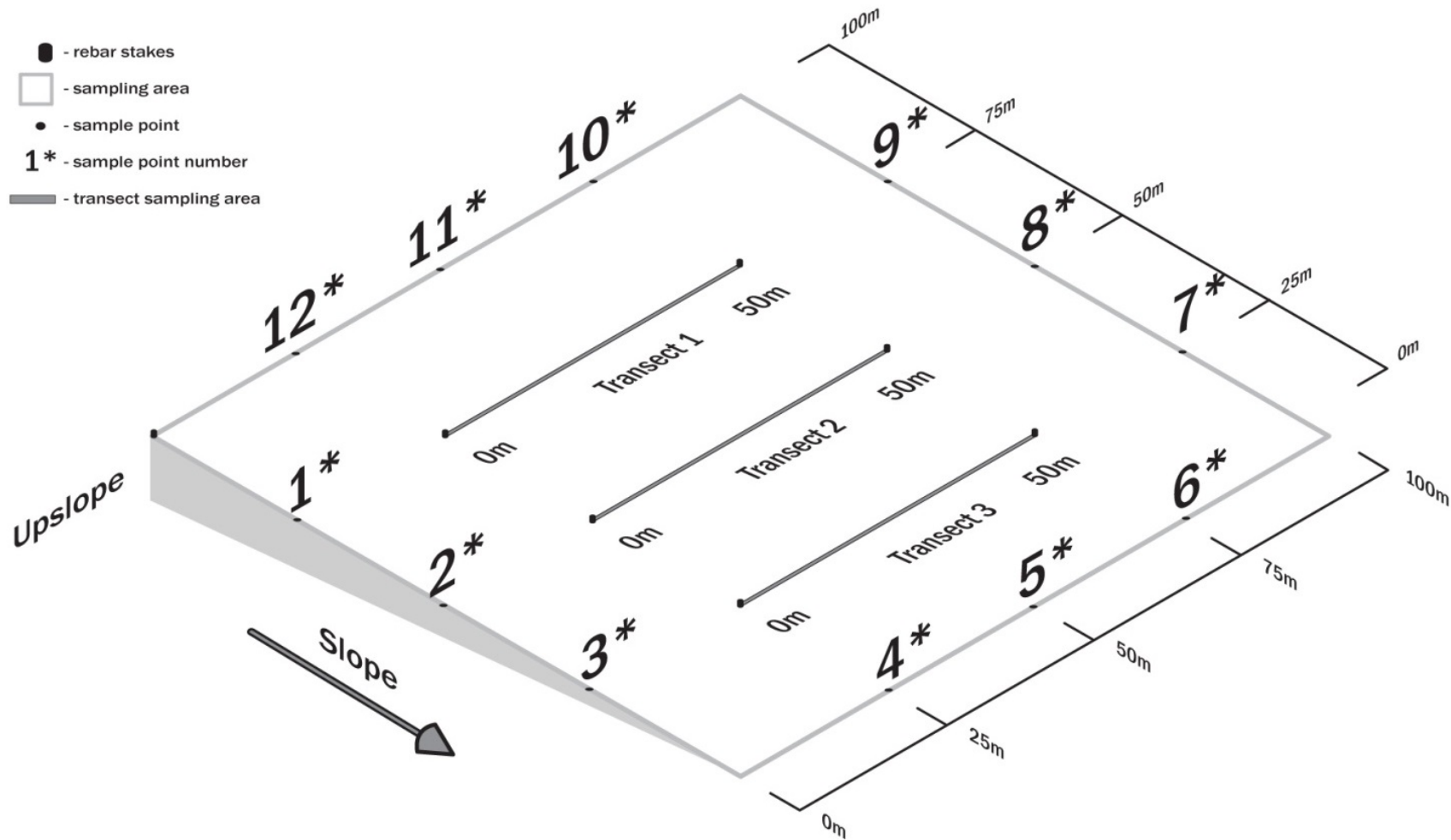


Figure 7.1. Standard macroplot and transect layout for upland monitoring. The filled cylinders represent rebar stakes. The numbers on the edge of the macroplot represent soil sampling points (see *SOP 11 – Soil Measurements* for details).

1.2. Establishing the Transects and Macroplot Corners

The upland macroplot consists of three, 50 m long transects running approximately parallel across the slope at intervals of 25 m (Figure 7.1). Conduct the following procedures and use pin flags to mark each of the designated points. Crews will double-check the macroplot set-up before inserting permanent rebar markers. *The ability to consistently and accurately read a compass is crucial for establishing transects and macroplots.*

It is assumed that transect tapes are already laid out as shown in Figure 6.1 from *SOP 6 – Site Characterization*. If tapes have not been laid out as in Figure 6.1, then perform steps 2-7, under section 1. *Locating Field Sites and Estimating the Macroplot Area* from *SOP 6 – Site Characterization* **BEFORE** starting this SOP. If transect tapes have been laid out correctly, then transects 1 and 3 are already established.

To help with macroplot relocation, the macroplot corner closest to the origin of transect 1 of each macroplot will be marked permanently with a rebar stake (see section 1.4. *Establishing the Permanent Markers*). The only macroplot corner that needs to be established during the first year is the one that will be permanently marked (steps 12-14) because, during the first year, soil sampling points are regularly spaced and can be established as part of the site characterization and/or macroplot establishment procedure. In subsequent years, all other macroplot corners will be marked with a pin flag and used to set-up the perimeter of the macroplot in order to establish the soil sampling points (see *SOP 11 – Soil Measurements*).

1. Fill in the compass bearings (in degrees) that were used to establish the transect tapes in *SOP 6 – Site Characterization* in appropriate boxes on the “bearings” diagram on the *Macroplot Establishment Field Form* (SOP 7 Appendix A).
You can think of the person recording the compass bearings as standing where the vertical and horizontal lines intersect.
2. Proceed 25 m downslope of the origin of transect 1 along the transect tape (there should already be a pin flag marking the point). This point is the origin of transect 2.
3. Crew member A will hold the reel end of a 100 m tape and direct crew member B 25 m in the compass bearing recorded in the box to the left of the horizontal line in the “bearings” diagram. This would be to the left of the origin of transect 2 (when facing upslope).
It is very important to have the compass level and to keep metal objects (i.e., rings, watches, chaining pins, transect tape ends) away from it to get an accurate reading.
4. Crew member B will take the free end of the transect tape, a pin flag, and chaining pin and proceed 25 m in the bearing indicated by crew member A. The line should be taut and as close to the ground as possible to avoid curvature in the line. If all shrubs are of similar height, the tape can be strung overtop the shrubs in order to keep the tape straight.
When crew member B reaches 25 m, he/she should take a compass bearing back to crew member A to check that the tape was pulled in the correct bearing (bearing recorded in the box to the right of the horizontal line). When the tape is in the correct bearing, crew member B will use a pin flag and chaining pin to secure the transect tape and then head back to crew member A.

5. Crew member B will locate the pin flag marking the 50 m point of the second transect tape that is perpendicular to the slope. The tape is to the right of the origin of transect 2 (when facing upslope) and marks the end of the transects (there is 50 m between the 2 tapes that are perpendicular to the slope).
Crew member B will take the reel end of the tape, 2 pin flags, and 2 chaining pins and head toward the pin flag marking the end of transect 2.
6. Crew member A will hold the 25 m mark on the tape and direct crew member B in the compass bearing recorded in the box to the right of the horizontal line in the “bearings” diagram. The compass bearing should be very close to where the pin flag is located. If it is not, then mark the new location along the perpendicular tape with a pin flag to help with orientation.
Crew member B will walk out 75 m in the compass bearing indicated by crew member A, or 25 m past the pin flag. Crew member B must walk downslope of the transect tape to avoid trampling the sampling area.
7. When crew member B reaches 75 m, he/she should take a compass bearing back to crew member A to check that the tape was pulled in the correct direction.
The compass bearing that crew member B reads should be 180° from crew member A’s reading, or the bearing recorded in the box to the left of the horizontal line in the “bearings” diagram on the field form.
8. Crew member B will use a pin flag to mark the point, which is along the macroplot edge.
9. Crew member A will go to the free end of the transect tape (25 m to the left of the origin of transect 2), release it from the chaining pin, and walk with it to the origin of transect 2.
At the same time, crew member B is heading to the end of transect 2 and rolling up the tape to the 50 m mark.
When the tape is taut, the 0 m mark should be at the origin and the 50 m mark at the end of transect 2.
Both crew members will attach the transect tape to the respective chaining pins using a loop of cord such that the 0-m and 50-m marks fall over or in-line with the pin flag.
10. As crew member B walks along the downslope side of the transect tape toward crew member A, he/she will use additional chaining pins along the tape to ensure that the transect tape does not move around.
Minimally, mark the center of the transect (25 m) with a pin flag and chaining pin.
11. Using the “bearings” diagram on the field form, calculate the angle from the origin and ends of transects 1 and 3 to the corners of the macroplot.
For the corner closest to the origin of transect 1, add 45° to the compass bearing recorded in the box to the left of the horizontal line in the “bearings” diagram on the *Macroplot Establishment Field Form* (SOP 7 Appendix A).
For the corner closest to the origin of transect 3, subtract 45° from the compass bearing recorded in the box to the left of the horizontal line in the “bearings” diagram on the field form.
For the corner closest to the end of transect 3, add 45° to the compass bearing recorded in the box to the right of the horizontal line in the “bearings” diagram on the field form.

For the corner closest to the end of transect 1, subtract 45° from the compass bearing recorded in the box to the right of the horizontal line in the “bearings” diagram on the field form.

12. Attach a 50 m transect tape to the chaining pin at the origin of transect 1.
13. Crew member A will direct crew member B, who is carrying the reel end of the tape, in the compass bearing determined in step 1.
Crew member B will pull the tape out 35.4 m and take a compass bearing back to crew member A to check that the tape was pulled in the correct direction.
The compass bearing that crew member B reads should be 180° from crew member A’s reading.
Once the tape is at the correct compass bearing, crew member B will use a pin flag to mark the macroplot corner.
14. Reel in the tape and both crew members will head to the origin of transect 3.
15. Attach a 50 m transect tape to the chaining pin at the origin of transect 3.
16. Repeat steps 12 and 13 to establish the corner of the macroplot closest to the origin of transect 3.
17. Reel in the tape and both crew members will head to the end of transect 3.
18. Attach a 50 m transect tape to the chaining pin at the end of transect 3.
19. Repeat steps 12 and 13 to establish the corner of the macroplot closest to the end of transect 3.
20. Reel in the tape and both crew members will head to the end of transect 1.
21. Attach a 50 m transect tape to the chaining pin at the end of transect 1.
22. Repeat steps 12 and 13 to establish the corner of the macroplot closest to the end of transect 1.
23. Both crew members will head to the origin of transect 1 and repeat steps 9-10 to set-up transect 1.
The tape should have the 0 mark at the transect origin and the 50 m mark at the transect end. If it does not, then reverse the tape so that it is in the correct orientation. Remember to only walk along the downslope side of the transect tape.
24. Both crew members will head to the origin of transect 3 and repeat step 23 for transect 3. Now the 3 transects are completely set-up.
25. If soil sampling points are to be taken, then do not remove any pin flags until the soil sampling points have been established (see *SOP 11 – Soil Measurements*).

1.3. Slope Measurements

1. Crew member A will stand downslope of the transect tape at the center (25 m) of transect 3 and face upslope toward transect 1.
2. Crew member B will serve as a reference point for crew member A and stand downslope of the transect tape at the center (25 m) of transect 1.
3. To determine the % upslope, crew member A will aim the clinometer at a point at eye level on crew member B.

Keeping both eyes open, crew member A will use one eye to read the scale in the clinometer and the other eye to sight crew member B. Crew member A will determine where his/her eye level would be on crew member B (if crew member B is shorter than crew member A, then crew member A's eye level may be above crew member B's head) and use that place as a sight.

4. Crew member A will read the scale on the clinometer and record the % upslope reading on the appropriate line on the *Macroplot Establishment Field Form*.

1.4. Establishing the Permanent Markers

Pin flags marking the origin and end of each transect and the corner of the macroplot closest to the origin of transect 1 will be replaced and permanently marked with a rebar stake. There will be a total of seven rebar stakes per macroplot.

1. Replace the pin flag at the origin of transect 1 with a 36" long, 3/8" diameter rebar stake. If there is an obstruction or the rebar stake cannot be securely inserted at the origin of transect 1, then offset the rebar stake by moving it in-line with, but off the transect (that is, do not put the rebar stake on the transect since it may affect data collection). Drive the rebar stake into the ground using a sledgehammer, leaving about 30 cm exposed. If the rebar is easily visible from a road or trail, leave only about 10 cm of rebar above ground or sink it to ground level. If necessary, the rebar stake can be trimmed to the appropriate height using rebar cutters.
2. Record the aboveground height in cm of the rebar stake in the "Height" field for the origin of transect 1 on the *Macroplot Establishment Field Form* (SOP 7 Appendix A).
3. Record the distance along the transect in m where the rebar is placed (i.e., at the origin, the rebar is generally installed at 0 m mark of the transect) in the "Location on Transect" field for the origin of transect 1.
If the rebar marker is offset from the origin, record the distance from the origin as a negative number (e.g., -1 m, -2 m). If the rebar stake is offset from the end, record the distance from the end as a number greater than 50 m (e.g., 51 m, 52 m).
4. Crew member B will cap the end of the rebar with a rebar cap and attach a metal tag with information about the permanent marker (Figure 7.2) to each rebar. Attach tags by threading the tag with a piece of wire and wrapping the wire at the base of the exposed rebar.
Tags should be stamped beforehand in the office or in camp with the following information:
Line 1: "NPS-MOJN".
Line 2: Park code followed by macroplot number (i.e., plot ID).
Line 3: Transect number (i.e., 1 = upper, 2 = center, or 3 = lower), transect location (i.e., O = origin, E = end), and year (yyyy).



Figure 7.2. Format of metal tags used to mark rebar stakes at the transect ends.

5. Record the date and tag code in the appropriate fields on the field form for the rebar marker.
6. Record the UTM coordinates of the rebar using the GPS (*MOJN I&M SOP M3*) and in the appropriate fields on the *Macroplot Establishment Field Form*.
7. Repeat steps 1-6 for the origin and ends of all transects.
Make sure that the correct tag is attached to each rebar marker.
8. For the macroplot corner permanent marker, repeat steps 1-2.
If, for some reason, the corner closest to the origin of transect 1 cannot be used, then indicate in the notes and on the “bearings” diagram which corner of the macroplot was marked on the *Macroplot Establishment Field Form*.
9. Cap the end of the rebar with a rebar cap and attach a metal tag with information about the permanent marker (Figure 7.3) to the rebar. Attach tags by threading the tag with a piece of wire and wrapping the wire at the base of the exposed rebar.

Tags should be stamped beforehand in the office or in camp with the following information:

Line 1: “NPS-MOJN”.

Line 2: Park code followed by macroplot number (i.e., plot ID).

Line 3: “M” for macroplot and year (yyyy).



Figure 7.3. Format of metal tags used on the rebar stake marking the corner of the macroplot.

10. Repeat steps 5-6 for the corner rebar marker.

1.5. Photograph Transects (see SOP 13 – Repeat Photos)

1.6. Collect All Data Along Transect (see SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling, SOP 9 - Measuring Basal and Canopy Gaps Using Line-Intercept Sampling, SOP 10 - Assessing Invasive Plant and Disturbance Frequency Using Quadrats)

1.7. General Macroplot Information

Before leaving the macroplot, make sure that all measurements have been completed and this information has been recorded on the *Macroplot Establishment Field Form*:

1. *Park code* – Use the standard 4-letter code to indicate the park unit.
Macroplot Nbr – A pre-assigned, unique number provided for each site.
Date – Use the format mm/dd/yyyy
Observer – Record the three initials (first, middle, and last name initials) of the observer.
Recorder – Record the three initials of the recorder.
Others – Record the three initials of any people with the crew but not participating in data collection.
2. Slope for the macroplot and the compass bearing of the transects and macroplot.
3. UTM coordinates and the position along the transect of each rebar marker (under “Location on Transect”).
4. Record directions to the macroplot, assuming that whomever using it to relocate the site has never been there before.
Begin with road travel from the MOJN I&M office to the park, from the park entrance to where to park the vehicle, and the hiking route used. Describe any landmarks used in navigating to the field site. Take pictures of road signs or which roads were taken, forks taken in the road, where to park the vehicle, or any useful landmarks; this information will be shared with future field crews. Note specific 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”.

2. Revisiting an Existing Monitoring Site

2.1. Navigating to a Macroplot

1. Navigate to the marked corner of the macroplot using a GPS unit, topographic map, and the UTM coordinates provided on the *Macroplot Revisit Field Form*.
Be careful not to walk through the macroplot. Display a map of the transect endpoints on the GPS or approach from the downslope side, if possible, to avoid trampling the macroplot.
2. When you reach the macroplot, locate the rebar marking the origin of transect 1 using the GPS (UTM coordinates).
3. Check the metal tag to make sure it is marked with the code for the origin of transect 1.
4. If any of the rebar marking the transect ends have been altered or removed and cannot be replaced at the same locations, they will need to be relocated. On the *Macroplot Revisit Field*

Form, note what has happened to the marker (altered, removed, lost, or other), that the marker has been relocated, and fill in the appropriate information on the field form to describe the location of the relocated marker (“Date”, “Tag code”, “Location on Transect”, “Rebar height”, and UTM’s).

Record the location of the new rebar markers with the GPS and on the field form.

2.2. Setting Up the Transects

1. Check the information provided about rebar marker placement and adjust the set-up of the transects accordingly below.
That is, if the rebar markers are not placed at the 0 and 50 m ends of the transect, then place the transect tape in a manner to ensure the correct area is being measured. For example, if the rebar marker was placed at 54 m, then make sure that when the transect tape is pulled such that the 54 m mark is over the rebar marker.
2. Place a chaining pin in-line with the rebar marker at the origin of transect 1.
3. Anchor the “0” end of the 50 m tape to a chaining pin using a cord loop so that the 0 m mark falls over the rebar at the origin end of the transect.
4. Take the reel end of the tape and walk on the downslope side of the transect tape towards the rebar marking the other end of the transect. Walk downslope of the transect to avoid trampling the sampling area.
If the rebar at the other end of the transect is not easily visible, mark it with a pin flag.
5. Secure the tape in place with chaining pins as you walk along the transect toward the other end.
6. Place a chaining pin past the end rebar, such that when you wrap the tape around the chaining pin, the 50 m mark falls over the rebar.
7. Repeat steps 1-5 to set-up transects 2 and 3.

2.3. Photograph Transects and Collect All Data (SOPs 8-13)

2.4. Before Leaving the Macroplot

1. Check all field forms before leaving the macroplot to be sure all fields are filled out and all measurements were taken.
Make any necessary updates to macroplot directions, rebar locations, or macroplot side slopes.
2. Make sure all equipment and materials have been collected and removed from the macroplot.

3. 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, New Mexico.

SOP 7 APPENDIX A: Macroplot Establishment Field Form

Integrated Uplands

SOP 7 - Macroplot Establishment (Initial Site Visit Only) Field Form

Date: ___/___/___ (MM/DD/YY)

Observer: _____

Recorder: _____

Others: _____

Park code: _____

Macroplot Nbr: _____

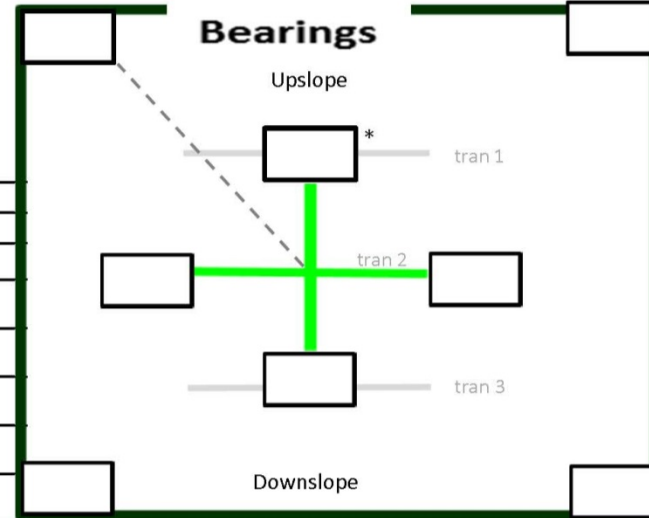
GPS Unit Nbr: ____

Upslope (%): ____

Directions to Macroplot/Notes: _____

Directions from Office: _____

Directions from Vehicle to Plot: _____



Plot Markers

Date	Description	Tag Code	Location on Transect (m)	Rebar Height (cm)	UTM Easting	UTM Northing
	1 (Upper) O					
	1 (Upper) E					
	2 (Center) O					
	2 (Center) E					
	3 (Lower) O					
	3 (Lower) E					
	Macroplot (0)					

7A-1

MOJN I&M IU SOP

Standard Operating Procedure (SOP) # 8: Measuring Cover of Vegetation and Soil Surface Features Using Point Intercept Sampling

Version 1.0

Revision History Log:

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

This SOP details methods for estimating cover of vegetation (specifically, shrubs by species and other vegetation by life form) and soil surface features using point-intercept sampling. Shrubs are defined as being woody, of relatively short stature, and with basal branching (Baldwin et al. 2002). A list of shrub species for each park will be provided based on designation in the USDA Plants database and Calflora. Depending on the environment, some plant species may appear “non-woody”, so it is important to check the list if there is any doubt. For any unknown shrub species (*SOP 14*), shrub status will be verified at the time of identification and, if the species is a shrub, it will be added to the shrub list for the park. A list of targeted status and trends invasive plants for each park is presented in Appendix A of the *Integrated Upland Protocol of the Mojave Desert Network, Volume 1: Protocol Narrative* and will be provided to field crews. Targeted status and trends species were determined using *MOJN I&M SOP M2 - Prioritizing Invasive Species for Status and Trends Monitoring*.

This SOP was adapted from *SOP 8 – Measuring Cover of Vegetation and Soil Surface Features Using a Point-Intercept Transect* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol (which was based on Herrick et al. 2005). *SOP 7 - Macroplot Establishment and Revisit Set-Up* should be completed before this SOP is implemented. *SOP 5 - Crust-Friendly Field Procedures* should be reviewed before sampling.

1. Point-Intercept for Cover Estimates

Point-intercept is used to sample vegetation on three, 50 m transects at 1 m intervals.

1.1. Filling Out the Field Form

For each transect, fill out relevant information at the top of the *Point-Intercept Field Form* (*SOP 8 Appendix A*) including:

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

Macroplot Nbr – A pre-assigned, unique number provided for each macroplot.

Date – mm/dd/yyyy

Transect – 1, 2, or 3

Observer – Record the three initials (first, middle, and last name initials) of the observer.

Recorder – Record the three initials of the recorder.

Others – Record the three initials of any people with the crew but not participating in data collection.

A crew of two is expected to conduct this SOP, with one member the observer and the other the recorder.

1.2. Point-Intercept Procedure

Record point-intercept data for each transect point using the following procedure:

1. Stand on the **downhill** side of the transect and work from the origin toward the 50 m end.
2. Start at 0 m on the tape and move forward 1 m for each consecutive point.

You will sample 50 points on each transect starting at 0 m and ending at 49 m.

3. Place the base of the pin flag on top of the soil as close to the point on the transect as possible.

Do not bias placement of the flag by trying to intercept or hit vegetation.

Do not force the pin flag into the ground, as this will bias placement of the pin flag on impenetrable materials.

If there is vegetation above the pin flag (i.e., >2 m), place a meter stick above the pin flag to intercept the vegetation.

4. Record each shrub species, life form category (i.e., annual forbs, annual grasses, perennial forbs, perennial grasses, trees), canopy cover type, or target invasive species that the pin flag intercepts, starting from the top-most layer.

Record each species/category only once, even if it is intercepted several times, except when there are live and dead plants for the same species/category (Figure 8.1). Then, the species/category would be recorded twice, once as live and once as dead. *If any part of a plant is alive, then the plant is considered live, even if it has dead branches attached.*

After a canopy layer has been recorded, it may be moved out of the way so that you can take subsequent hits for lower canopy and surface layers.

For each point, record the following information:

A. **Overstory** (layers >2 m)

1. If there are species >2 m tall, record the tallest species intercepted in the “Overstory” column using the USDA Plants Database code (for shrubs or target S&T invasive species only) or by life form (Tables 8.1-8.2; Figure 8.1).
If the intercepted plant is dead, indicate with a “-D” after the species code.
Unknown shrub species should be recorded as described in *SOP 14*.
If there is no overstory, then enter a “0” in the first “Overstory” column and proceed to top canopy (step 4B).
2. Record the next tallest species >2 m tall in the “Overstory 2” column. If there is no overstory, then enter a “0”.

Only two overstory hits will be recorded for each point. If there are more species >2 m tall, they will be recorded under “top canopy”.

B. Top canopy

The level of the different canopies are relative to each other. Thus, whatever plant material is intercepted first (except for overstory plants), will be recorded under “Top canopy”. If there is only one canopy layer, it will go under “Top canopy”.

Record the species of the top plant intercepted in the “Top canopy” column using the USDA Plants Database code (for shrubs or target S&T invasive species only), life form (Tables 8.1-8.2; Figure 8.1), or canopy cover type (Table 8.3).

Only litter and woody debris elevated above the soil surface and not embedded is considered a canopy layer (Table 8.3). Embedded litter and woody debris are considered under “Soil surface features” (Table 8.4).

If a plant is not intercepted, enter a “0” in this column.

If the intercepted plant is dead, indicate with a “-D” after the species code.

Unknown shrub species should be recorded as described in *SOP 14*.

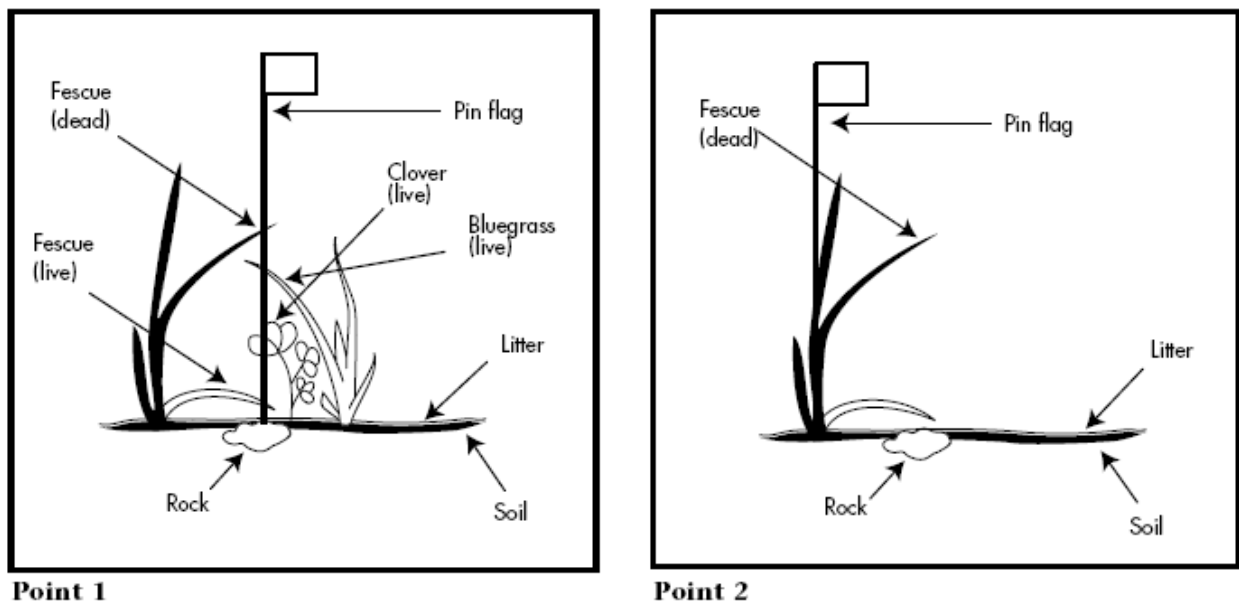


Figure 8.1. Points along a transect associated with the example shown in Table 8.2 (from Herrick et al. 2005).

Table 8.1. Two-letter plant codes for life forms.

Life form	Plant Code
Annual Forb	2FA
Annual Grass	2GA
Perennial Forb	2FP
Perennial Grass	2GP
Tree	2TREE

Table 8.2. Sample data for examples illustrated in Figure 8.1. In Point 1, the pin flag is touching live annual grass (2GA), perennial grass (2GP), live annual forb, and litter (L). If there a live and dead annual grass, then it would be recorded twice, once as dead and once as live. In Point 2, the pin flag touches live annual grass, litter, then the live annual grass plant base. In Point 3 (not shown in Figure 8.1), the pin flag touches dead *Atriplex canescens*, annual grass, and then litter. There is also an ant mound found at Point 3, which is recorded under disturbance. The table below shows how to record these three points.

Pt.			Top canopy	Lower canopy layers			Soil surface feature	Disturbance
	Overstory	Overstory 2		1	2	3		
1	0		2GA	2GP	2FA	L	SR	0
2	0		2GA	L			2GA	0
3	0		ATCA2-D	2GA	L		S	ant
etc.								

C. Lower canopy layers

1. From the top canopy species, move down the pin flag and record species intercepted in the order that they occur.
2. Use the “Lower canopy” columns (Figure 8.1; Table 8.2) to record all additional species intercepted by the pin flag. If you do not encounter any lower canopy layers, enter a “0” in the 1st lower canopy column.
If the intercepted plant is dead, indicate with a “-D” after the species code.
If there are fewer than four canopy layers, then enter a “0” in the column after the *last* recorded lower canopy layer (e.g., if there are 2 lower canopy layers, then enter a “0” under “lower canopy layer 3”).
3. If you hit more lower canopy layers than the number of columns available on the field form, record data for those layers in the additional lower canopy layers section of the field form.

Table 8.3. Codes and definitions of litter and woody debris as canopy layer classes for point-intercept sampling.

Code	canopy cover type	Definition
L	Litter	Detached dead plant material less than 2.5 cm in diameter that is not embedded in the soil surface
W	Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and not in direct contact with soil
SW	Scat, wildlife	Small scat droppings that do not serve as a soil surface, e.g., rabbit, mouse, and can roll away.

D. Soil surface features

Record what the pin flag intercepts at the soil surface in the “Soil surface” column of the *Point Intercept Field Form* (SOP 8 Appendix A); record the type of soil surface feature using the abbreviations defined in Table 8.4. These features are in direct contact with the soil or part of the soil; removal of feature would leave an indentation in the soil surface or would disturb the soil surface.

All points must have a code entered in the “Soil surface” column (Figure 8.1; Table 8.2).

If the pin flag intercepts a plant base (Figure 8.2), record the USDA Plants Database code (for shrubs or target S&T invasive species only) or life form category code. If the plant is dead, indicate with a “-D” after the code. If the base is an unknown shrub species, then record as described in *SOP 14*.

Use Figure 8.3 to help distinguish between undifferentiated crust and dark cyanobacteria.

To determine whether the soil surface on a macroplot is *bare soil* or *undifferentiated BSC*, test an area of bare soil just outside the macroplot (select an area that seems most representative of the macroplot). Use a spray bottle filled with water to wet the area. Then, carefully lift up the surface (~0.5 cm deep) of a small section of the wetted soil and hold up to the light. If you see clearish thread-like filaments protruding from the edges of the soil section, then undifferentiated BSC is present and all areas of “bare soil” on the macroplot should be recorded as “U” (crust, undifferentiated) for soil surface feature. If no clearish thread-like filaments are protruding from the soil section, then all “bare soil” will be recorded as “S” under soil surface feature.

E. Soil surface disturbance

Record whether the pin flag intercepts a disturbance on the soil surface in the “Disturbance” column of the *Point-Intercept Field Form* (Figure 8.1; Table 8.2). Enter a “0” in this column if there is no disturbance.

If the soil surface feature (scat, plant base, woody debris, large rock, bedrock) prevents determination of disturbance by covering up the area to be assessed, then enter “0” in the cell under “Disturbance”. Washes, human, livestock, and wildlife trails may be discerned by looking around the point of interest. That is, if a cow pie is in the middle of a livestock trail, it is reasonable to determine that the trail continues under the cow pie.

Use only abbreviations from Table 8.5 to label the type of disturbance.

In unusual cases, the base of the pin flag may intercept multiple disturbances (e.g., wash with wildlife track). Record both in the same cell of the “Disturbance” column, using a comma to separate the disturbance types.

5. Proceed to the next point on the transect and repeat steps 3-4.
Continue until all 50 points are completed.
6. When sampling for all points and transects is complete, proceed to *SOP 9 - Measuring Basal and Canopy Gaps Using Line-Intercept Sampling*. If *SOP 9* was conducted simultaneously with this *SOP*, then proceed to *SOP 11 – Soil Measurements* before removing any transect tapes and chaining pins to clear the macroplot.

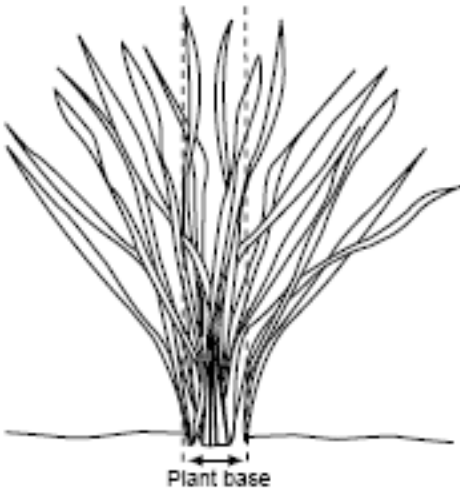


Figure 8.2. Area defined as a plant base (from Herrick et al. 2005).

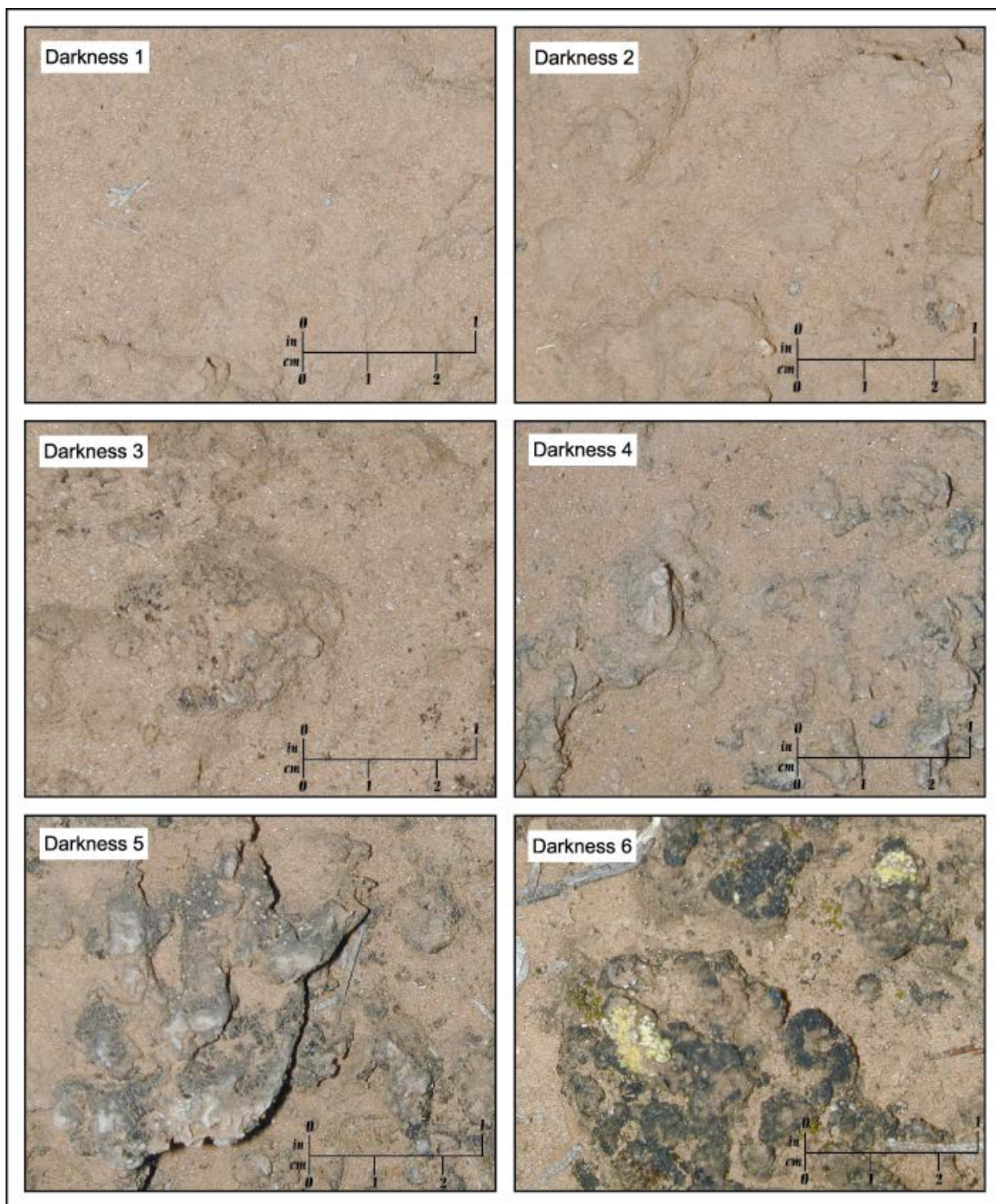


Figure 8.3. Photographic key to a six-class scheme for describing degrees of biological soil crust development (Belnap et al. 2008). Darkness 1-3 show mainly undifferentiated crust while Darkness 4-6 contain substantial areas of dark cyanobacteria. Darkness 6 also includes lichens.

Table 8.4. Codes and definitions of soil surface feature classes for point-intercept sampling. For plant bases, use USDA plant codes (see step 4c).

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 (Figure 8.3, darkness 1-3)
CY	Cyanobacteria	Darkened cyanobacterial soil crust, typically black in color (Figure 8.3, darkness 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	Embedded litter that is less than 2.5 cm in diameter, where removal of the litter would leave an indentation in the soil surface or would disturb the soil surface
W	Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and in direct contact with soil
SR	Small rock	Rock fragments 2 mm-10 cm in diameter
LR	Large rock	Rock fragments >10 cm in diameter
BR	Bedrock	Exposed bedrock
SL	Scat, livestock	Any type of livestock scat that sits on or is embedded into the soil or does not easily roll away
SW	Scat, wildlife	Any type of wildlife scat that sits on or is embedded into the soil or does not easily roll away

Table 8.5. Codes and definitions of soil surface disturbance classes for point-intercept sampling.

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

2. References

- Baldwin, B. G., S. Boyd, B. J. Ertter, R. W. Patterson, T. S. Rosatti, and D. H. Wilken. 2002. The Jepson desert manual: vascular plants of southeastern California. University of California Press, Berkeley, California.
- 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* 62:1257-1264.

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, New Mexico.

SOP 8 APPENDIX A: Point-Intercept Field Form

Integrated Uplands - VGS
SOP 8 - Point Intercept Field Form

Date: __/__/__ (MM/DD/YY)

Park code: _____

Macroplot Nbr: _____

Page 1 of 4

Observer: _____

Recorder: _____

Others: _____

Transect: 1 2 3

Point	Over Story (1)	Over Story (2)	Top Canopy	Lower Canopy Layers				Soil Surface	Point Disturbance
				1	2	3	4		
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

8A-1

MOJN I&M IU SOP

Integrated Uplands - VGS
SOP 8 - Point Intercept Field Form

Date: __/__/__ (MM/DD/YY)

Park code: ____

Macroplot Nbr: ____

Page 2 of 4

Transect: 1 2 3

Point	Over Story (1)	Over Story (2)	Top Canopy	Lower Canopy Layers				Soil Surface	Point Disturbance
				1	2	3	4		
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									

8A-2

MOJN I&M IU SOP

Integrated Uplands - VGS
SOP 8 - Point Intercept Field Form

Date: __/__/__ (MM/DD/YY)

Park code: _____

Macroplot Nbr: _____

Page 3 of 4

Transect: 1 2 3

Point	Over Story (1)	Over Story (2)	Top Canopy	Lower Canopy Layers				Soil Surface	Point Disturbance
				1	2	3	4		
32									
33									
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									
47									

8A-3

MOJN I&M IU SOP

Integrated Uplands - VGS
SOP 8 - Point Intercept Field Form

Date: __/__/__ (MM/DD/YY)

Park code: _____

Macroplot Nbr: _____

Page 4 of 4

Transect: 1 2 3

Point	Over Story (1)	Over Story (2)	Top Canopy	Lower Canopy Layers				Soil Surface	Point Disturbance
				1	2	3	4		
48									
49									

Point	Lower Canopy Layers				
	5	6	7	8	9

8A-4

MOJN I&M IU SOP

Standard Operating Procedure (SOP) # 9: Measuring Basal and Canopy Gaps Using Line-Intercept Sampling

Version 1.0

Revision History Log:

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

This SOP provides instructions for measuring gaps between plant canopies and between plant bases of perennial species.

This SOP was adapted from *SOP 9 – Measuring Canopy and Basal Gaps* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol (which was based on Herrick et al. 2005). *SOP 7 - Macroplot Establishment and Revisit Set-Up* should be completed before this SOP is implemented; that is, the transect tapes have been laid out. This SOP can be conducted simultaneously with *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling*. *SOP 5 - Crust-Friendly Field Procedures* should be reviewed before sampling.

1. Filling out the Field Form

For each transect, fill out relevant information at the top of the *Canopy and Basal Gap Field Form* (SOP 9 Appendix A) including:

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

Macroplot Nbr – A pre-assigned, unique number provided for each macroplot.

Date – mm/dd/yyyy

Transect – 1, 2, or 3

Observer – Record the three initials (first, middle, and last name initials) of the observer.

Recorder – Record the three initials the recorder.

Others – Record the three initials of any people with the crew but not participating in data collection.

A crew of two is expected to conduct this SOP, with one member the observer and the other the recorder.

If there are multiple field form pages for this SOP, make sure to record the page number of the field form. When you finish, fill in the space on each field form that indicates the total number of field forms.

2. Canopy gaps

A canopy is defined as the aboveground portion of the plant. The canopy of a plant extends past the base of a plant and leads to a greater area being covered if we consider the canopy from edge to edge (Figure 9.1). In this SOP, we consider canopies to be the aboveground part of **perennial shrubs, trees, grasses, and forbs**. Canopies can be formed by live or dead plants. For this protocol, perennial plants growing close together may form one continuous canopy.

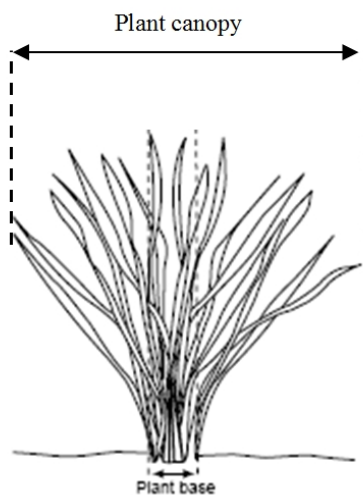


Figure 9.1. Canopy and base of a grass plant (from Herrick et al. 2005).

1. Stand on the downhill side of the transect tape.
2. Start at the 0-m end and work from left to right towards the 50-m end.
3. Look straight down the tape and go to the first perennial plant with a canopy overhanging the transect tape (remember canopies can be live or dead).

Canopy occurs any time 50% of any 3 cm segment of tape edge intercepts live or dead perennial plant canopy based on a vertical projection from canopy to ground (Figure 9.2).

4. Go to the edge of the canopy closest to the transect origin (this would be the left side of the plant, if the origin is to the left).

Use a meter stick or other stiff stick to project a line vertically to the ground on the uphill side of the tape to determine the distance of the canopy edge, to the nearest hundredths of a meter, from the transect origin. If the canopy is taller than the meter stick, you may need to project the meter stick from the canopy edge onto the ground.

If the gap from the transect origin to the closest part of the canopy is ≥ 20 cm, then this would be considered the first canopy gap (the transect origin, 0 m, is the *start* of the gap and the edge of the canopy the *end* of the gap). Record the start and end points in the first row of cells under the respective canopy gap columns.

If the gap from the transect origin to the closest part of the canopy is <20 cm, then this is not considered a canopy gap. Proceed across the canopy to the first gap and use the edge of the canopy as the beginning (left-edge) of the first gap.

5. Go to the other side of the canopy, away from the transect origin (this would be the right side of the plant, if the origin is to the left).
6. 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 number on the transect tape, to the nearest hundredths of a meter, as the start point of the second canopy gap (second row of cells).

7. Go to the closest edge of the next perennial plant that has a canopy (Figures 9.3 – 9.4). The distance from the previous point must be at least 20 cm (Figures 9.3 – 9.4, Table 9.1). If the distance is <20 cm, then move onto the next perennial plant that has a canopy. If the gap is ≥ 20 cm, then use a meter stick to project a line vertically to the ground on the uphill side of the tape.

Record this number as the end point of the second canopy gap.

8. Repeat step 6 for the other side of the plant canopy; this will be the beginning of the next canopy gap.
9. Repeat step 7 to get the end of the canopy gap.
10. Repeat steps 8-9 for the rest of the canopy gaps.

Record the start and end of each canopy gap to the nearest hundredths of a meter.

If the last canopy gap goes past the 50 m end of the transect tape, then enter “50” into the appropriate “canopy gap end” cell on the field form.

Keep in mind the following rules when measuring canopy gaps:

- a. Canopy occurs any time 50% of any 3 cm segment of tape edge intercepts live or dead perennial plant canopy based on a vertical projection from canopy to ground (Figure 9.2). The only exception to this rule occurs when you have a space between canopies <20 cm.
- b. If a space <20 cm occurs on either end of the transect (from the 0 or 50 m mark), do not count this as a gap. That is, if there is a perennial plant with a canopy <20 cm from either end of the transect tape, the distance from the plant to the end of the tape is **not** considered a canopy gap.

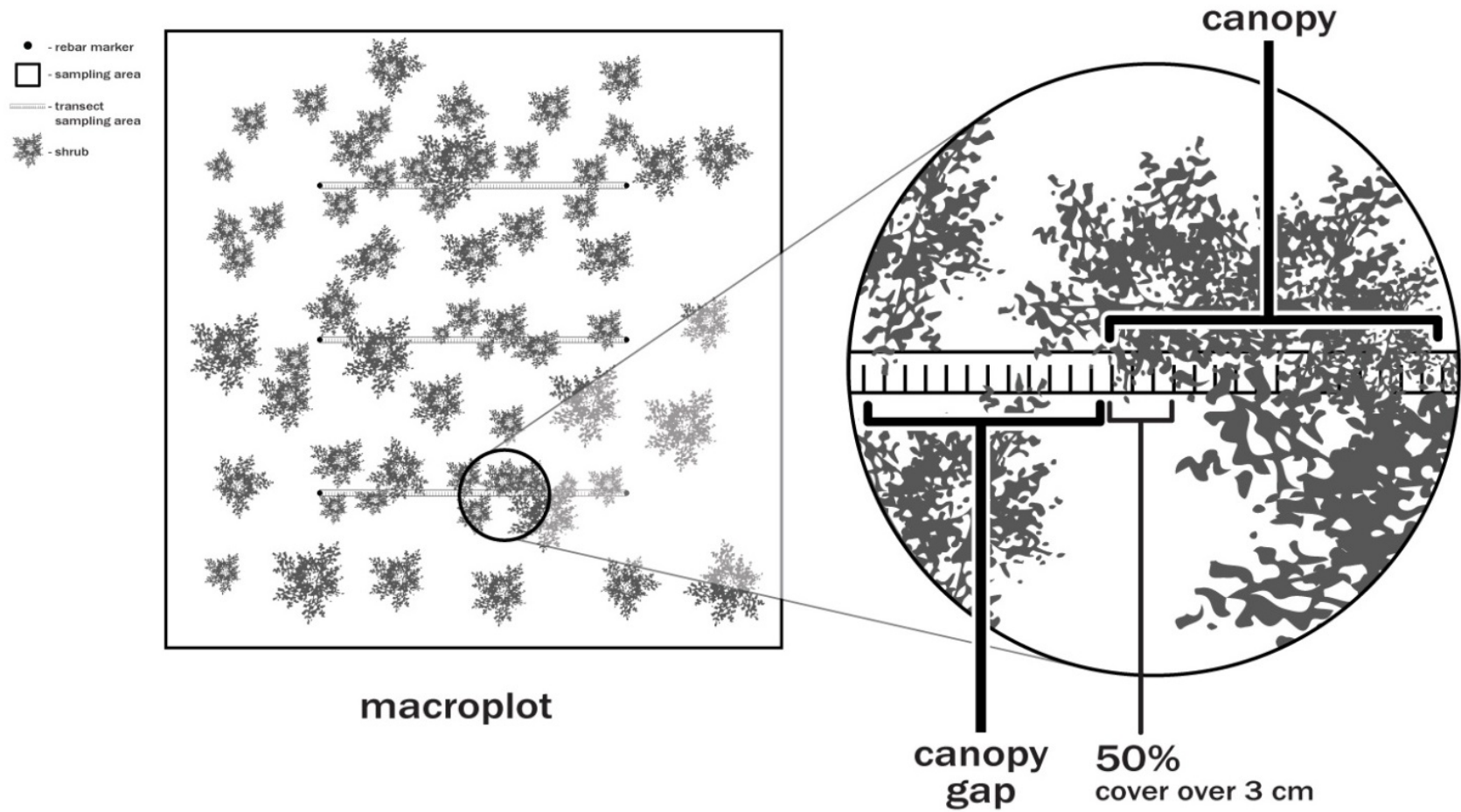


Figure 9.2. Example of 50% canopy cover over a 3 cm segment of the transect. Tick marks are in cm.

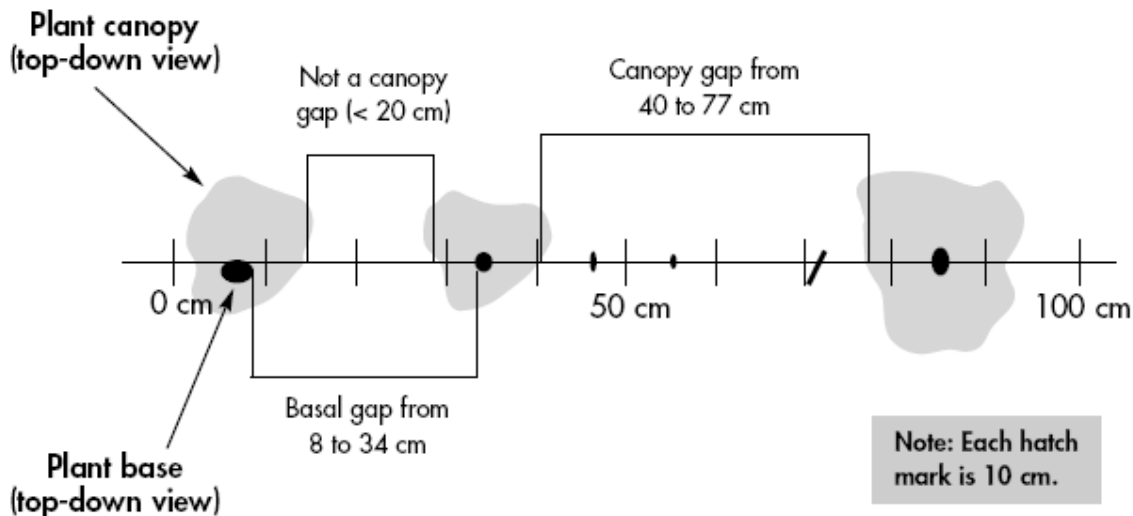


Figure 9.3. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 1 m (100 cm) of a 50-m transect. Canopy gaps: There is a gap between 40 cm (0.40 m) and 77 cm (0.77 m) because the plant canopies do not cover more than 50% of any 3 cm segment. On the other hand, even though the first two plants along the transect are shrubs, the space in between is less than 20 cm (0.20 m), so the entire segment from 0-40 cm (0.40 m) is considered shrub canopy. Basal gaps: There is a basal gap between 8 cm (0.08 m) and 34 cm (0.34 m). Since the three small plant bases between 34 cm (0.34 m) and 86 cm (0.86 m) are all within 20 cm of an adjacent plant base, there are no basal gaps even though there is a canopy gap. (From Herrick et al. 2005.)

Table 9.1. Gap intercept field form example associated with Figure 9.2.

Canopy Gaps		Basal Gaps	
Gap start (m)	Gap end (m)	Gap start (m)	Gap end (m)
0.40	0.77	0.08	0.34
0.93		0.85	

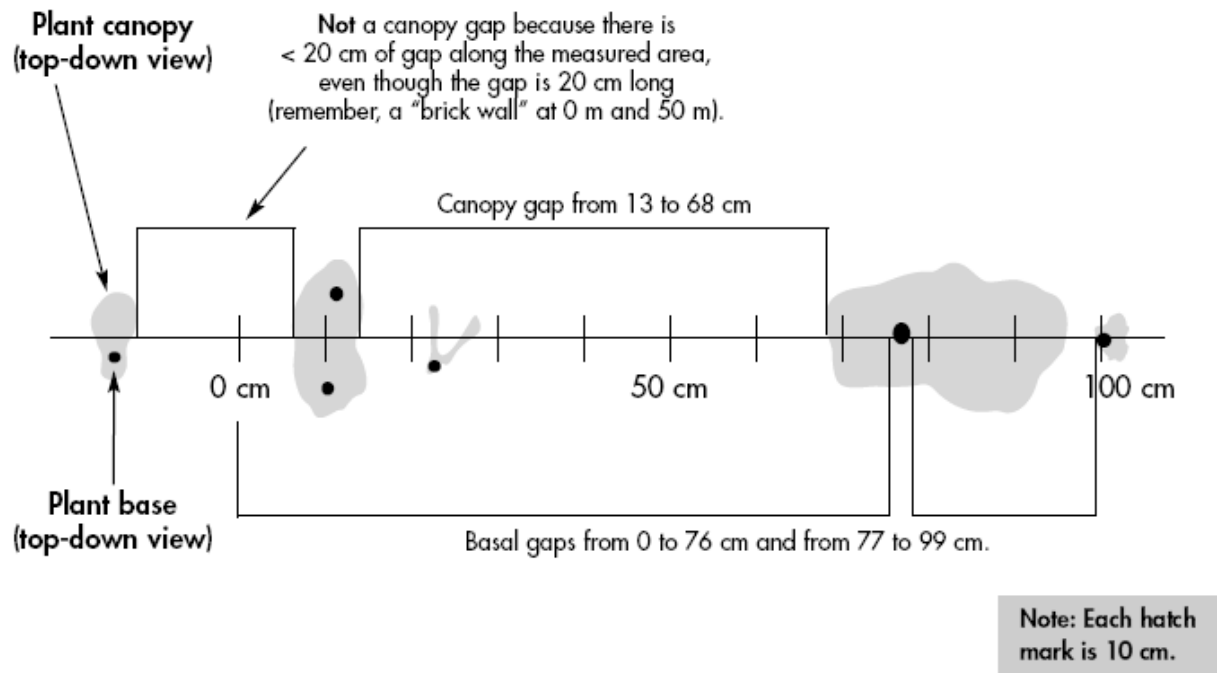


Figure 9.4. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 1 m (100 cm) of a 50-m transect. Canopy gaps: Shrub canopy starts at 6 cm (0.06 m) since the space from 0 to 6 cm (0.06 m) is not large enough to be considered a canopy gap. Look at the plant canopy intercept between the 20 and 30 cm (0.20-0.30 m) 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. (From Herrick et al. 2005)

3. Basal gaps

Immediately after you finish recording canopy gaps, begin sampling basal gaps from the 50 m end of the tape and work back towards the 0 m origin of the tape. We consider a plant base to be 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 of plant base = 1 mm). Plant bases must be anchored to the ground and can be either live or dead (Figure 9.1). We will only be measuring basal gaps formed by **perennial shrubs, trees, grasses, and forbs**.

1. Remain on the downhill side of the transect.
2. Look straight down on the tape, toward the transect origin, and go to the first perennial plant base that falls under the transect tape.
3. Go to the edge of the plant base closest to the 50 m end (this would be the right side of the plant, if the transect origin is to the left).

Use a meter stick or other stiff stick to project a line vertically to the ground on the uphill side of the tape to determine the distance of the plant base, to the nearest hundredths of a meter, from the 50 m end of the transect.

If the gap from the 50 m mark to the plant base is ≥ 20 cm, then this would be considered the first basal gap (remember that since you are moving from the 50 m end of the transect toward

the transect origin, the 50 m mark is the *end* of the gap and the closest edge of the plant base, the *start* of the gap). Record the start and end points in the first row of cells under the respective basal gap columns.

If the gap from the 50 m mark to the plant base is <20 cm, then this is not considered a basal gap.

4. Go to the edge of the plant base on the side of the tape away from the 50 m mark (this would be the left side of the plant, if the transect origin is to the left).

Use a meter stick or other stiff stick to project a line vertically to the ground on the uphill side of the tape to determine the distance of the plant base, to the nearest hundredths of a meter, along the transect tape. Record this number as the end of the second basal gap.

5. Walk toward the origin of the transect tape to search for the next plant base that falls under the transect tape. If the base is ≥ 20 cm from the previous base, then this plant base would be the start of the basal gap.

Repeat step 3 and record the gap start, to the nearest hundredths of a meter, as the start of the second basal gap (Figures 9.3 – 9.4, Table 9.1).

6. Repeat steps 4 and 5 to measure the remaining basal gaps.

Keep in mind the following rules when measuring basal gaps:

- a. The minimum diameter of a plant base is 1 mm (0.001 m).
- b. A basal gap occurs any time there is at least 20 cm of transect tape without a plant base under it. Therefore, there should always be at least 20 cm between basal gap starts and basal gap ends.
- c. If a basal gap of <20 cm occurs on either end of the transect, do not count this as a gap.

4. 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, New Mexico.

SOP 9 APPENDIX A: Canopy and Basal Gap Field Form

Integrated Uplands - VGS
SOP 9 - Canopy and Basal Gap Field Form

Date: ____/____/____ (MM/DD/YY) Park code: ____ Macroplot Nbr: ____ PAGE ____ of ____
 Observer: _____ Recorder: _____ Others: _____

[illegible]

Standard Operating Procedure (SOP) # 10: Assessing Invasive Plant and Disturbance Frequency Using Quadrats

Version 1.0

Revision History Log:

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

This SOP provides detailed instructions on how to determine the frequency of targeted invasive plant species, soil disturbances, and developed biological soil crust (BSC) using quadrats. BSC was added to this SOP because we found that *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling* did a poor job of detecting it (Pan and Tallent 2013). A list of targeted status and trends invasive plants for each park is presented in Appendix A of the *Integrated Upland Protocol of the Mojave Desert Network, Volume 1: Protocol Narrative* and will be provided to field crews. Targeted species were determined using *MOJN I&M SOP M2 - Prioritizing Invasive Species for Status and Trends Monitoring*.

This SOP was adapted from *SOP 10 - Measuring shrub and tree seedling density, exotic frequency, species richness, and canopy closure* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol (which was based on Herrick et al. (2005)). *SOP 7 - Macroplot Establishment and Revisit Set-Up* should be completed before this SOP is implemented; that is, the transect tapes have been laid out. This SOP should be completed after *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling* and *SOP 9 - Measuring Basal and Canopy Gaps Using Line-Intercept Sampling*. *SOP 5 - Crust-Friendly Field Procedures* should be reviewed before sampling.

1. Filling Out the Field Form

For each transect, fill out relevant information at the top of the *Invasive Species Frequency Field Form* (SOP 10 Appendix A) including:

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

Macroplot Nbr – A pre-assigned, unique number provided for each macroplot.

Date – mm/dd/yyyy

Transect – 1, 2, or 3

Observer – Record the three initials (first, middle, and last name initials) of the observer.

Recorder – Record the three initials and last name of the recorder.

Others – Record the three initials of any people with the crew but not participating in data collection.

A crew of two is expected to conduct this SOP, with one member the observer and the other the recorder.

If there are multiple field form pages for this SOP, make sure to record the page number of the field form. When you finish, fill in the space on each field form that indicates the total number of field forms.

2. Assessing the Quadrats

Record the presence of target invasive plant species rooted within 0.25×0.25 m quadrats placed every meter along each transect beginning at 0 m. There will be a total of 50 quadrats along each transect.

1. Start at the origin (0-m mark) of transect 1 (Figure 10.1).
2. Use 2 meter sticks to delineate a 0.25×0.25 m quadrat to the right of the starting point on the *uphill* side of the transect tape (walk only on the downhill side of the transect tape). One end of the quadrat will be perpendicular to the 0 m mark and the other end of the quadrat will be perpendicular to the 0.25 m mark.
3. Determine whether the targeted invasive species (dead or alive) are present within the quadrat. Plants must be rooted at least 50% within the quadrat to be considered in the quadrat.
Record a “0” in the invasive species cell for any quadrats that do not contain any of the target invasive species and proceed to step 5.

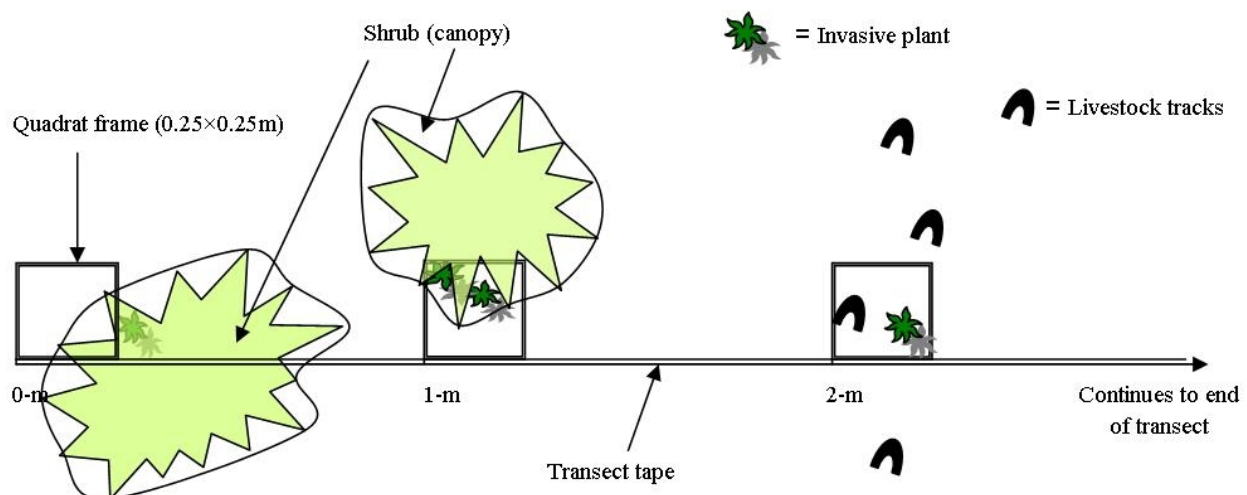


Figure 10.1. Diagram of invasive plant and disturbance frequency quadrat placement showing the first three sample points on a transect. Invasive species are absent from the quadrat at the 0 m mark because the invasive species is not rooted within the quadrat. Invasive species are present in the quadrat at the 1 m mark and they are located under canopy (“C”). For the quadrat located at the 2 m mark, both invasive species and disturbance are present in this quadrat; the invasive species is found in the interspace (“I”).

4. Record the following data for each target invasive species found in the quadrat on the *Invasive Species Frequency Field Form* (SOP 10 Appendix A).
 - a. Determine the dominant phenological stage of the species by examining all individuals within the quadrat and determining what stage a majority of them are in. Circle the most common phenological stage of the species (Table 10.1).
 - b. Circle “C” to indicate whether plants are primarily located under canopies, or fall within an area influenced by canopy (see Figure 10.1), or “I” for interspaces. If plants of a target species appear equally under both canopies and interspaces, then indicate with a “CI”. In order for plants to be considered under both areas, individuals of the particular species must have 40-60% of the individuals found under canopies and in interspaces.
5. If any disturbances are found in the quadrat, then record the disturbance codes (Table 10.2) of each disturbance in the quadrat. Separate different disturbance codes with commas. If there are no disturbances, enter “0” under “Disturbance” on the field form.
6. If any developed biological crusts are found in the quadrat, then circle the “P” for present under BSC. If no developed crusts are found, then circle the “A” for absent. Developed BSC is present when there are obvious structures of BSC (Figure 10.2). There may be crust present in the absence of BSC structures, or when only sandy soil is present (that is, cyanobacterial filaments can be seen when surface soils are wetted and lifted from the ground), but these would be considered undeveloped BSC and not recorded for this SOP.
7. When all data has been recorded, pick up the quadrat frame and proceed to the next point. The “next” point will be 1 m greater than the previous point.
8. Repeat steps 1-6 for each point along that transect that is an increment of 1 m (e.g., 1, 2, 3). The last point will be at 49 m; do not measure the 50 m mark.
9. After the transect is complete, pick up the quadrat frame and proceed to the origin of transect 2.
10. Repeat steps 1-9, except for step 9, proceed to transect 3.

Table 10.1. Phenological stages (phenophases) for major plant growth forms. Record the code of the prevailing phenophase of the invasive plant within each quadrat on the field form.

Phenophase Code	Woody plant (Shrub/Tree)	Forb	Grass
1	leaf buds formed/ leafing out	seedling/early vegetative	seedling/early vegetative
2	fully open leaves	vegetative/basal rosette	vegetative - multiple tillers
3	reproductive/flowering	reproductive/flowering	reproductive/flowering
4	fruit formation/ripening	fruit formation/ripening	seed ripening
5	dead/senescent	dead/senescent	dead/senescent

Table 10.2. Disturbance type and codes of soil-surface disturbances.

Code	Disturbance type	Definition
Ant	Ant mound	Holes and mounds created by ants
Bike	Bicycle	Disturbances caused by non-motorized bicycles
Human	Human track/trail	Tracks or trails created by humans
Live	Livestock track/trail	Tracks, marks, or trails created by livestock
Auto	Motor vehicle	Disturbances caused by any motorized vehicle
Wash	Water erosion	Small to large eroded channels caused by (temporary) flowing water where obvious soil and vegetation displacement occurs with some regularity.
Wilde	Wildlife excavation	Holes and mounds created by wildlife (e.g. rodents)
Wildt	Wildlife track	Tracks, marks, or trails created by wildlife
Other	Other anthropogenic	Any human disturbance other than tracks and trails
Undiff	Undifferentiated	Any disturbance of indeterminate origin or not classified as one of the other categories

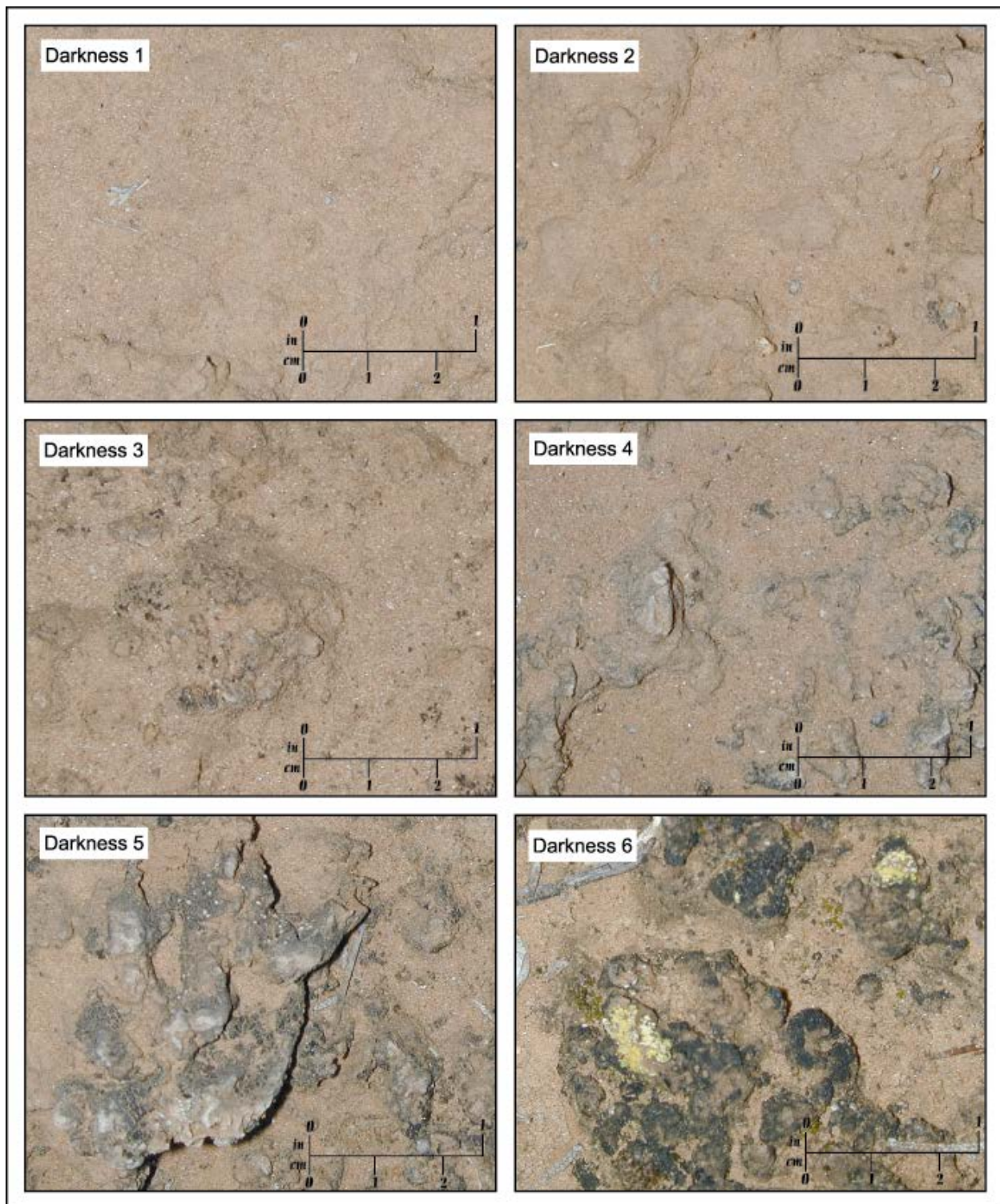


Figure 10.2. Photographic key to a six-class scheme for describing degrees of biological soil crust development (Belnap et al. 2008). Darkness 1-3 show mainly undifferentiated crust while Darkness 4-6 contain substantial areas of dark cyanobacteria. Darkness 6 also includes lichens.

3. 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, New Mexico.
- Pan, J. J., and N. Tallent. 2013. Mojave Desert Network integrated upland monitoring: 2012 pilot study for Mojave National Preserve. Natural Resource Technical Report NPS/MOJN/NRTR—2013/827 National Park Service, Fort Collins, Colorado.

Integrated Uplands - VGS
SOP 10 - Invasive Species Frequency Field Form

Date: ____/____/____ (MM/DD/YY) Park code: ____ Macroplot Nbr: ____

Observer: _____ Recorder: _____

Others: _____ Page ____ of ____

Transect: 1 2 3

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Standard Operating Procedure (SOP) # 11: Soil Measurements

Version 1.0

Revision History Log:

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

This SOP details methods for assessing multiple soil parameters, including soil chemistry and hydrologic functions, within monitoring plots. These parameters may be measured during each sampling period or at periodic intervals as determined by MOJN I&M. Soil disturbance is assessed in other SOPs (specifically, *SOP 10 - Assessing Invasive Plant and Disturbance Frequency Using Quadrats*, and *SOP 12 – Site Assessment for Invasive Plant and Target Tree Species*).

The procedures in this SOP were based on those developed by the Natural Resources Conservation Service (NRCS) and described in Schoeneberger et al. (2002). *SOP 7 - Macroplot Establishment and Revisit Set-Up* should be completed before this SOP is implemented.

1. Sampling Design

In the first year, there will be 12 sampling points, three along each edge of the 100 by 100 m macroplot, 25 m apart (Figure 11.1). Some of the points may already be marked if the transects and corners of the macroplot have been set-up (see *SOP 7 – Macroplot Establishment and Revisit Set-up*). The procedure below describes how to locate the 12 sampling locations the first year. If the soil sampling point lands on an area with no soil (i.e., bedrock, boulder), then the correct material type should be indicated under the soil texture cell on the field form and no other soil parameters need to be measured for that sampling point.

In subsequent years, the 12 sampling points will be randomly located along the edge of the macroplot (see section 4. *Revisiting the Macroplot*).

1. Fill out relevant information at the top of the *Soil Measurements Field Form* (SOP 11 Appendix A) including:
Park code – Use the standard 4-letter code to indicate the park unit.
Macroplot Nbr – A pre-assigned, unique number provided for each site.
Date – mm/dd/yyyy
Observer – Record the three initials (first, middle, and last name initials) of the observer.
Recorder – Record the three initials of the recorder.

Others – Record the three initials of any people with the crew but not participating in data collection.

pH meter Nbr – MOJN assigned number that is on each meter.

EC meter Nbr – MOJN assigned number that is on each meter.

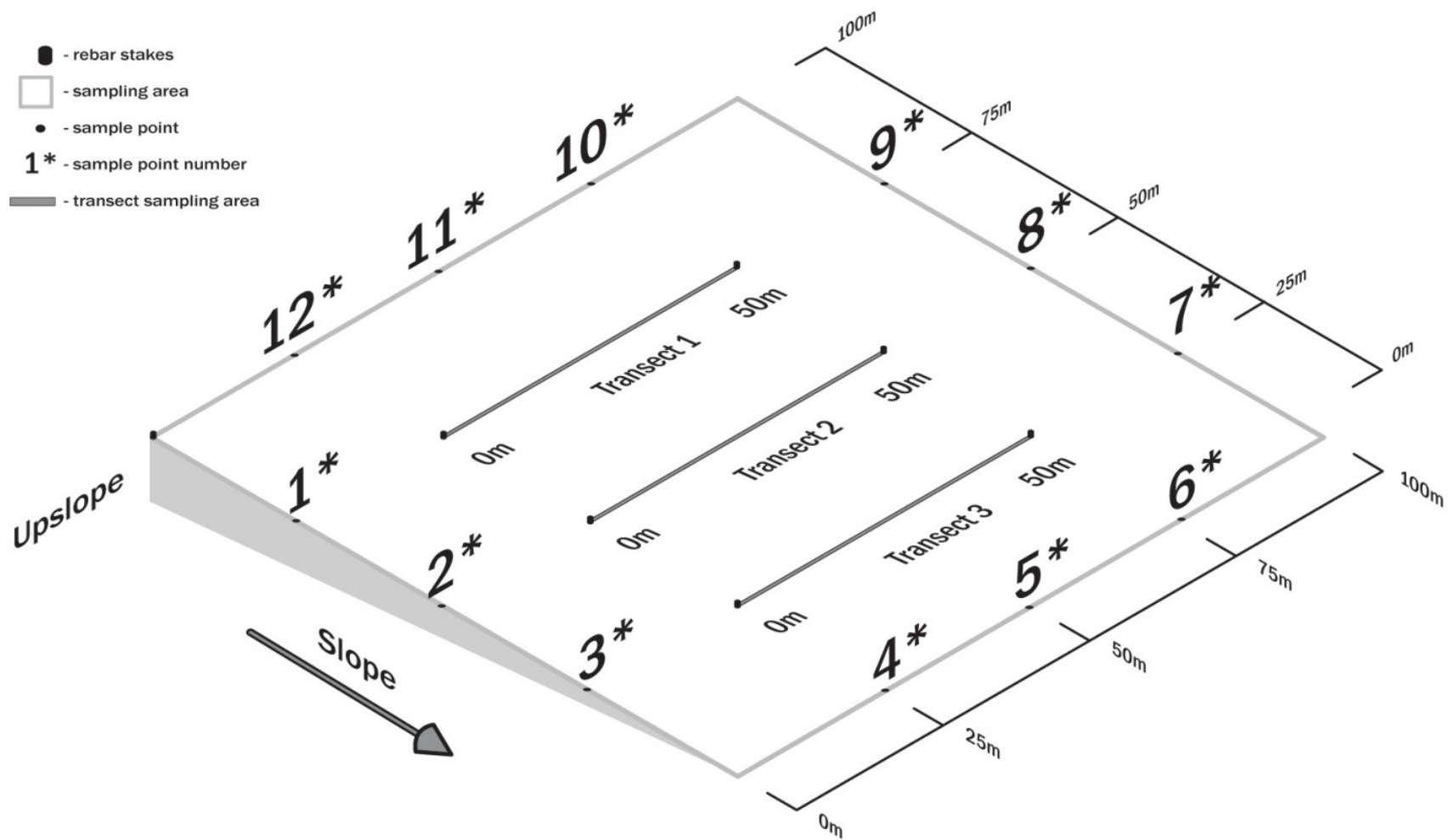


Figure 11.1. Standard macroplot and transect layout showing soil sampling points. Locations on the edge of the macroplot indicated by an “*” are sampling locations for soil parameters during the first year of implementation only. The number next to the “*” is the sampling location number.

2. Since *SOP 7 – Macroplot Establishment and Revisit Set-up* was conducted prior to this SOP, there are only 2 soil sampling points remaining to be established.
Starting from the center (25 m) point of transect 1, crew member B will take the free end of a 50 m tape, a pin flag, and head upslope for 25 m. Crew member A will direct crew member B in the correct compass bearing (the bearing in the box above the vertical line in the “bearings” diagram on the *Macroplot Establishment Field Form*).
3. Crew member B will take a compass bearing back to crew member A to check that the tape was pulled in the correct direction. The compass bearing that crew member B reads should be 180° from crew member A’s reading.
Crew member B will use a pin flag to mark the correct point.
4. Starting from the center (25 m) point of transect 3, crew member B will take the free end of a 50 m tape, a pin flag, and head downslope for 25 m. Crew member A will direct crew member B in the correct compass bearing (the bearing in the box below the vertical line in the “bearings” diagram on the *Macroplot Establishment Field Form*).
5. Crew member B will take a compass bearing back to crew member A to check that the tape was pulled in the correct direction. The compass bearing that crew member B reads should be 180° from crew member A’s reading.
Crew member B will use a pin flag to mark the correct point.

2. Measuring Soil Parameters

All soil parameters will be measured at each sampling location. It may be easier to take **all measurements for one location before proceeding to the next location**. For all measurements except *2.1 Soil Strength - Penetration Resistance*, two soil samples will be collected from each location, one from underneath plants (dead or alive) and another from a barren area (may be covered by plant material but is not underneath a plant). Soil samples should be collected from the side of the pin flag that is inside of the macroplot. Crew members should stand along the outside edge (edge away from center) of the macroplot when taking soil measurements.

All soil measurements that require soil collection should be conducted at one time on the same soil samples. Sieved soils should be used for all tests *except* penetration resistance and rupture resistance. Minimize the amount of soil collected to reduce impacts to the site.

2.1. Soil Strength - Penetration Resistance

One way to quantify soil strength is to measure the force needed to insert a penetrometer (i.e., a standard cone-tipped rod) into the soil. Five measurements will be averaged for each soil sampling location to determine penetration resistance. The following procedure describes how to use a portable or pocket penetrometer (Humboldt H-4200 or equivalent):

1. Start near the flag at sampling point 1 (Figure 11.1).
2. The scale indicator (top of penetrometer) should be fully inserted into the penetrometer (only the 0.0 should be showing).

3. Choose a location near the flag and push the tip of the penetrometer into the soil until it reaches the engraved part (1/4" from the tip). To obtain consistent readings, do not push the penetrometer beyond the engraved portion of the tip.
If the penetrometer is obstructed by large roots or rocks beneath the soil surface, then choose a location that is away from the obstructing materials.
4. Record the number that corresponds to the line showing just over the top of the penetrometer (just over the black handle) in the appropriate column on the *Soil Measurements Field Form* (SOP 11 Appendix A). Lines are in 0.25 increments. The maximum reading of the penetrometer is 4.5 tons/ft².
5. Wipe off the tip of the penetrometer.
6. Repeat steps 2-5 for four other randomly chosen locations around the pin flag.
The randomly chosen locations should all be within 10 cm of the pin flag. If it is not possible to sample five locations within 10 cm of the pin flag (e.g., the area is covered with roots or the presence of rocks in the subsurface prevents insertion of the penetrometer), then expand the circle to a 25 cm radius and indicate this on the *Soil Measurements Field Form* (SOP 11 Appendix A).
7. During data entry in the office, convert the scale reading on the penetrometer to megapascals (MPa) using Table 11.1. It is important to note that the penetrometer does not directly measure penetration resistance. The penetrometer scale is correlated to and provides an estimate of the unconfined compressive strength of soil in the field.
8. Determine the Penetration Resistance Class by comparing the MPa reading with the Penetration Resistance Class boundaries indicated in Table 11.2.
9. Record the Penetration Resistance Class code (Table 11.2), which range from extremely low (EL) to extremely high (EH) on the *Soil Measurements Field Form* (SOP 11 Appendix A).
10. Repeat steps 1-9 for the remaining eleven sampling locations.

Table 11.1. Conversion of the scale reading on the Humboldt H-4200 pocket penetrometer to penetration resistance in MPa.

Penetrometer Scale Reading (tons/ft ²)	Penetration Resistance (MPa)
0.25	0.02
0.50	0.05
0.75	0.07
1.00	0.09
1.25	0.11
1.50	0.14
1.75	0.17
2.00	0.19
2.25	0.22
2.50	0.25
2.75	0.26
3.00	0.29
3.25	0.31
3.50	0.33
3.75	0.36
4.00	0.38
4.25	0.41
4.50	0.43

Table 11.2. Penetration resistance ranges for each penetration code.¹ See Table 11.1 for conversion from penetrometer readings to penetration resistance.

Penetration Resistance Class	Code	Criteria: Penetration Resistance (MPa)
Extremely Low	EL	<0.01
Very Low	VL	0.01 to <0.1
Low	L	0.1 to <1
Moderate	M	1 to <2
High	H	2 to <4
Very High	VH	4 to <8
Extremely High	EH	≥8

¹ Table reproduced from Schoenberger et al. (2002).

2.2. Soil Consistence and Texture

Soil consistence is specifically defined as the degree and kind of cohesion and adhesion exhibited by the soil and/or the resistance of soil to deformation or rupture under an applied stress (Schoeneberger et al. 2002). For soil consistence, we will evaluate rupture resistance (blocks, peds, and clods or surface crusts and plates), soil stickiness, and soil plasticity. Soil color will also be assessed under soil consistence. Soil color is influenced by additions of organic matter and other constituents, as well as parent materials.

Soil texture is defined as the “relative proportions of the various soil separates (i.e., sand, silt, and clay-sized particles) in a soil” (Soil Science Society of America 2008). The soil is placed in a textural class based on the percentage of sand, silt and clay within the ≤2 mm size fraction.

Sieved soil will be used for soil texture analysis, soil stickiness, and soil plasticity. *All three parameters should be assessed on the same soil sample (i.e., when the soil is moistened for soil stickiness, its' plasticity and texture can be assessed on the same wet sample).*

2.2.1. Rupture Resistance

Rupture resistance is an evaluation of the force required to rupture or break a moist and dry soil aggregate (Figure 11.2).

1. Choose the closest location *within* the macroplot to the pin flag at the sampling point.
If it is a barren sample, then you will also need find the nearest vegetated sample. Record “v” for vegetated sample and the distance from the pin flag to the *vegetated sample* under the “sample distance” column on the *Soil Measurements Field Form* (SOP 11 Appendix A).
If the pin flag marks a vegetated sample, then you will need to find the nearest barren sample. Record “b” for barren sample and the distance from the pin flag to the *barren sample* under the “sample distance” column on the *Soil Measurements Field Form* (SOP 11 Appendix A).
2. Obtain structural aggregates of soil from the area nearest the pin flag and from the corresponding barren/vegetated area by using the trowel to lift a section of the soil to be sampled.

Block-or cube-shaped aggregates should be about 1 inch across.

Plate-shaped aggregates (surface crusts or platy structure) should be about ½-inch long and ¼-inch thick (Figure 11.2).

If it is not possible to obtain an aggregate (e.g., soils with a high percentage of sand will not form aggregates), then describe the sample as **dry** under the “moisture” column and “blocks, peds, clods” under the “structural” column, and “loose” under the rupture resistance column under soil consistence.

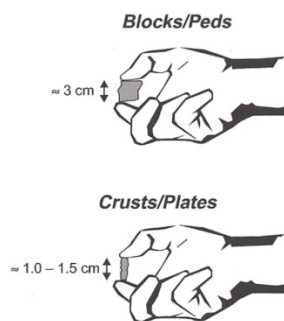


Figure 11.2. Illustration of how to assess soil rupture resistance.

3. Estimate the moisture content of each of the aggregates as either **dry**, **moist**, or **wet** and record in the “moisture” column under soil consistence.
If the aggregate is wet, allow it to become moderately dry before proceeding to step 5.
4. Place each soil aggregate between your fingers and determine how difficult it is to break the soil unit.

If the aggregate is block- or cube-shaped, use the class and codes in Table 11.3 for rupture resistance.

If the aggregate is a surface crust or platy aggregate, use the class and codes in Table 11.4 for rupture resistance.

5. Record the aggregate type in the appropriate spaces under “structural” under soil consistence and rupture resistance code in the appropriate spaces on the *Soil Measurements Field Form* (SOP 11 Appendix A).
6. Repeat steps 1-5 for the remaining eleven sampling locations.

Table 11.3. Rupture Resistance for Blocks, Peds, and Clods.¹

Dry ²		Moist ²		Specimen Breaks Under ³
Class	Code	Class	Code	
Loose	L	Loose	L	Intact specimen cannot be obtained
Soft	S	Very Friable	VFR	Very slight force between fingers; <8 N
Slightly Hard	SH	Friable	FR	Slight force between fingers; 8 to <20 N
Moderately Hard	MH	Firm	FI	Moderate force between fingers; 20 to <40 N
Hard	HA	Very Firm	VFI	Strong force between fingers; 40 to <80 N
Very Hard	VH	Extremely Firm	EF	Moderate force between hands; 80 to <160 N
Extremely Hard	EH	Slightly Rigid	SR	Foot pressure by full body weight; 160 to <800 N
Rigid	R	Rigid	R	Blow of <3 J but not body weight; 800 N to <3 J
Very Rigid	VR	Very Rigid	VR	Blow of ≥3 J (3 J = 2 kg weight dropped 15 cm)

¹ Table reproduced from Schoeneberger et al. (2002).

² Dry Rupture Resistance column applies to soils that are moderately dry or drier. Moist column applies to soils that are slightly dry or wetter.

³ The SI standard unit of force is the newton (N). The British unit of force is the pound-force (lbf), and 1 lbf = 4.48 N or 1N = 0.2247 lb. Joules (J) are a measure of energy; 1 calorie = 4.186 J.

Table 11.4. Rupture Resistance for Surface Crust and Plates.¹

Class (air dried)	Code	Force ² (Newtons)
Extremely Weak	EW	Intact specimen cannot be obtained
Very Weak	VW	Removable, <1 N
Weak	W	1 to <3 N
Moderate	M	3 to <8 N
Moderately Strong	MS	8 to <20 N
Strong	S	20 to <40 N
Very Strong	VS	40 to <80 N
Extremely Strong	ES	≥80 N

¹ Table reproduced from Schoeneberger et al. (2002).

² In the field, estimates of force (N) can be made using the *Specimen Breaks Under* column in the Rupture Resistance for Blocks, Peds, and Clods table. The SI standard unit of force is the newton (N).

2.2.2. Soil Texture

We will analyze soil texture by placing a small sample of sieved soil in a vial of water to assess the % of sand, silt, and clay in the sample. The textural classification may be modified by the addition of adjectives when particles >2 mm in diameter compose more than 15% of the soil material.

1. From each of the holes dug to assess rupture resistance (see section 2.2.1. *Rupture Resistance*), use a trowel to dig up enough soil to collect about 250 ml of sieved soil (use a beaker to measure soil volume). Stay within the first 3 inches of soil to limit the mixing of soil from different depths.
Make sure to remove any biological soil crust, loose litter, or loose rocks/gravel from the soil surface *before* collecting the soil. Replace the biological soil crust back on the surface of the soil sampling point when sampling is complete.
Indicate in the notes section whether biological soil crusts or the type of soil particles (Table 11.6) that were found on the surface of the soil sampling point.
2. Use a #10 sieve to remove all particles >2 mm from each of the soil samples. Place the sieve on top of the pan, add soil sample to the sieve, place the sieve cover on the sieve, and shake the soil through the sieve. Use the material in the sieve pan for soil analyses.
Save part of the sieved material for soil plasticity and texture analyses (see section 2.2.3 *Soil Stickiness* and 2.3.4 *Soil Plasticity*).
Do not discard any of the soil sample until the next step has been completed.
3. If particles >2 mm are >15% of the original sample (Table 11.6), consult Table 11.7 for texture modifier descriptors.
You can determine the % of particles >2 mm by comparing the amount of material left on the sieve (>2 mm particles) to the material in the pan of the sieve. If the amount in the sieve appears to be more than 15% of the total materials, then a soil texture modifier descriptor should be included. The Munsell soil-color chart includes pages that illustrate various percentages of coarse fragments.
Record the soil texture descriptor under soil texture on the *Soil Measurements Field Form* (SOP 11 Appendix A).
IF SOIL SAMPLES ARE TO BE COLLECTED FOR ANALYSIS IN THE OFFICE,
then place 250 ml of the sieved soil in a zip-lock bag and label with the macroplot ID, soil sampling point, and whether the sample was from a vegetated or barren area. Follow step 6 to discard the remaining soil and repeat steps 1-3 for the other sample. Complete steps 4-5 in the office.
4. Determine the soil color of the sieved soil using the Munsell soil-color chart. Use the following procedure (adapted from <http://www.soilsurvey.org/tutorial/page7.asp>):
 - a. Place a small sample of soil on a white piece of paper or on one of the white depression plate spots.
Soil color interpretation can be distorted if you do not use a white background.
 - b. Make sure the light is behind you.
Interpretation of soil color is highly dependent on the amount and quality of light.
Avoid determining soil color when the sun is low in the sky or when it is smoky.

- c. Find the page in the soil-color chart that seems to be closest in color to the soil sample. Compare the sample to the color on the chart by holding the chart over the sample and viewing the sample through the holes.
Do not place the soil on the color chips as this will damage the color chips and cause the color chip to discolor.
 - d. Find the best color match for the soil sample.
If the sample is yellower or redder than the closest match, then move one chart back or forward, respectively.
 - e. Repeat step 3c-d until you find the best color match.
 - f. Record values for the three elements of color, hue, value, and chroma, into the appropriate space on the *Soil Measurements Field Form*.
Hue is listed at the top of each page, and value and chroma along the sides. An example of a Munsell description is 7.5YR 6/1, where 7.5 YR is the hue, 6 is the value, and 1 is the chroma.
5. Starting with one of the sieved soil samples, follow the flow chart (Figure 11.3) to determine the soil texture of the sieved sample. Record the appropriate code designated in Table 11.5 under soil texture on the *Soil Measurements Field Form*.
Use the vial method to help determine the amount of sand, silt, and clay in your sample. Fill a clear vial about 1/3 full of sieved soil (note the volume of soil as it will be needed to determine the % of each component). Add enough water to fill the vial ¾ full and then shake the vial until the soil is completely mixed into the water. Place the vial on a flat surface and let the soil sample settle in the vial for at least 15 minutes (longer is better).
When the contents have settled, assess the % of sand (heaviest particles), silt (medium particles), and clay (suspended particles) that are in the soil sample *relative to the starting volume of soil* (this may require a long settling period as water between the soil particles may increase the volume of the soil sample). Clay particles settle out of solution extremely slowly, so the clay portion may be determined by subtracting the sand and silt component from the starting volume of soil.
Consult the soil texture triangle (Figure 11.4) to help verify the results of the flow chart (Figure 11.3).
6. Repeat steps 4-5 for the other soil sample.
After all the soil measurements have been completed, then refill the hole by replacing all of the sieved soil materials.
7. Repeat steps 1-6 for the remaining eleven sampling locations.

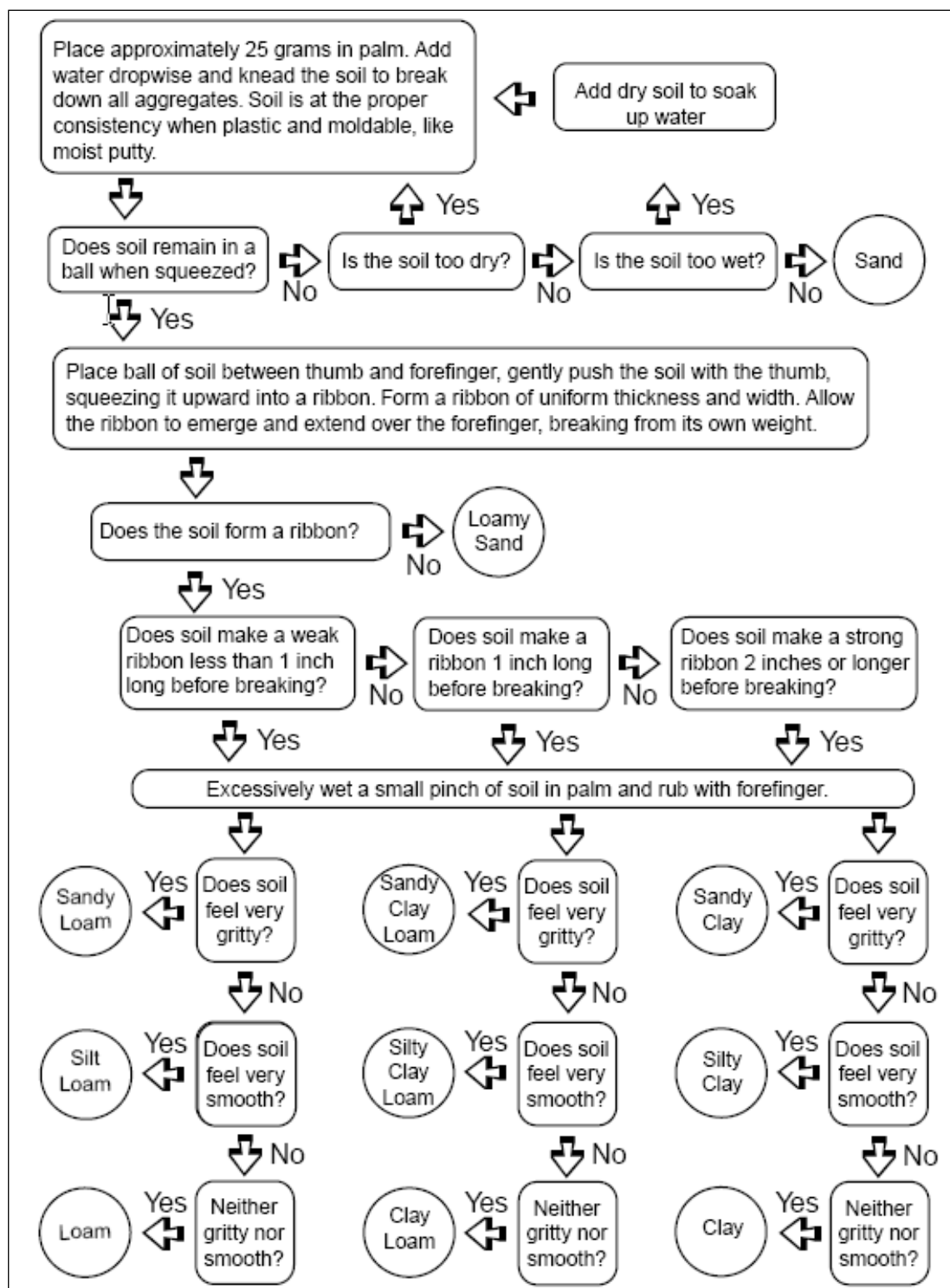


Figure 11.3. Flow chart for soil texture key (from Herrick et al. 2005). Begin in the top left corner and answer the yes/no questions to determine soil texture.

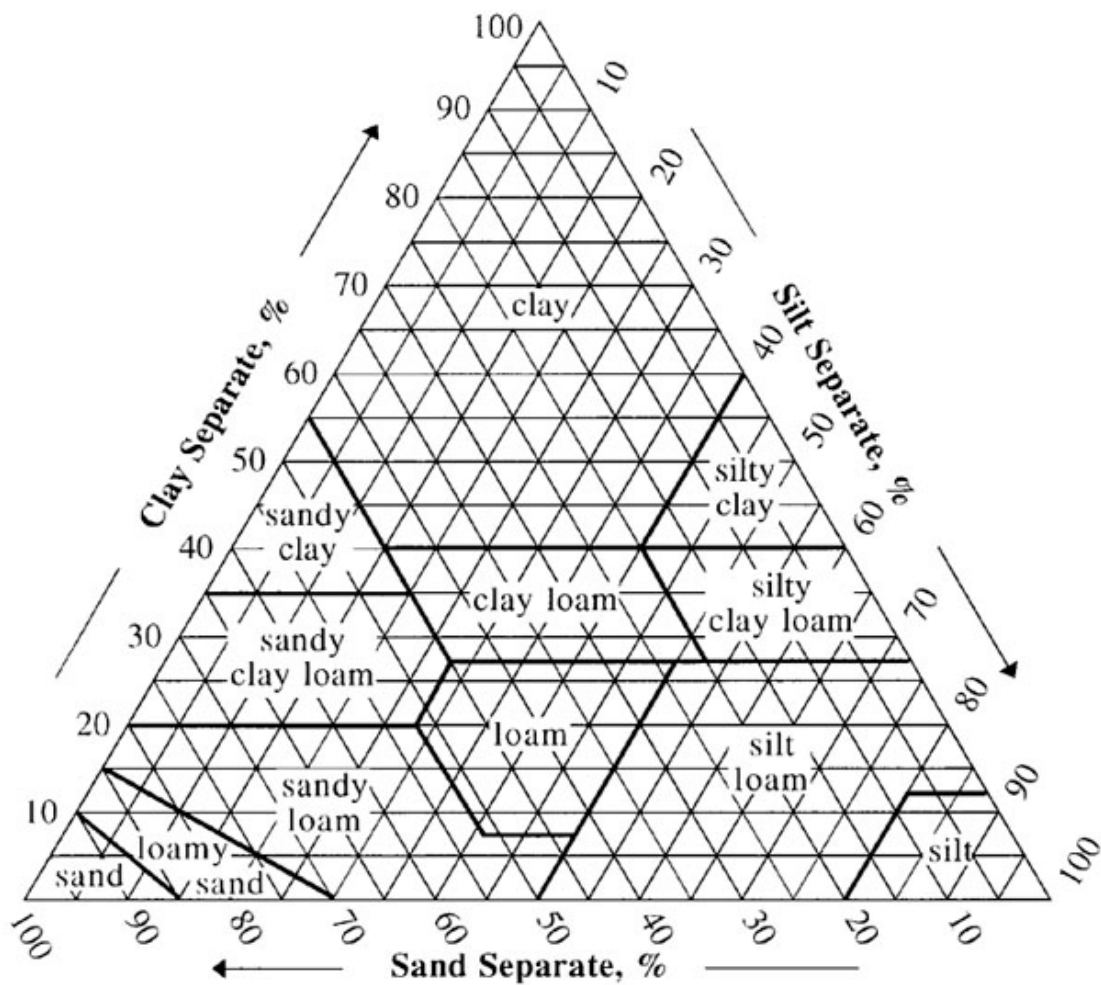


Figure 11.4. Soil texture triangle (from <http://soils.usda.gov/technical/aids/investigations/texture/>).

Table 11.5. Soil texture codes for Figure 11.3.

Soil Texture Class	Code
Sand	S
Loamy sand	LS
Sandy loam	SAL
Silt loam	SIL
Loam	L
Sandy clay loam	SACL
Silty clay loam	SICL
Clay loam	CL
Sandy clay	SAC
Silty clay	SIC
Clay	C

Table 11.6. Classification of soil particles by the USDA system.

Particle Classification	Particle Diameter	
	Inches	Millimeters
Boulders	>24	>600
Stones	10-24	250-600
Cobbles	3-24	75-250
Gravel	0.08-3	2 – 75
Sand	0.002-0.08	0.05-2
Silt	0.00008-0.002	0.002-0.05
Clay	<0.00008	<0.002

Table 11.7. Soil texture modifiers based on particles >2 mm in diameter that compose more than 15% of the soil material. See Table 11.6 for the particle classification modifier.

Fragment Content % by Volume	Rock Fragment Modifier Usage
<15	No texture modifier is used (texture only; e.g., loam)
15 to <35	Use modifier for appropriate size of rock fragments; e.g., gravelly loam
35 to <60	Use “very” with the appropriate size of rock fragments; e.g., very gravelly loam
60 to <90	Use “extremely” with the appropriate size of rock fragments; e.g., extremely gravelly loam
≥90	No modifier. If coarse fragments comprise ≥90%, use the appropriate classification for the dominant size class; e.g., gravel

2.2.3. Soil Stickiness

Soil stickiness refers to the capacity of the soil to adhere to other objects. We will evaluate stickiness by how the soil adheres to the hand after it is wetted.

1. Starting with approximately 20 g of one of the sieved soil samples, wet the soil while continuing to squeeze and mix the soil, alternately adding water and drier soil until the greatest degree of stickiness is achieved.
2. Place a sample of the soil between the thumb and forefinger, squeeze and release. The stickiness class is determined based on observations of how the soil reacts when the thumb and forefinger are separated.
3. Choose the most accurate description of the stickiness from the four stickiness classes provided in Table 11.8.
4. Record the stickiness code in the appropriate space on the *Soil Measurements Field Form*.
5. Repeat steps 1-4 for the other soil sample.
6. Repeat steps 1-5 for the remaining eleven sampling locations.

Table 11.8. Criteria for determining soil stickiness classes.¹

Stickiness Class	Code	Criteria: Work moistened soil between thumb and forefinger
Non-sticky	SO	Little or no soil adheres to fingers, after release of pressure
Slightly sticky	SS	Soil adheres to both fingers, after release of pressure. Soil stretches a little on separation of fingers.
Moderately sticky	MS	Soil adheres to both fingers, after release of pressure. Soil stretches some on separation of fingers.
Very sticky	VS	Soil adheres firmly to both fingers, after release of pressure. Soil stretches greatly upon separation of fingers.

¹ Table reproduced from Schoeneberger et al. (2002).

2.2.4. Soil Plasticity

Plasticity is an estimate of the soil's ability to be permanently deformed without rupturing. It is evaluated by forming a roll or wire with the soil and seeing how easily it is deformed.

1. Starting with one of the soil samples, mold a handful of soil by alternately wetting and adding dry soil until maximum plasticity is obtained.
2. Form a "roll" or "wire" by rolling the material between the hands.
Plastic soils are distinguished from non-plastic soils based on the length and diameter of the soil ribbon that is formed.
A ribbon cannot be formed in soils containing a high percentage of sand. More plastic soils can form rolls with smaller diameters.
3. Choose the most accurate description of plasticity from the four plasticity classes provided in Table 11.9.
4. Record the plasticity code in the appropriate space on the *Soil Measurements Field Form*.
5. Repeat steps 1-4 for the other soil sample.
6. Repeat steps 1-5 for the remaining eleven sampling locations.

Table 11.9. Criteria for determining soil plasticity classes.¹

Plasticity Class	Code	Criteria: Make a roll of soil 4 cm long
Non-Plastic	PO	Will not form a 6 mm diameter roll, or if formed, cannot support itself if held on end
Slightly Plastic	SP	A 6 mm diameter roll supports itself; a 4 mm diameter roll does not.
Moderately Plastic	MP	A 4 mm diameter roll supports itself; a 2 mm diameter roll does not.
Very Plastic	VP	A 2 mm diameter roll supports its weight.

¹ Table reproduced from Schoeneberger et al. (2002).

2.3. Abundance of Carbonates – Effervescence Test

In this test, we will be adding acid to the soil sample and watching for the formation of carbon dioxide bubbles that are produced when the acid interacts with the carbonate base.

1. Place a small amount of sieved soil from a vegetated area and from an adjacent barren area from the soil sampling point onto different spots of a spot-plate depression. Do not include large chunks of soil.
2. Add 2-3 drops of 1 M HCl to each soil sample and observe the reaction.

3. The bubbling reaction may occur slowly so wait for 2 minutes before making a determination of effervescence class (Table 11.10).
4. Repeat steps 1-3 for the remaining eleven sampling locations.

Table 11.10. Criteria to determine effervescence classes.

Effervescence Class	Code ¹	Criteria
Noneffervescent	NE	No bubbles form.
Very slightly effervescent	VS	Few bubbles form.
Slightly effervescent	SL	Numerous bubbles form.
Strongly effervescent	ST	Bubbles form a low foam.
Violently effervescent	VE	Bubbles form a thick foam.

¹ NASIS code.

2.4. Soil pH and Electrical Conductivity (EC)

Soil pH is often referred to as the “master variable” of soils because of its significant effect on a number of chemical reactions and processes (Sparks 2003). EC (electrical conductivity) is the preferred index to evaluate soil salinity (Sparks 2003, Essington 2004). Procedures for soil pH and EC are combined into one section because both will be measured on a saturated soil paste (Rhoades 1982).

1. Fill a 250 ml plastic container about half full (100-125 ml of soil) with soil from a vegetated area and a second 250 ml plastic container from an adjacent barren area for each soil sampling point.
Use a black Sharpie marker to label the container with the soil from the vegetated area with a “V” and the container with the soil from the barren area with a “B”.
2. Starting with one of the soil samples, add distilled water to the soil while stirring with a stainless steel spatula or glass rod until the soil is nearly saturated.
The soil is saturated when 1) the soil paste glistens as it reflects light and 2) flows slightly when tapping or jarring the container after a trench is formed in the paste with the side of the spatula
Free water should not collect on the soil surface, nor should the paste stiffen or lose its glisten.
3. After saturation is attained, allow the paste to stand for at least 15 minutes.
Record the amount of time that the paste stands prior to measurement on the *Soil Measurements Field Form* and be consistent between samples.
4. Repeat steps 2-3 for the other soil sample.
5. During the wait time, verify that the pH and EC meters are working properly by:
pH meter general procedure (follow the instrument’s instruction manual for specific procedures):
 - a. The pH meter **MUST** be calibrated before starting sample measurements at each macroplot.
 - b. Rinse the pH probe with deionized water and wipe dry with a kimwipe.

Make sure the sponge at the bottom of the cap is moist when the meter is not in use. If the sponge is dry, moisten with a small amount of pH 4 standard solution.

- c. Turn on the meter and conduct a 2 point calibration (refer to instruction manual for procedure) using pH standards 4, 7, or 10, depending on the likely range of readings. In arid areas, soil pH values are often near neutral to alkaline, making the 7 and 10 standards most appropriate.

For best readings, make sure to wait for the meter to equilibrate after placing in each standard.

Make sure to rinse the probe with deionized water and wipe dry with a kimwipe when moving between standards and after calibration is complete.

- d. Check the accuracy of the pH meter by measuring the pH of the pH 7 and 10 standards (*do not use the calibrate mode to measure the standards*).

Record the reading for the standards for each sampling point on the appropriate spaces in the *Soil Measurements Field Form*.

If the meter is not reading the standards correctly (within an acceptable error range (± 0.2 units); see instruction manual), then recalibrate.

If the meter is reading the standards correctly, then the meter is ready for use.

- e. Repeat step d before measuring soil pH at each sampling point within a macroplot. If the pH meter is reading the standards correctly, then there is no need to recalibrate the meter.

EC meter general procedure (follow the instrument's instruction manual for specific procedures; the following is for the Hanna 98331 Direct Soil Conductivity meter):

- a. The EC meter **MUST** be calibrated before starting sample measurements at each macroplot.
- b. Rinse the EC probe with deionized water and wipe dry with a kimwipe.
- c. Turn on the meter and conduct a 1 point calibration using the provided standard:
 1. There should be at least 2 inches of liquid standard (1413 $\mu\text{S}/\text{cm}$ standard) in the standard bottle. If there is not, refill the bottle until there is at least 2 inches.
 2. Place the clean EC probe into the standard solution (the probe should not be touching the walls or bottom of the bottle). Wait for the reading on the meter to stabilize.
 3. If the meter does not read 1.41 mS/cm, then use the screwdriver to calibrate the meter.
Push the screwdriver into the hole in the side of the meter and turn clockwise or counter-clockwise to calibrate the meter to read 1.41 mS/cm (for the 1413 $\mu\text{S}/\text{cm}$ standard).
 4. Wait until the meter stabilizes to the correct standard reading for 30 sec before completing calibration.
 5. Make sure to rinse the probe with deionized water and wipe dry with a kimwipe after calibration is completed.

- d. Check the accuracy of the EC meter by measuring the EC of the standard (*do not use the calibrate mode to measure the standard*).
Record the reading for the standard for each sampling point on the appropriate space in the *Soil Measurements Field Form*.
If the meter is not reading the standard correctly (within an acceptable error range (± 0.05 mS/cm), see instruction manual), then recalibrate.
If the meter is reading the standard correctly, then the meter is ready for use.
 - e. Repeat step d before measuring soil EC at each sampling point within a macroplot. If the EC meter is reading the standard correctly, then there is no need to recalibrate the meter.
6. Measure the pH of the saturated paste samples, making sure to rinse the probe with deionized water and wiping dry with a kimwipe when moving between samples.
 7. Record the pH in the appropriate spaces on the *Soil Measurements Field Form*.
 8. Measure the EC of the saturated paste samples, making sure to rinse the probe with deionized water and wiping dry with a kimwipe when moving between samples.
 9. Record the EC in the appropriate spaces on the *Soil Measurements Field Form*.
 10. Repeat steps 1-9 for the remaining eleven sampling points.
For step 5, start with step d for both the pH and EC meters.

3. Soil Erosion

Both quantitative and qualitative soil parameters will be used to assess soil erosion. We will evaluate soil erosion quantitatively by estimating soil loss using macroplot permanent markers as “soil erosion pins” (as described below) and evaluating basal and canopy gap sizes (i.e., more and larger gaps indicate greater potential for soil erosion). We will combine qualitative measures, specifically soil consistence and texture parameters (e.g., change in rupture resistance categories) and visually identifying, estimating the degree, and photo documenting the different types of erosion on macroplots, to have a more comprehensive understanding of soil erosion within upland communities.

Soil erosion will be directly measured by using permanent rebar markers as soil erosion pins (Keay-Bright and Boardman 2009). At each macroplot, there will be seven permanent markers across the macroplot, one on each end of transects and one marker at the macroplot corner closest to the origin of transect 1 (Figure 7.1). See section 1.8. *Establishing the Permanent Markers* in *SOP 7 - Macroplot Establishment and Revisit Set-Up* for details on permanent marker establishment.

Soil erosion will be measured by comparing the amount of rebar above the soil between visits.

1. Before heading to the field, make sure that information about the location and height of the rebar aboveground from the previous site visit is available.
2. Locate the permanent rebar markers. Measure the height of the rebar marker aboveground in centimeters.
Record the height of the marker on the field form.
3. Subtract the height of the marker *during the previous visit* from the current height.

Record the difference in the appropriate space on the field form.

4. Revisiting the Macroplot

After the first sampling period, soil sampling points will be chosen at random along the edges of the macroplot (three samples per edge for a total of 12). Transect tapes must be laid out as described below so that tapes go from 0 to 100 m along each side, starting from the macroplot corner marker and going in a counter-clockwise direction (two sides are shown in Figure 11.1). Twelve random numbers will be generated for each macroplot using a random number generator (e.g., excel) that selects points from 0.00 m to 100.00 m. Sampling points will be determined as follows:

1. Before heading to the field, use a random number generator to generate 12 random numbers from 0 to 100 m that are at least 0.25 m apart (to prevent overlap of penetrometer readings).
2. In the field, use 100 m transect tapes to build the edges of the macroplot by:
 - a. Starting at the corner of the macroplot marked with a rebar stake (upper, left corner), stretch out the transect tape downslope for 100 m.
Crew member A, who is holding the free end of the tape at the rebar stake, will use a compass to direct crew member B stretching the tape in the compass bearing determined in *SOP 7 – Macroplot Establishment and Revisit Set-up, 1.2 Establishing the Transects*, step 1 (this compass bearing will be provided during revisits).
 - b. Mark the corner with a chaining pin.
 - c. Taking a second 100 m tape, crew member B will attach the free end to the chaining pin, and stretch out the tape in the compass bearing perpendicular to the first tape (see *SOP 7 – Macroplot Establishment and Revisit Set-up, 1.2 Establishing the Transects*; this compass bearing will be provided during revisits).
Again, crew member A, at the chaining pin, will use a compass to direct crew member B, who is stretching the tape.
 - d. Mark the corner with a chaining pin.
 - e. Add 180 degrees to the compass bearing in step a.
Then, crew member B will attach the free end of a new tape to the chaining pin and stretch out the transect tape upslope in the determined compass bearing for 100 m as described in step a.
 - f. Mark the corner with a chaining pin.
 - g. Crew member A will use the compass to determine the compass bearing from the chaining pin to the rebar marked corner of the macroplot.
The compass bearing should be the bearing in step c, plus 180 degrees. If the compass bearing is substantially off, then double-check the chaining pin marked corners to adjust the corner that is off.
 - h. Once the compass bearing between the last chaining pin and the rebar stake is in-line, crew member B will attach the free end of a new tape to the chaining pin, head to the rebar stake, and stretch out the transect tape for 100 m (at which point, the tape should be approximately at the rebar stake).

3. Starting with the first macroplot edge that was laid out, mark the first three random numbers along the tape using pin flags.
Make sure to walk only along the *outside* edge of the macroplot.
If there is an obstruction at a particular point (e.g., boulder), then record that obstruction under the point number, using descriptions in Table 11.6 as appropriate.
4. Move counter-clockwise to the next transect tape and repeat step 3 with the next set of three random numbers.
5. Repeat step 4 until all edges of the macroplot have been marked with sampling points.
6. Sampling locations will be numbered in a counter-clockwise fashion from the macroplot corner marked with a rebar (see Figure 11.1). For instance, the first sampling location as you head downslope from the marked corner would be sample 1.
On the *Soil Measurements Field Form*, make sure to indicate the distance along the tape for each sampling point.
7. Repeat the steps under section 2. *Measuring Soil Parameters* for all 12 sampling points.

5. References

- Cooperative Soil Survey. 2012. Soil Color - Physical Properties. Missouri Cooperative Soil Survey, Columbia, Missouri. Available at <http://www.soilsurvey.org/tutorial/page7.asp>.
- Essington, M. E. 2004. Soil and water chemistry, an integrative approach. CRC Press, Boca Raton, Florida.
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- Keay-Bright, J., and J. Boardman. 2009. Evidence from field-based studies of rates of soil erosion on degraded land in the central Karoo, South Africa. *Geomorphology* 103:455-465.
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SOP 11 APPENDIX A: Soil Measurements Field Form

Integrated Uplands
SOP 11 - Soil Measurements Field Form

Date: __/__/__ (MM/DD/YY)

Park code: ____

Macroplot Nbr: ____

Page 1 of 4

Observer: _____

Recorder: _____

Others: _____

Soil Consistence

Sample Loc#	Transect Distance (m)	Sample Distance (m)	Penetrometer Reading					Class Code	Structural		Moisture	
			1	2	3	4	5		Veg	Barren	Veg	Bar.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

Notes:

11A-1

MOJN I&M IU SOP

Integrated Uplands
SOP 11 - Soil Measurements Field Form

Date: __/__/__ (MM/DD/YY)
Observer: _____

Park code: _____
Recorder: _____

Macroplot Nbr: _____
Others: _____

Page 2 of 4

Sample Loc#	Rupture Resistance		Texture		Color (veg)		
	Veg	Barren	Veg	Barren	Hue	Value	Chr.
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Notes: _____

11A-2

MOJN I&M IU SOP

Integrated Uplands
SOP 11 - Soil Measurements Field Form

Date: __/__/__ (MM/DD/YY)
Observer: _____

Park code: _____
Recorder: _____

Macroplot Nbr: _____
Others: _____

Sample Loc#	Color (barren)			Stickiness		Plasticity		Effervescence	
	Hue	Value	Chr.	Veg	Barren	Veg	Barren	Veg	Barren
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

Notes: _____

Integrated Uplands
SOP 11 - Soil Measurements Field Form

Date: __/__/__ (MM/DD/YY)

Park code: _____

Macroplot Nbr: _____

Page 4 of 4

Observer: _____

Recorder: _____

Others: _____

EC Meter#: _____ pH Meter#: _____

Sample Loc#	Standing Time	pH				Standard 1413 μ s	EC	
		Standard		Reading			dS m ⁻¹	dS m ⁻¹
		7	10	Veg	Barren		Veg	Barren
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Notes: _____

11A-4

MOJN I&M IU SOP

Standard Operating Procedure (SOP) # 12: Site Assessment for Invasive Plant and Target Tree Species

Version 1.0

Revision History Log:

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

This SOP provides instructions for detecting and describing target invasive plant species infestations that were not detected on all three transects by the previous SOPs (see *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using a Point-Intercept Sampling* and *SOP 10 - Assessing Invasive Plant and Disturbance Frequency Using Quadrats*) and for counting target tree species in Joshua tree (*Yucca brevifolia*) communities (specifically, Joshua trees). The search pattern described in this SOP should take no more than 20 minutes per macroplot. Data collected from the patterned walk will be recorded at the macroplot level.

This SOP should be conducted after macroplot establishment (*SOP 7 - Macroplot Establishment and Revisit Set-Up*) and following transect-based measurements (SOPs 8-10). *MOJN I&M SOP M2 - Prioritizing Invasive Species for Status and Trends Monitoring* and *SOP 5- Crust Friendly Field Procedures* should be reviewed prior to implementing this SOP. If any invasive species selected for early detection monitoring are found on the macroplot, they will be documented separately following the procedure described in *MOJN I&M SOP M1 - Reporting Incidental Observations of Incipient Invasive Species*.

1. Filling Out the Field Form

For each macroplot, fill out relevant information at the top of the *Site Assessment for Invasive Plant and Target Tree Species Field Form* (SOP 12 Appendix A) including:

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

Macroplot Nbr – A pre-assigned, unique number provided for each macroplot.

Date – mm/dd/yyyy

Observer – Record the three initials (first, middle, and last name initials) of the observer.

Recorder – Record the three initials of the recorder.

Others – Record the three initials of any people with the crew but not participating in data collection.

To insure that this SOP is completed, each macroplot will have a *Site Assessment for Invasive Plant and Target Tree Species Field Form* (SOP 12 Appendix A), even if there are no invasive plant

sightings for this SOP. If there are no invasive plant sightings from this SOP, circle “none” next to the species that you were searching for in this SOP.

2. Searching the Macroplot for Invasive Plant Species

Crews will conduct a systematic search for target invasive plant species in macroplots using the search pattern described below (Figure 12.1). There are two primary search patterns for the macroplot, one for each member of a 2-person crew. Crew members are expected to work in tandem so that the area scanned overlaps their fields of view.

A list of target invasives will be provided to crews (see *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using a Point-Intercept Sampling* or *SOP 10 - Assessing Invasive Plant and Disturbance Frequency Using Quadrats*). Crew members must compare the provided list of status and trends invasive species to the invasive species found on transects. Crews will fill out the table at the top of the *Site Assessment for Invasive Plant and Target Tree Species Field Form* (SOP 12 Appendix A) to eliminate any invasive species that were found on all three transects; the **remaining species will be the target of this SOP**.

At sites with significant coverage of physical and/or biological soil crusts, it is important not to impact soil stability more than is absolutely necessary (see *SOP 5- Crust Friendly Field Procedures*).

1. Crew members will conduct the primary search pattern in tandem. Crew member A will walk the perimeter of the macroplot (pattern A, Figure 12.1), while crew member B will walk within the macroplot, closer to the transects (pattern B, C, D; Figure 12.1).
2. As crew members walk their pattern, each crew member should scan a 12.5 m belt around where they are walking. However, crew member A will only look for invasives *inside* the macroplot.
3. Each crew member will keep individual notes on what they observe.
4. When both crew members have finished their walks around the macroplot, they will meet outside the macroplot and discuss their findings. Based on both their observations, they will come to an agreement on the following information and record the information on the *Site Assessment for Invasive Plant and Target Tree Species Field Form* (SOP 12 Appendix A):
 - a. Circle the *species code* for the invasive species that were found during the patterned walk.
 - b. *Dispersion type of the invasive plant(s)*: Circle the dispersion code that best describes the spatial distribution of plants for a species (Figure 12.2; Table 12.1).
 - c. *Cover class*: Make an ocular estimate of the % cover of the target invasive species within the macroplot and record the cover class under % cover. This measure will provide information on the severity of the invasion.
Record the appropriate cover class as listed in Table 12.2.
 - d. *Plant phenology*: Circle the phenology (or phenophase) of the invasive plant population (Table 12.3). If there are many plants exhibiting different phenophases, select the phenophase that best represents the overall population.

5. Provide a visual description of infestation(s) for each species using the macroplot diagram form (part of the *Site Assessment for Invasive Plant and Target Tree Species Field Form*, SOP 12 Appendix A).

Use the species codes to label specific points or areas of infestations.

6. If none of the invasive species targeted for this SOP are found on the macroplot, then circle “none” next to the species that you were searching for in this SOP.

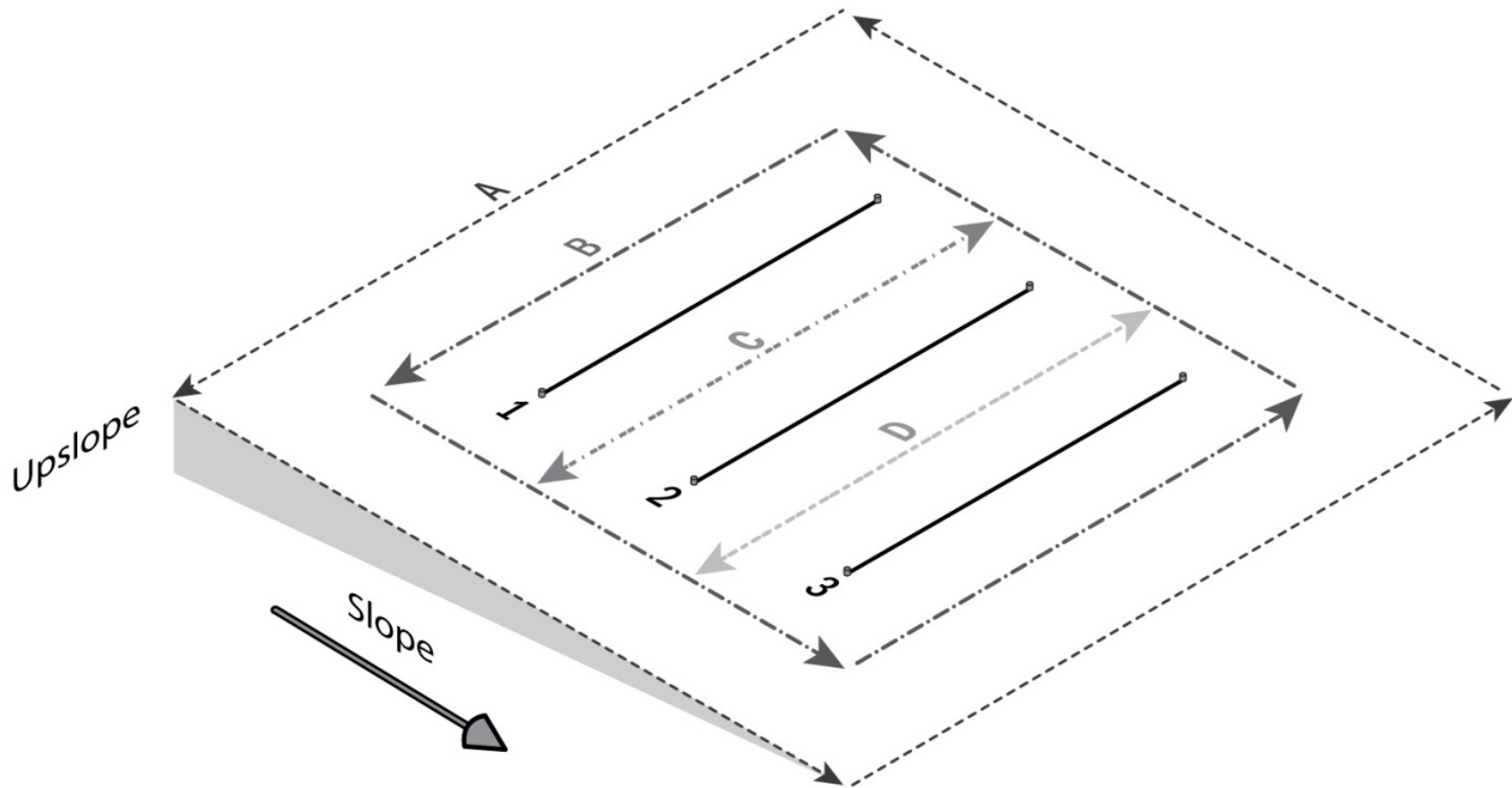


Figure 12.1. Macroplot diagram showing the search pattern for target invasive plant species. The numbered lines correspond to transects 1, 2 and 3 whereas the lettered and arrowed lines correspond to the search pattern. Letter A indicates the macroplot perimeter walk, B indicates the box-pattern walk 12.5 meters inside the macroplot perimeter, C indicates the search line halfway between transects 1 and 2, and D indicates the search line halfway between transects 2 and 3. Arrows correspond to the direction of travel; however, this does not have to be counter-clockwise as indicated, as long as crews work in tandem.

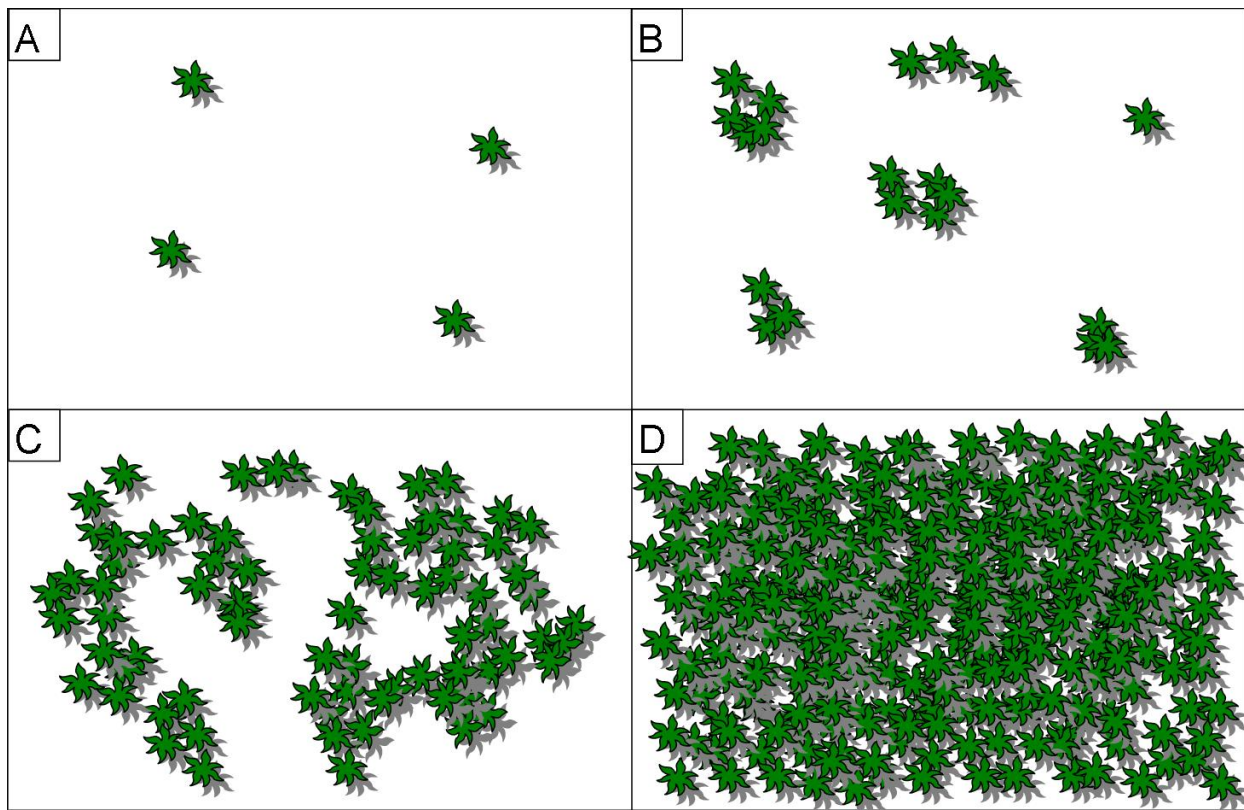


Figure 12.2. Dispersion types of invasive plant populations: A) scattered individuals, B) scattered patches, C) clumped, and D) continuous cover of plants.

Table 12.1. Description and codes for invasive plant dispersion within the macroplot.

Dispersion code	Dispersion description
1	Single plant
2	Scattered plants (Figure 12.2A)
3	Scattered patches of plants (Figure 12.2B)
4	Clumped (Figure 12.2C)
5	Continuous cover of plants (Figure 12.2D)

Table 12.2. Cover classes for the area infested within the macroplot.

% cover classes
>75%
51%-74%
26%-50%
3%-25%
>0-2%

Table 12.3. Phenological stages (phenophases) for major plant growth forms. Circle the code of the prevailing phenophase of the invasive plant population on the field form.

Phenophase Code	Woody plant (Shrub/Tree)	Forb	Grass
1	leaf buds formed/ leafing out	seedling/early vegetative	seedling/early vegetative
2	fully open leaves	vegetative/basal rosette	vegetative - multiple tiller
3	reproductive/flowering	reproductive/flowering	reproductive/flowering
4	fruit formation/ripening	fruit formation/ripening	seed ripening
5	dead/senescent	dead/senescent	dead/senescent

3. Searching the Macroplot for Target Tree Species

In a pilot study testing the field methods of this protocol, we found that tree species were greatly under-detected (Pan and Tallent 2013, 2014). This was particularly problematic for Joshua tree communities, the communities to be monitored at MOJA and JOTR, as the species characterizing the community has a tree-like life form and is of special management concern. Thus, field crews will conduct a quick count of Joshua trees within macroplots to provide a quantitative assessment of Joshua tree populations.

Crews will conduct a systematic search for Joshua trees in macroplots using the search pattern described above (see 2. *Searching the Macroplot for Invasive Species*; Figure 12.1). Crews will take a continuous tally of the number of juvenile (≤ 1 m) and adult (> 1 m; Barrows and Murphy-Mariscal 2012) trees by whether they are live or dead. If needed, trees can be temporarily marked with chalk dust during the count.

4. References

- Barrow, C. W., and M. L. Murphy-Mariscal. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions. *Biological Conservation* 152:29-36.
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SOP 12 APPENDIX A: Site Assessment for Invasive Plant and Target Tree Species Field Form

This example field form is for LAKE. Target invasive species will vary by park. When target tree species are to be counted, an additional table will appear at the bottom of the first page of the field form, so the number of live juvenile, dead juvenile, live adult, and dead adult trees can be recorded.

Integrated Uplands - VGS SOP 12 - Site Assessment for Invasive Species Field Form

Date: __/__/__ (MM/DD/YY)

Park code: ____

Macroplot Nbr: ____

Page 1 of 2

Observer: _____

Recorder: _____

Others: _____

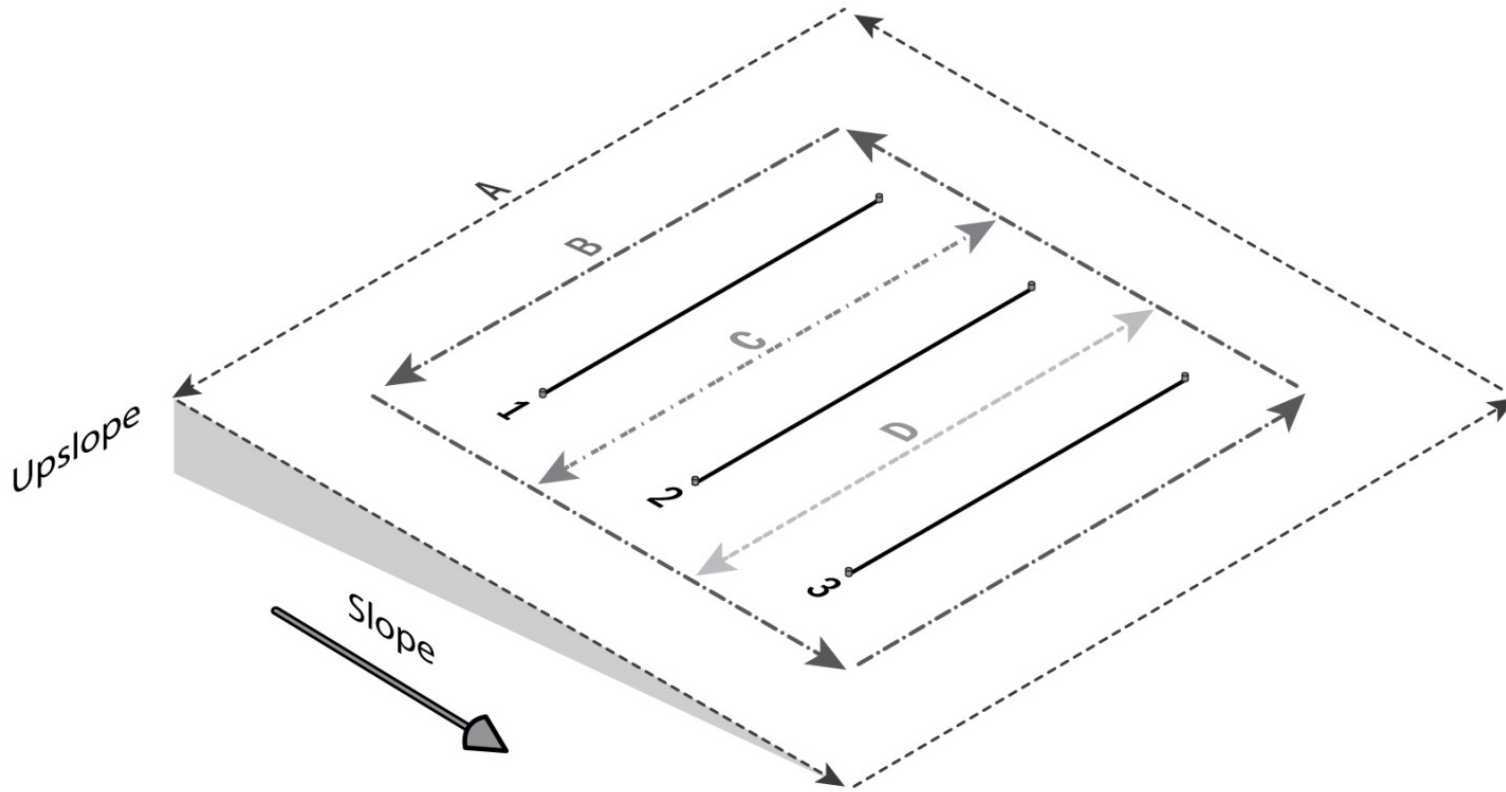
Species	USDA code	Presence on			Search species
		Transect 1	Transect 2	Transect 3	
<i>Brassica tournefortii</i>	BRT0				
<i>Bromus rubens</i>	BRRU2				
<i>Bromus tectorum</i>	BRTE				
<i>Erodium cicutarium</i>	ERIC6				
<i>Schismus</i> spp. (<i>S. arabicus</i> , <i>S. barbatus</i>)	SCHIS				
<i>Sisymbrium irio</i>	SIIR				

	Species	Dispersion	% Cover	Phenophase
none	<i>Brassica tournefortii</i>	1 2 3 4 5		1 2 3 4 5
none	<i>Bromus rubens</i>	1 2 3 4 5		1 2 3 4 5
none	<i>Bromus tectorum</i>	1 2 3 4 5		1 2 3 4 5
none	<i>Erodium cicutarium</i>	1 2 3 4 5		1 2 3 4 5
none	<i>Schismus</i> spp.	1 2 3 4 5		1 2 3 4 5
none	<i>Sisymbrium irio</i>	1 2 3 4 5		1 2 3 4 5

12A-1

MOJN I&M IU SOP

Integrated Uplands - VGS
SOP 12 - Site Assessment for Invasive Species Field Form



Standard Operating Procedure (SOP) # 13: Repeat Photos

Version 1.0

Revision History Log:

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

This SOP provides instructions for taking digital photos showing an overview of the macroplot, vegetation change along transects, and soil erosion for each upland monitoring macroplot. For photos other than those described here (e.g., unknown shrub images, wildlife), fill out the *Photo Log* (SOP 13 Appendix A) for each image. The outlined procedures were based on the Nikon D5000 SLR camera, but may be implemented with any SLR camera with slight modifications.

Some sections of this SOP were adapted from *SOP 7 – Repeat Photos* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol. *SOP 7 - Macroplot Establishment and Revisit Set-Up* should be completed before this SOP is implemented. *MOJN I&M SOP M3 – GPS* and *SOP 5 - Crust-Friendly Field Procedures* should be reviewed before starting this SOP.

1. Transect Overview Photos

Photos will be used to provide qualitative documentation of vegetation change along transects through time. One photo will be taken per transect.

1. Label a field form with the park code, macroplot number, and camera number (last 5 digits of the NPS inventory tracking tag). Fill in the part of *Repeat Photos Field Form* under “Transect Overview Photos” from the steps below.
2. For transects 1 & 3, take the photo from the origin end of the tape.
For transect 2, take the photo from the 50 m end of the tape.
Having different views along the tape will provide documentation on multiple sides of the macroplot.
3. Stand at the origin end of the transect tape for transect 1.
Record “1” under the “transect #” column and “O” under the “transect end” column on the field form.
Fill in the date that the photo is taken for the transect under the “date” column.
4. Stand 3 meters directly back (in-line with the transect) from the rebar stake marking that end of the transect.

Mark the spot with a pin flag; this will be the photopoint for transect 1.

5. Set up the tripod such that the center of the tripod is directly over the pin flag and the front of the tripod is pointing toward the transect.
6. Place the camera on the tripod stand and adjust the pan-head (Figure 13.1a) so that the image will be in the portrait (vertical) view.

The platform (where the camera is attached) of the tripod is removable by pulling the knob forward (Figure 13.1a) and lifting the platform up at an angle. Place the screw on the platform into the screw hole at the bottom of the camera and then tighten using the knob on the bottom of the tripod platform.

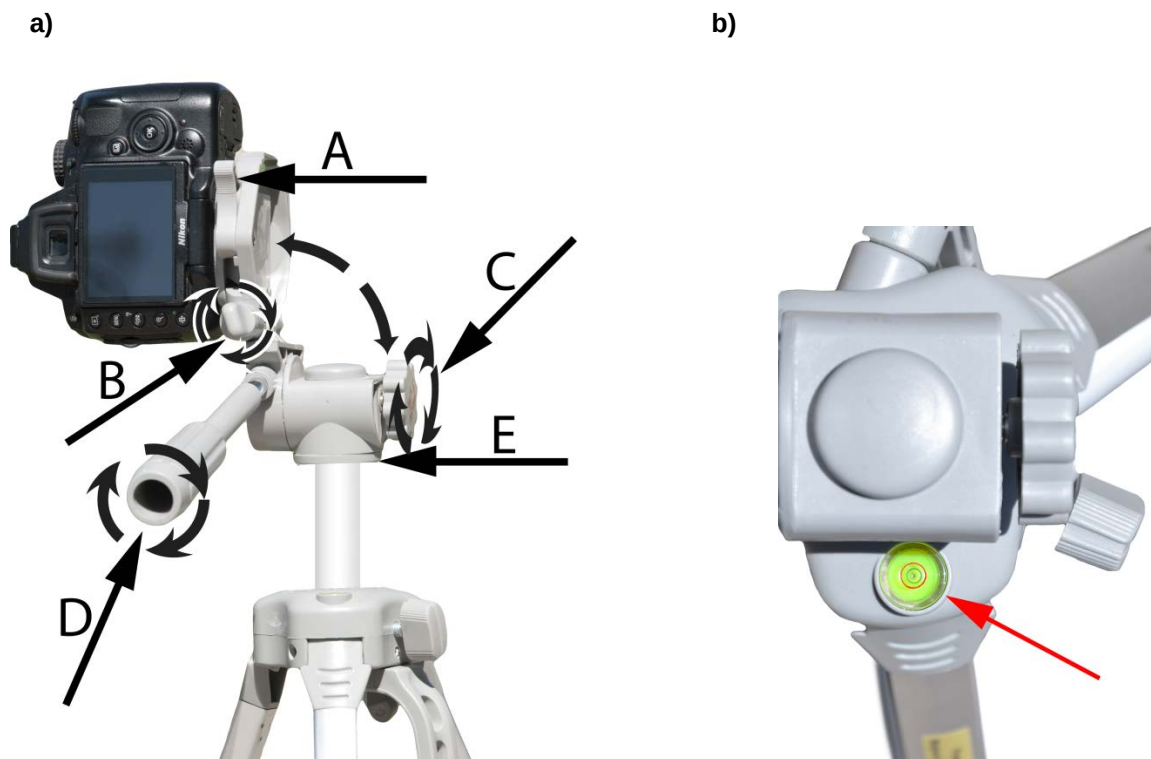


Figure 13.1. How to use the camera tripod. a) Pan-head of the tripod. “A” indicates the knob used to remove the camera attachment. “B” is used to move the pan-head from horizontal to vertical, “C” is used to raise the pan-head, and “D” is used to tilt the pan-head from horizontal. “E” indicates the base of the tripod’s pan-head, where the height of the camera from the ground should be measured (see step 7). b) Bubble level on the camera tripod (indicated by the arrow). The bubble needs to be completely within the marked circle to be considered level.

7. Look through the viewfinder of the camera (Figure 13.2a) to choose an appropriate height for the tripod (start around 150 cm).
Place the camera such that the rebar is visible and the transect tape is toward the right part of the image (sampled vegetation is above the transect tape). The image should clearly capture as much of the vegetation along the transect as possible, without complete overlap of the vegetation along the transect.

If you cannot see the transect tape due to an obstruction, take a second photo at some other distance along the transect where you can see more of the tape. Be sure to record information for this photo, especially the location along the transect.

The photo should have no more than 20% sky in the field of view (but include some sky to help with orientation).

If possible, try to include a distinguishing feature (boulder, geological feature, long-lived vegetation) in the image to help with future relocation. However, the priority is to represent the transect vegetation and the placement of the rebar should help with future image relocation.

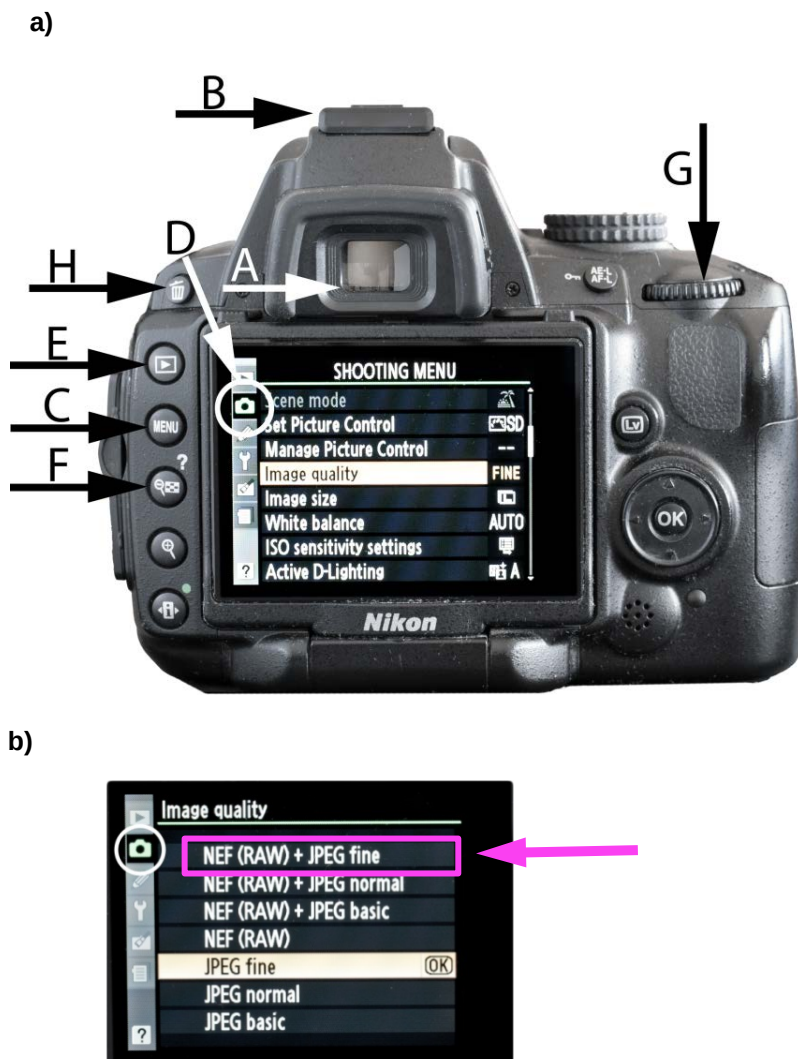


Figure 13.2. Nikon D5000 camera showing the a) back of the camera with camera buttons and shooting menu on the camera screen and b) image quality menu. “A” indicates the camera viewfinder, “B” the external flash shoe, “C” the menu button, “D” the camera icon (circled), “E” the image playback button, “F” the zoom button, “G” the scroll wheel, and “H” the trash can or delete button.

8. Use the bubble level to balance the tripod (Figure 13.1b).
9. Adjust the focal length (Figure 13.3c) and position of the camera as if you are about to take an image, BUT DO NOT TAKE A PICTURE YET.
You will need to fill out the information on the *Repeat Photos Field Form* (SOP 13 Appendix A) and whiteboard first.
10. Make sure that the image quality is set to the highest resolution JPEG (“JPEG fine”) by scrolling through the camera menu.
Push the menu button on the back of the camera (Figure 13.2a). Scroll to the camera icon on the left and check the image format by scrolling through the shooting menu (Figure 13.2b).
11. In order to help with relocating the field of view during repeat visits, camera height, compass bearing, and angle of the camera need to be determined.
Measure the height of the camera off the ground (in m) using a tape measure and record in the appropriate line on the field form. Measure from the ground to the base of the tripod’s pan head (Figure 13.1a).
Take a compass bearing for the camera lens in degrees. Take the compass bearing in front of the camera lens; make sure the base of the compass is flush against the protective lens filter (Figure 13.3a). Record the information on the appropriate line in the field form.
Use a clinometer (on the compass) to determine the vertical angle of the camera. Place the compass flush against the flat screen on the back of the camera (Figure 13.3b; be careful not to scratch the screen) and record the reading, in degrees, on the appropriate line in the field form; circle “u” for up or “d” for down under angle to indicate whether the *camera lens* is pointed “up” or “down” from horizontal. Make sure that the compass is flush with the screen and not obstructed by any parts of the camera as this will affect your reading.



Figure 13.3. Nikon D5000 camera and lens showing how to determine the: a) compass bearing for the camera lens and b) the angle of the camera using the clinometer on the compass. In a), the arrow indicates the direction of the lens to the line of the compass bearing; the number directly under the white line of the compass (circled) is the bearing in degrees. In b), the clinometer reading is circled.

b)

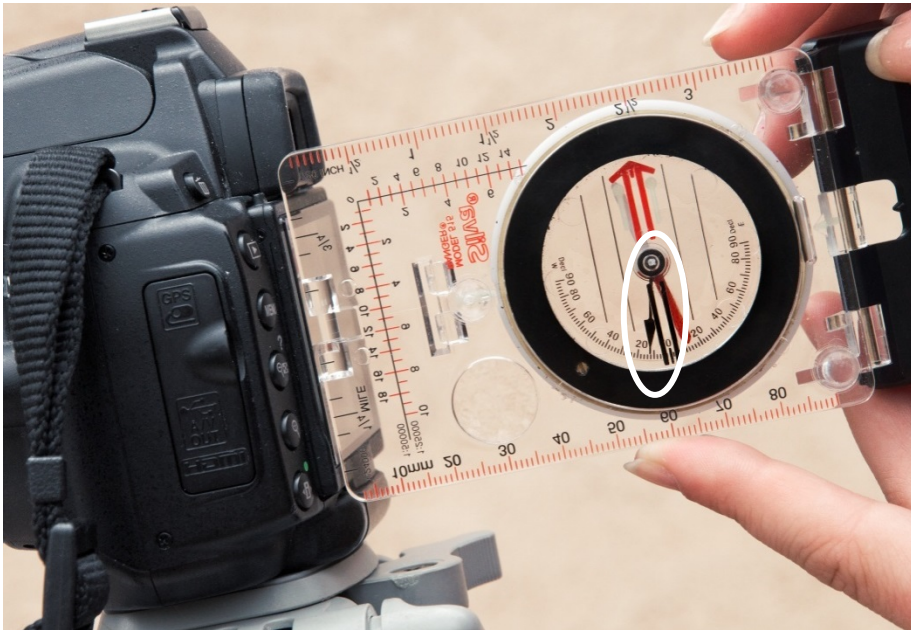


Figure 13.3. Nikon D5000 camera and lens showing how to determine the: a) compass bearing for the camera lens and b) the angle of the camera using the clinometer on the compass. In a), the arrow indicates the direction of the lens to the line of the compass bearing; the number directly under the white line of the compass (circled) is the bearing in degrees. In b), the clinometer reading is circled (continued).

12. Photos should be taken under enough light (e.g., sunny days are preferred over dark, overcast days). Avoid taking photos into the sun, as that will obscure the image.

We will be using the “auto” preset setting on the camera (Figure 13.4), for ease of use.



Figure 13.4. Preset settings knob and info button on Nikon D5000 camera. The “auto” (A) and “landscape” (B) settings, and “info” button (C) are indicated by the arrows.

13. The **FIRST** photo for each photopoint should be of a photoboard (Figure 13.5).

Fill in the following information on the photoboard using a black marker:

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

Macroplot Nbr – A pre-assigned, unique number provided for each site.

Transect Nbr

Transect end – “O” for origin, “E” for 50 m end, or appropriate distance (m) on transect tape

Date – mm/dd/yyyy

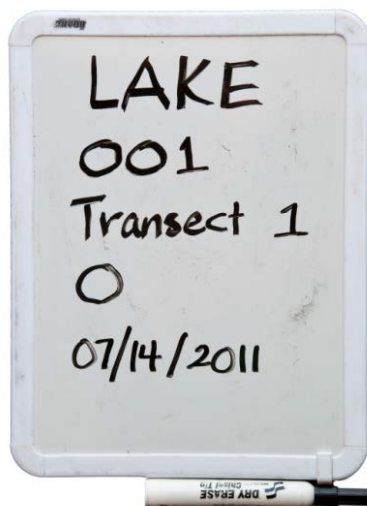


Figure 13.5. Example photoboard for a transect overview photo showing the required information for each photopoint.

14. Hold the whiteboard in front of the camera and take a picture of it.

Playback the image and record the file number of the photoboard image (e.g., DSC_0001) under “Photoboard #” on the field form. The file number should be below the image during playback.

15. Take the overview photo and check the image for clarity on playback.

This may require zooming in on the image (push the magnifying glass button and use the scroll wheel on the upper right of the camera, Figure 13.2a) to make sure that everything is in focus. Because the camera screen is small, the photo may appear in focus but actually be blurry when it is blown up.

Delete any photos that are not in focus or unusable by pushing the trash can button (Figure 13.2a).

If it is not possible to see the whole transect in the image (e.g., there is an obstruction in the middle of the transect), then additional photos may need to be taken (see step 17).

16. Record the image file number (below the image during playback) under “Photo #” on the field form.

17. If additional photos need to be taken of the transect, start by taking an image at the other end of the transect (steps 1-16). Try to place the camera such that as much of the transect is seen in the image as possible; record the distance along the transect of the camera placement (i.e., 0 or 50 m) under the “transect #” and “transect end” columns.
If the middle of the transect is still obscured, then additional photos may need to be taken. Find a location somewhere along the transect that captures the part of the transect that is obscured. Repeat steps 1-16 and make sure to record on the field form the distance along the transect where the camera is placed for the image under the “transect end” column.
Take additional photos as needed to show the vegetation along the transect, making sure to record relevant information on the *Repeat Photos Field Form* (SOP 13 Appendix A).
18. When all photos are taken, take the flag, tripod, and camera and head to the next transect.
19. Repeat steps 1-18 for the remaining transects.
20. When all transects are completed, take the camera equipment and proceed to the next section.

2. Macroplot Overview Photos

Macroplot overview photos will be used to record overall change in the macroplot through time, including disturbances. One photo will be taken per macroplot from the rebar marking the macroplot.

1. Go to the rebar stake marking a corner of the macroplot.
2. Stand 3 meters diagonally back from the rebar (not in the directions that would be parallel to the edges of the macroplot) and mark the spot with a pin flag; this will be the photopoint for the macroplot.
3. Set up the tripod such that the center of the tripod is directly over the pin flag and the front of the tripod is pointing toward the rebar stake.
Use the bubble level to balance the tripod (Figure 13.1b).
4. Place the camera on the tripod stand; the camera should be in the landscape (horizontal) view. If the camera is not, then adjust the pan-head (Figure 13.1a) so that the image will be in the landscape (horizontal) view.
5. Look through the viewfinder of the camera to choose an appropriate height for the tripod (start around 1.50 m).

The image should capture as much of the macroplot as possible. A wide-angle lens may be most appropriate for this photo.

If the view of the macroplot is obstructed for some reason (e.g., large tree or rock), move the photopoint so that the obstruction is to one side of the field of view. Note on the *Repeat Photos Field Form* (SOP 13 Appendix A), under the “Macroplot Overview Photo” section, that you have moved the photopoint and provide information on how to relocate it.

The photo should have no more than 20% sky in the field of view (but include some sky to help with orientation).

If possible, try to include a distinguishing feature (boulder, geological feature, long-lived vegetation) in the image to help with future relocation. However, the priority is to represent the macroplot vegetation and the placement of the rebar (may need to attach a flag to the rebar to indicate the location of the rebar in the image) to help with future image relocation.

6. Follow steps 9-11 from section 1. *Transect Overview Photos*.
7. The **FIRST** photo for each photopoint should be of a photoboard (see Figure 13.5 for example).
Fill in the following information on the photoboard using a black marker:
 Park code
 Macroplot Nbr
 Date
8. Follow steps 13-16 from section 1. *Transect Overview Photos*.
9. Make sure that the appropriate spaces on the *Repeat Photos Field Form* (SOP 13 Appendix A) are filled in under “Macroplot Overview Photo”.
When completed, take the camera equipment and proceed to the next section.

3. Soil Erosion Photos

The goal of these photos is to document whether and what kind of soil erosion is occurring at monitoring sites over time. One overview photo and multiple close-up photos may be taken to illustrate soil erosion on a macroplot.

3.1. Soil Erosion Overview Photo

The goal of this photo is to provide an overview of the monitoring macroplot and whether erosion is occurring. Since erosional processes will proceed downslope, the soil erosion overview photopoint will be downslope of the macroplot, looking upslope toward the monitoring macroplot.

1. Head downslope of the monitoring macroplot far enough so that when you look upslope, most of the macroplot is visible.
2. Once an appropriate spot has been found, place a pin flag at the location to mark the photopoint.
3. To provide the general vicinity of the photopoint, use a Global Positioning System (GPS) to collect the Universal Transverse Mercator (UTM) coordinates of the pin flag (all parks are NAD 83 and zone 11, except PARA, which is zone 12).
Take notes that will help with relocating the photopoint, as there will be no permanent marker for this photopoint.
4. Follow steps 3-4 from section 2. *Macroplot Overview Photos*.
5. If the wide angle lens is not on the camera, attach the wide-angle lens to the camera and attach the camera to the tripod.
If the wide-angle lens is not used, then note that on the *Repeat Photos Field Form*.
6. Look through the viewfinder of the camera to choose an appropriate height for the tripod.
If possible, the photo should have no more than 20% sky in the field of view and a distinguishing feature (e.g., geological feature) in the image to help with future relocation.
7. Follow steps 9-11 from section 1. *Transect Overview Photos*.
8. The **FIRST** photo for each photopoint should be of a photoboard.

Fill in the following information on the photoboard using a black marker:

Soil Erosion Overview

Park code

Macroplot Nbr

Date

9. Follow steps 13-16 from section 1. *Transect Overview Photos*.
10. Make sure that the appropriate spaces on the *Repeat Photos Field Form* are filled in under “Soil Erosion Overview Photos”.

When completed, take the camera equipment and proceed to the next section.

3.2. Soil Erosion Close-up Photos

1. Look around the macroplot for signs of soil erosion (see Figures 13.6-13.7 for examples of soil erosion).
2. Take a photo of each area that exhibits soil erosion (use the 18-55 mm lens).
Since these photos will not be repeat photopoints, no tripod or camera placement details are needed.
3. For each photo, record the date, image number, and describe the type of erosion under the “Soil Erosion Close-up Photos” on the *Repeat Photos Field Form* (SOP 13 Appendix A).
4. When all photos are taken, carefully wipe off any soil or dust from the camera equipment before putting them away. This will help to reduce inadvertent transport of biological materials to other field sites.
5. Follow guidelines in *SOP 17 – Data Management* on frequency of downloading and backing up digital photos in the field, image naming conventions, and QA/QC.

a)



b)



Figure 13.6. Soil erosion by wind. a) Wind erosion in progress and b) sand dunes created by years of wind erosion. Photographs from USDA NRCS.



Figure 13.7. Example of rill erosion in a cultivated field (example of eroded area is indicated by the arrow). The erosion has washed away seedlings in the impacted area. Photograph from USDA NRCS.

4. Revisiting the Photopoints

For sections 1. *Transect Overview Photos* and 2. *Macroplot Overview Photos*, be sure to take a copy of the notes and images from the previous visit when photos were taken. Follow the procedure described in sections 1 and 2, using the documents from the previous visit to help relocate the photopoint and photo frame.

For section 3.1 - *Soil Erosion Overview Photo*, be sure to take a copy of the notes and images from the previous visit when an overview photo was taken. Then follow the procedure below:

1. Navigate to the photopoint site, using the UTM coordinates and a GPS unit.
2. When you are in the general vicinity of the photopoint, use the location notes and previous overview photo to find the photopoint.
3. Mark the location with a pin flag.
4. Follow steps 4-10 in section 3.1 - *Soil Erosion Overview Photo*.
5. When the soil erosion overview photo is completed, make sure to complete section 3.2 – *Soil Erosion Close-up Photos* before leaving the macroplot.

SOP 13 APPENDIX A: Repeat Photos Field Form and Photo Log

Integrated Uplands Macroplot SOP 13 - Repeat Photos Field Form

Date: ___/___/___ (MM/DD/YY)

Park Code: _____

Macroplot Nbr: _____

Page 1 of 2

Photos by: _____

Camera Nbr: _____

Downloaded to (folder path/name): _____

Transect Overview Photos

Transect		Camera			Up Down	Photo Board#	Photo#	Comments (include any shift from expected photopoint)
#	End	Height (m)	Bearing (°)	Angle (°)				
					U D			
					U D			
					U D			
					U D			
					U D			
					U D			
					U D			
					U D			
					U D			

Macroplot Overview Photos

Camera			Up Down	Photo Board#	Photo#	Comments (include any shift from expected photopoint)
Height (m)	Bearing (°)	Angle (°)				
			U D			
			U D			

13A-1

MOJN I&M IU SOP

Integrated Uplands Macroplot
SOP 13 - Repeat Photos Field Form

Date: __/__/__ (MM/DD/YY)

Park Code: _____

Macroplot Nbr: _____

Page 2 of 2

Photos by: _____

Camera Nbr: _____

Downloaded to (folder path/name): _____

Soil Erosion Overview Photos

Date	UTM Easting	UTM Northing	Camera			Up Down	Photo Board#	Photo#	Comments
			Height	Bearing	Angle				
						U D			
						U D			
						U D			
						U D			
						U D			

Soil Erosion Close-up Photos

Date	Photo#	Erosion Type/Comments

13A-2

MOJN I&M IU SOP

Integrated Uplands
Photo Log Field Form

Camera Nbr: _____

PAGE ____ of ____

Downloaded to (folder path/name): _____

[illegible]

Standard Operating Procedure (SOP) # 14: Unknown Shrub Species

Version 1.0

Revision History Log:

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

Before undertaking monitoring activities, crews will review the field herbaria for parks and previously collected species from field macroplots. However, crews may come across unknown shrub species during their monitoring activities. Whenever a species identity is questionable, use procedures detailed in this SOP for handling unknown shrub species and do not use your “best guess” on the monitoring field forms. Since all other species are recorded based on life form and not by species, there will not be any unknown species for other life forms.

This SOP was adapted from *SOP 16 – Unknown Plant Species* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol.

1. Encountering an Unknown Shrub Species

When you encounter an unknown shrub species, search the immediate area for other specimens of the unknown plant with characteristics (i.e., flowers or fruits) that can help you identify the species. If the unknown shrub can be keyed out in a timely manner (that is, does not hinder the ability to complete a macroplot), then use the plant guides to determine the species. If the unknown shrub cannot be keyed out in a timely manner in the field, then collect a specimen (step 1.2) and ID the species at camp or in the office.

If the unknown shrub is not easily identified, determine the following and then proceed to the indicated step:

- A1.** Plant is not identifiable, go to **step 1.1**.
For example, specimen is senesced (e.g., only stems), chewed to the ground, or has no identifying features other than life form.
When in doubt, assume that it is identifiable.
- A2.** Plant is probably identifiable, go to **step 1.2**.
For example, some identifying features are present (e.g., leaves, old fruits).

1.1. Unidentifiable Shrub Species

Use the unknown species code “UNKS” on data field forms for all unidentifiable shrub species. Since there is no hope of identifying these species, there is no need to fill out an *Unknown Shrub Species Field Form* (SOP 14 Appendix A); these species will be lumped as “UNKS” for analyses.

1.2. Identifiable Unknown Shrub Species

The following describes how to name identifiable unknown species, record pertinent information on the plant, and how to collect a plant sample.

1. Create an unknown species code using the following system:
Unknown Code =
unks + 4 letter park code + macroplot number + your initials (use 3 letters) +
collection number for the macroplot (use 2 digits, e.g., 01, 02, etc.)
For example, if we came across an unknown shrub in Great Basin National Park on macroplot 001, it would be named “unksGRBA001-MOJ01”.
2. Record the unknown species code on the *Unknown Shrub Species Field Form* (SOP 14 Appendix A) and fill out the rest of the form.
If the unknown can be easily identified to genus, then record this information on the *Unknown Shrub Species Field Form* (SOP 14 Appendix A). The genus can be a good starting point for identifying the specimen to species.
3. Take photos of the unknown shrub with any distinguishing features and record the image numbers on the *Photo Log* (SOP 13 Appendix A) and *Unknown Shrub Species Field Form* (SOP 14 Appendix A).
Be sure to take a photo that shows the whole plant.
4. Label a blank sticky label with the following information:
Unknown code – As determined in step 1, under 2. *Identifiable Unknown Shrub Species*.
Date – mm/dd/yyyy
5. Collect a specimen of the unknown species, including any distinguishing characteristics (e.g., flowers, fruits).
If possible, collect the specimen from outside the macroplot. Do not collect the plant if it is the only one on the macroplot (i.e., it may be a rare species). Do not collect specimens from the sampling area above the tape as this may affect future monitoring data.
6. Attach the blank sticky label to the base of the plant part(s).
Fold the sticky label so that the label is around the base of the plant and the ends of the label stick to itself (this will prevent the label from falling off the plant).
7. Place the specimen in a zip-lock bag or place it in a plant press.
8. Record the unknown code on the *Unknown Shrub Log* (SOP 14 Appendix A) and provide a brief description of the plant with a few distinguishing characteristics. The description and characteristics will be used to figure out whether the same unknown is encountered later.
There will be one *Unknown Shrub Log* (SOP 14 Appendix A) per park.
If the same unknown species is encountered on other macroplots and has not been positively identified to species, then give it a new unknown code and collect a sample of it each time.
Many plant species look alike based on gross morphology but may differ when more specific

features are examined. It is important to collect a sample to make sure that UNKS that appear similar are actually the same species.

9. Use the unknown species code on the monitoring field forms.
Try to ID the collected material as soon as possible.

SOP 14 APPENDIX A: Unknown Shrub Species Field Form and Log

Integrated Uplands
SOP 14 - Unknown Shrub Species Field Form

Date: ____/____/____ (MM/DD/YY)

Park code: ____ Macroplot Nbr: ____

Unknown Code: _____

Photo #: _____

Collected by: _____

Transect 1 2 3

Position on Transect: ____ . ____ (m)

Shrub General Description:

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*)

General and Microhabitat Characteristics:

Collected: Yes No

Best Guess:

Confirmed to be:

Identified by:

Date:

Integrated Uplands
SOP 14 - Unknown Shrub Log

Park code: _____

Page ____ of ____

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Standard Operating Procedure (SOP) # 15: End of Field Tour and Season Activities

Version 1.0

Revision History Log:

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

This SOP details procedures performed at the end of each field tour and field season, including equipment maintenance and data management. The Field Lead will be responsible for organizing administrative paperwork (i.e., travel vouchers, timesheets, extra work authorizations, leave requests) and briefing the crew on what to expect on the next field tour if monitoring has not finished. All inventory and monitoring projects will have an end of season close-out at least once a year, or for each monitored park, when all data for the field season is received and certified. Season closeout for data management is described in *MOJN I&M DM SOP M15 – Season Closeout*.

This SOP was adapted from *SOP 17 – After each Field Visit and after the Field Season* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol.

1. Roles and Responsibilities

Field crews will work in cooperation with the Field Lead, Protocol Lead, Network Data Manager, and Global Information Systems (GIS) Specialist to close-out the field season. Table 15.1 outlines the individuals responsible for specific tasks. In general, data and files are managed appropriately as soon as the files are generated to reduce the time necessary for close-out.

Table 15.1. General roles and responsibilities to close out the field season.

Task	Role (primary lead is first in list)
Field crew close out	Field Lead
Field equipment close out	Field Lead; consult with Data Manager and Protocol Lead for next season needs
Data certification (data received from Data Manager)	Protocol Lead
Field forms and data	Protocol Lead, GIS Specialist, and Data Manager
Images/Photographs processing	Field Lead and Data Manager
Images/Photographs metadata and catalog	Protocol Lead and Data Manager
Species (IRMA NPSpecies)	Data Manager
References (IRMA Data Store)	Data Manager
Geospatial data organization and metadata	GIS Specialist and Protocol Lead
Archiving	Data Manager

2. Relevant SOPs

For this SOP, please refer to the following associated SOPs (those listed as MOJN I&M SOPs are MOJN I&M network-wide SOPs and not reproduced in this protocol; please refer to *Volume 1: Protocol Narrative* for how to obtain network-wide SOPs):

For this SOP, please refer to the following associated SOPs (those listed as MOJN I&M SOPs are MOJN I&M network-wide SOPs and not reproduced in this protocol):

- *SOP 1 - Preparations and Equipment Setup Prior to the Field Season* – for field equipment list
- *MOJN I&M DM SOP M13 – Project Deliverables* - for creating a directory structure and organizing files, for photograph organization
- *MOJN I&M DM SOP M17 – Naming Conventions* - for file naming conventions
- For metadata, consult:
 - MOJN I&M DM SOP M12 - NPS Metadata Tools and Editor* - for how to create metadata and what is required
 - MOJN I&M DM SOP M9 - Documentation Non-Spatial* - for tabular metadata
 - MOJN I&M DM SOP M10 - Documentation Spatial* - for geospatial data metadata
 - MOJN I&M DM SOP M6 – Biological Data Profile* – for creating a Biological Data Profile for geospatial and non-spatial metadata using the Integrated Taxonomic Inventory System
 - MOJN I&M DM SOP M11 – Image Management* – for digital photo metadata
- For species documentation in IRMA NPSpecies, refer to <https://irma.nps.gov/App/Species/Welcome>

3. End of Field Tour or Park Field Work Activities

At the end of each field tour or upon conclusion of field work at a park, follow the procedures described in this section and in section 5. *After the Field Season*. There are a number of tasks that must be accomplished by the field crew upon return to the office and prior to going into the field again (if applicable).

3.1. Before Leaving the Park

Field crews must perform the following activities before leaving a park. It is an important step to prevent transport of biological materials (e.g., invasives, infectious agents) between parks.

1. ID any collected specimens of unknown shrubs.
All collections that can be IDed and verified should be discarded appropriately before leaving the park. Collections that cannot be identified in the field will be discarded as described under section 4. *After the Field Season*.
2. Wash and clean the field vehicles, inside and out.
At the very least, make sure to use water to spray the outside of the field vehicle, particularly areas where biological material may have accumulated (e.g., undercarriage, tires, truck bed).

Sweep out or vacuum the inside of the vehicle.

If field sampling is finished at a particular park, then the vehicle *MUST* be taken to a car wash and thoroughly washed and vacuumed before proceeding to the next park.

3. Check all camping gear, equipment, and personal belongings for “volunteer” travelers (e.g., seeds, insects). Brush all clothing, particularly socks and shoes, to remove plant material; be especially aware of seeds that are stuck to clothing. Clean brush before leaving park-do not leave the brush filled with accumulated plant material.

Any items that can be rinsed (e.g., camping gear, muddy equipment, shoes) should be hosed down.

If possible, clothing, packs, and shoes should be washed near the park to localize the biological materials.

All camping gear, equipment, and personal belongings should be washed or vacuumed. If field sampling is finished at a particular park, then washing and vacuuming *MUST* be done.

3.2. General Tasks

1. Complete documentation for unknown plants.

The Field Lead is responsible for ensuring complete resolution of all unknown plants.

Annotate the field forms with the correct identifications and ensure that species are entered correctly in the database.

Label and mount the appropriate specimens for the field herbarium.

Update park plant species lists, species list in the database, and submit for updates in Integrated Resource Management Applications (IRMA) NPSpecies.

2. The Field Lead will update park access documents, such as road closures, park contacts, and complete a trip report, detailing the location, dates of field work, crew members participating, work completed, travel and housing availability, access issues, safety concerns and how they were accommodated, weather conditions, any equipment problems or needs, any major deviations from the SOP (including deviation in the order of macroplot visits), and any other pertinent information.

3.3. Field Equipment

1. Clean and disinfect all used field equipment, including those used for camping, and field equipment bins.
2. Thoroughly inspect the field vehicles and provide a list of damages, repairs, and missing/damaged vehicle equipment to the Field Lead.

3.4. Data Management

1. Field Forms
 - a. Organize by macroplot number, check, and Quality Assurance/Quality Control (QA/QC) field forms. All field forms must be legible – resolve any questions about field forms with the crew members who collected the data.
 - b. Scan all field forms to PDF format (1 PDF file per macroplot) and use the proper naming convention (*MOJN I&M DM SOP M17 - Naming Conventions*).

- c. Place files into appropriate folders (see *MOJN I&M DM SOP M13 – Project Deliverables*) and archive (see *MOJN I&M DM SOP M5 - Archiving*).
 - d. Manage the hard copy forms according to the *MOJN I&M DM SOP M5 - Archiving*.
 - e. After returning to the office, store site packet and field forms in designated location.
2. Geospatial Data
 - a. GPS units returned to GIS Specialist for data download of all recently collected spatial data
3. Images (all those created for the spatial data collection)
 - a. All images downloaded from cameras to appropriate project folder within “Originals” folder

4. After the Field Season

In addition to the tasks outlined in section . *End of Field Tour or Park Field Work Activities*, the following tasks will be completed as part of end of season close-out:

1. The Protocol Lead and Field Lead will conduct a field season debriefing with the crew to discuss issues with the existing monitoring protocol, field logistics, and how field monitoring can be improved.
 - A final report documenting project personnel impressions, feedback, difficulties, recommendations, and an evaluation to help better serve the project and the network in the future will be part of that field seasons’ documentation.
2. Check in all equipment/supplies on the equipment check-out form.
 Return the GPS units to the GIS Specialist and the laptops to the Data Manager.
 Make a list of all missing or damaged equipment, with a description of the damage. Include any supplies that were consumed (e.g., pH standards).
 Provide the list to the Field Lead, so that equipment can be ordered or repaired.
3. Organize and properly pack equipment into bins for storage.
 Electronic equipment should have the batteries removed to prevent corrosion and leaking.
 Batteries should be stored separately in case they explode.
 Equipment should be organized by function, stored together (e.g., camping gear), and clearly labeled.

4.1. Data Management

1. Data entry/database
 - a. All data are entered from the field forms into the most recent version of the protocol working database.
 - b. Data are verified by a different person than entered the data ($\geq 95\%$ confidence).
 - c. Data are certified by the Protocol Lead and Data Manager ($\geq 95\%$ confidence), with final approval from the Program Manager.
 - d. The Data Manager migrates the certified data to the Master Database.
 - e. All digital data are archived.
2. Geospatial Data

- a. All data are projected in Universal Transverse Mercator (UTM) coordinate system NAD83 datum using the appropriate zone.
 - b. Metadata is created using NPS Metadata Tools and Editor and ArcCatalog (see *MOJN I&M DM SOP M12 - NPS Metadata Tools and Editor* and *MOJN I&M DM SOP M10 - Documentation Spatial*), and submitted to IRMA Data Store.
 - c. All spatial data are verified and validated by the Field Lead or GIS Specialist ($\geq 95\%$ confidence).
 - d. GPS data
 - All GPS Waypoints/Tracks/Routes located in appropriate folders
 - GPS data dictionaries provided, if applicable
 - All GPS data loaded into Geodatabases (.mdb)
 - All GPS data post-processed, if applicable
 - Geodatabases are the most current ArcGIS version
 - All Geodatabases and Waypoints/Tracks/Routes have proper naming conventions
 - e. GIS datasets
 - All spatial files created for the project or developed from field data are in geodatabases
 - Files named using the proper naming convention
 - Located in the appropriate geospatial folder
 - f. Maps
 - MXD files created for project maps in appropriate folders
 - Digital copies of all maps (e.g. maps included in reports) in appropriate folder
 - Metadata created using NPS Metadata Tools and Editor (see *MOJN I&M DM SOP M12 - NPS Metadata Tools and Editor*)
3. Images (all those created for the spatial data collection)
- a. All images have associated metadata (XMP file) and are named according to appropriate file naming conventions (refer to *MOJN I&M DM SOP M11 - Image Management*)
 - b. All images processed, organized, and images located in appropriate folder structure (see *MOJN I&M DM SOP M11 - Image Management* and *MOJN I&M DM SOP M13 – Project Deliverables*)
 - c. Edit location metadata tags for geospatial coordinates in geographic latitude and longitude
 - d. Voucher images
 - If any of the images are to be used as vouchers, then an original raw image from the camera must be retrieved from the “Originals” folder (see *MOJN I&M DM SOP M11 - Image Management*) and submitted with the voucher
4. Other Metadata
- a. Tabular data metadata created in NPS Metadata Tools and Editor (refer to *MOJN I&M DM SOP M12 - NPS Metadata Tools and Editor* and *MOJN I&M DM SOP M9 - Documentation Non-Spatial*)

- b. All written materials (e.g. reports, proposals, etc.) entered into IRMA Data Store (<http://irma.nps.gov/app/portal/home>)
- c. Species reported to IRMA NPSpecies

Standard Operating Procedure (SOP) # 16: Information Management Workflow and Tasks

Version 1.0

Revision History Log:

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

This SOP outlines the steps required to receive and process the data generated from the IU protocol. IU information management workflow is an inclusive description of all data generated, processed on-site by the network, processed off-site at parks, stored on-site and off-site, reported, and archived.

1. Information Management Workflow

Information Management workflow describes the steps required to receive and process data generated from monitoring to report production (Figure 16.1). Below, we outline the activities of the workflow, with the exception of the uploading and processing of the annual database (described in *SOP 17 – Data Management*) and annual reporting (described in *SOP 19 – Data Analysis and Reporting*).

1.1. Roles and Responsibilities

Information management tasks are the responsibility of the Data Manager, Protocol Lead, and Field Lead. While many of the tasks are carried out by field technicians, the ultimate responsibility for proper field training and data collection is with the Protocol Lead. The Data Manager is responsible for training MOJN I&M staff and/or field crew on proper data management procedures, ensuring that all information, primarily in the form of digital and non-digital data, associated with the protocol is properly received, processed, stored, and archived.

1.2. Summary of Devices and Data Collections

The IU protocol couples data collection downloaded from devices (e.g., Global Positioning System (GPS), camera) with field data collected from field measurements that are recorded on hard copy field forms.

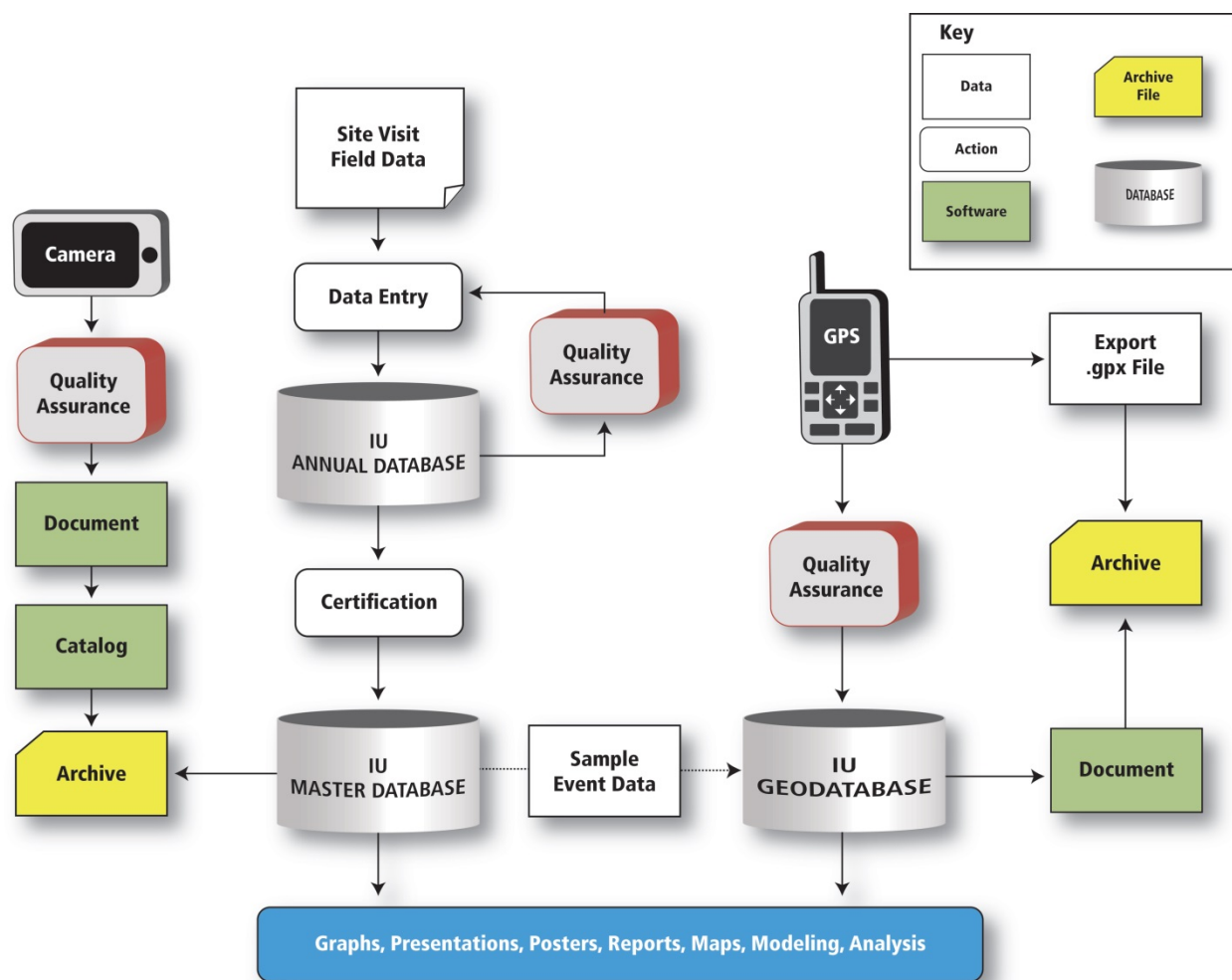


Figure 16.1. Overview of data collection, analyses, archiving, processing, and storing IU data.

1.3. Vegetation Data

Vegetation data are measured at frequencies of every three years using procedures described in *SOP 8 - Measuring Vegetation and Surface Cover Using Point-Intercept Sampling*. Table 16.1 shows a sample of the vegetation data collected (see *SOP 18 – Database Design* for more complete list).

Table 16.1. Sample of measurements taken for vegetation during IU monitoring.

Type of Measurement
Total Vegetation Cover
Cover by Life Form
Cover by Shrub Species

1.4. Soils Data

Soils data are collected every three years at each park using standard soil methods (described in *SOP 11 – Soil Measurements*). Soil surface data are collected in *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling*, soil disturbance data in *SOP 8*, *SOP 10 -*

Assessing Invasive Plant and Disturbance Frequency Using Quadrats, and soil erosion data in *SOP 9 - Measuring Basal and Canopy Gaps Using Line-Intercept Sampling* and *SOP 13 – Repeat Photos*. Some of the parameters collected for soils in the IU protocol are shown in Table 16.2 (see *SOP 18 – Database Design* for more complete list).

Table 16.2. Some of the measurements taken for soils during IU monitoring.

Type of Measurement
Soil Surface Features
Soil Strength
Abundance of Carbonates
Soil Color
Soil Consistence
Soil Texture
pH
Electrical Conductivity
Soil Erosion
Soil Disturbance

1.5. Invasive Plant Data

Target invasive plant data for status and trends (S&T) is collected every three years from *SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling*, *SOP 10 - Assessing Invasive Plant and Disturbance Frequency Using Quadrats*, and *SOP 12 – Site Assessment for Invasive Plant and Target Tree Species*. Some of the measurements taken for invasive species S&T is shown in Table 16.3 (see *SOP 18 – Database Design* for more complete list).

Table 16.3. Some of the measurements taken for invasive species S&T during IU monitoring.

Type of Measurement
Target Species Cover
Frequency of Invasive Species
Phenological Stage
Dispersion

1.6. Archiving

A critical aspect of data management for all MOJN I&M projects is the archiving of all data in a format that ensures future access and at multiple locations as a safeguard to a catastrophic event. The standards and procedures for archiving are outlined in the *MOJN I&M DM SOP M5 - Archiving*. The following sections provide a general overview of how the different types of data generated for this protocol are handled.

1.6.1. Field Data

All digital data will be archived on the MOJN read-only shared drive (N:) in the IU archive folder (N:\Archive\Monitoring\IntegratedUpland\). Detailed procedures for digital data archiving, including roles and responsibilities, are provided in the *MOJN I&M DM SOP M5 – Archiving*.

1.6.2. Hard Copy Field Forms

The originals of all hard copy field forms will be archived in NPS-approved storage facilities. An electronic scanned copy of the originals will be housed for reference at the MOJN I&M offices. Detailed procedures for hard copy data archiving, including roles and responsibilities, are provided in the following SOPs:

1. *MOJN I&M DM SOP M5 – Archiving*
2. *MOJN I&M DM SOP M18 – Digitizing Information and Photographs*

2. Tasks and Schedule

Table 16.4 lists the major tasks associated with the Information Management workflow. Each task has an estimate of the task duration for the Data Manager (DM), GIS Specialist (G), and Data Technician (DT) and a frequency for which this task is carried out. Other MOJN I&M staff will assist on the various data management tasks.

3. Project Records Management

MOJN I&M records management is legally mandated per NPS Director's Orders #19 (NPS 2001). Records management ensures all items pertaining to the operation of MOJN I&M are retained, preserved, and accessible according to law and regulations. Network protocols, data, and photographs are considered records. To facilitate efficient management of these records, MOJN I&M manages records using a structured workspace and standardized procedures for file naming conventions, protocol deliverables, end-of-season closeout, and archiving.

3.1. Project Workspace

The project workspace is a hierarchical folder structure where all digital files are stored, including original templates, all project data, and reports. Hard copy files, such as notebooks and field forms, are scanned to digital format; however, these hard copy records are retained and managed according to NPS Director's Order #19. The project workspace for the IU protocol is structured as detailed in *MOJN I&M DM SOP M16 - Directory Structure Non-Spatial*.

3.2. Project Files

Specific files are archived permanently during the workflow, as mentioned previously. Other files are submitted as project deliverables during the workflow and these may accumulate within a season, i.e. annually, as a duplicate copy separate from the workspace on the MOJN I&M SharePoint site. Project deliverables may include field forms, camera images, master databases, and geospatial data. *MOJN I&M DM SOP M13 - Project Deliverables* lists the specifications and procedures for processing project deliverables. Project deliverables must also use the standardized naming conventions.

At the end of the season, there is an annual closeout of the project files and data, during which all files are organized, reviewed for proper metadata and naming conventions, unnecessary files or duplicate files are removed from the project workspace and MOJN I&M SharePoint site, and all project deliverables are verified as received (refer to *MOJN I&M DM SOP M15 - Season Closeout*).

The entire set of annual project deliverables is compiled within a single folder directory on the MOJN I&M SharePoint site and Integrated Resource Management Applications (IRMA) Data Store for dissemination and access by the parks, and archived according to *MOJN I&M SOP M5 - Archiving*. A collection of project files and, in the case of the master database, long-term working files that are updated annually are also maintained for long-term easy access during the project life cycle in the project workspace.

Table 16.4. Information Management Tasks showing duration, who is primarily responsible for the task, and how often the task is performed. DM = data manager and G = GIS specialist.

Task	DM Duration (hrs)	Responsibility	Frequency
Master Database			
Update structure (tables & relationships)	16	DM	Annually
Annual Database (field forms for data entry)			
Update structure	4	DM	Annually
Update data entry forms	24	DM	Annually
Data Acquisition (field datasheets data)			
Standardize Location IDs; Update db tables	2	DM	Annually
Train data entry technician	8	DM	Annually
Data entry	6	DT	Twice a month
Upload device data (camera, etc) to db/folders	4	DM	Twice a month
GPS data download, quality assurance, and upload to gdb	2	G	Twice a month
Image Management (download and process)	3	DM	Twice a month
Electronic Devices			
Pre-season equipment set-up	2	DM	Annually
Pre-season equipment set-up	8	G	Annually
Post-season close-out	4	DM	Annually
Quality Assurance (QA)			
Develop QA queries	16	DM	Annually
Implement QA queries, correct, and flag data	8	DM	Annually
Data certification	4	DM	Monthly
Transition data to Master db	16	DM	Annually
Data Delivery to Protocol Lead			
Develop output format and contents	8	DM	Annually
Generate data output	8	DM	Annually
Reporting			
Summary data from IU database	16	DM	Annually
Compile and submit IU data and metadata	16	DM	Annually
Maps and geospatial needs	24	G	Annually
Trend reporting needs (every 3 years, hours are 1/3 of total)	3	DM	Annually
Trend reporting needs (every 3 years, hours are 1/3 of total)	8	G	Annually
Project Deliverables			
Compile and disseminate project deliverables	4	DM	Annually
Post data and reports to NPS IRMA Data Store	2	DM	Annually
Close-out			
Season close-out (organize and eliminate)	32	DM	Annually
Season close-out (organize and eliminate)	8	G	Annually
Metadata for data, db, and archive files	8	DM	Annually
Metadata for geospatial data, db, and archive files	4	G	Annually
Archive	4	DM	Annually

4. References

National Park Service. 2001. Director's order 19. National Park Service, Washington, D.C. Available from <http://www.nps.gov/policy/DOrders/DOrder19.html> (accessed 1 September 2011).

Standard Operating Procedure (SOP) # 17: Data Management

Version 1.0

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This SOP describes data management procedures for all data collected for the MOJN I&M IU protocol. The procedures for data management given in this SOP follow guidelines and standards that are described in the MOJN I&M Data Management Plan (2011) and the NPS I&M National Data Management Plan (NPS 2008).

1. Database Design

The primary dataset associated with the MOJN I&M IU monitoring protocol is based on a tabular dataset in Microsoft (MS) Access database that was originally created by the data management staff at Northern Colorado Plateau Inventory and Monitoring Network (NCPN). The MOJN I&M IU 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. See *SOP 18 – Database Design* for details. The IU database has a frontend/backend file structure:

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

2. Populating the IU Database

Prior to each field season, the working database for the IU protocol is produced 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 and enumeration tables and certain "static" macroplot 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 data in the working database is certified, it is merged into the master IU database.

For the remainder of this document, the term “upland database” refers to either the working database or one of its copies. The upland database will be populated via a combination of data import and data entry.

2.1. Data Import

All IU monitoring macroplot records will be initially established in the database by importing macroplot location data created from the Generalized Random Tessellation Survey (GRTS) design. This allows the location data in the database to be populated with adjusted centroids used to identify all of the potential macroplots and to provide the ability to populate the field Global Positioning System (GPS) units with all centroids for a given park. Importing is the preferred method for establishing macroplot records in the database because it reduces the data entry effort, which in turn, improves the accuracy of the data.

GPS field data will be populated from the locations table prior to sampling and the edited GPS field data updated in the table locations upon return. The macroplot locations for a park will be imported into the GPS. The GPS and field forms are updated after determining whether a macroplot is accepted or rejected using *SOP 6 – Site Characterization*. Rejected macroplots are documented but not deleted from the database. Accepted macroplots will have additional attributes to reflect the establishment of a permanent monitoring site and the initial field data collection. The locations table is updated upon return from the field to reflect the changes and provide for import to the GPS for subsequent field visits to the site. 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 17.1 lists the attributes derived from the GPS data (see *MOJN I&M SOP M3 - GPS* and *SOP 4 - Spatial Data Naming Conventions*).

Table 17.1. Fields derived from GPS data into locations tables.

GPS Field	Locations Table	Description
Perm_ UTME	Perm_ UTME	Permanent Corner Marker, easting
Perm_ UTMN	Perm_ UTMN	Permanent Corner Marker, northing
Perm_ Elev_m	Perm_ Elev_m	Elevation at permanent corner marker
T1O_UTME	T1O_UTME	Transect 1, origin, easting
T1O_UTMN	T1O_UTMN	Transect 1, origin, northing
T1E_UTME	T1E_UTME	Transect 1, end, easting
T1E_UTMN	T1E_UTMN	Transect 1, end, northing
T1O_Elev_m	T1_Elevation	Elevation at origin of transect 1, as a representation of the entire transect
T2O_UTME	T2O_UTME	Transect 2, origin, easting
T2O_UTMN	T2O_UTMN	Transect 2, origin, northing
T2E_UTME	T2E_UTME	Transect 2, end, easting
T2E_UTMN	T2E_UTMN	Transect 2, end, northing
T2O_Elev_m	T2_Elevation	Elevation at origin of transect 2, as a representation of the entire transect
T3O_UTME	T3O_UTME	Transect 3, origin, easting
T3O_UTMN	T3O_UTMN	Transect 3, origin, northing
T3E_UTME	T3E_UTME	Transect 3, end, easting
T3E_UTMN	T3E_UTMN	Transect 3, end, northing
T3O_Elev_m	T3_Elevation	Elevation at origin of transect 3, as a representation of the entire transect
recvr_type	recvr_type	Receiver type for each feature which has been collected

Macroplot location data are expected to be relatively static over time. Thus, GPS data will normally only be imported when a macroplot is initially established. If the location information for a given macroplot 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, macroplot location data will be imported from corrected GPS files into the working database. In such cases, the information should be entered into the field notes.

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

- Upon returning from the field, the Field Lead provides the shapefiles, raw data dot text files, and GPS units to the Global Information Systems (GIS) Specialist.
- The GIS Specialist, Field Lead, and Data Manager all agree upon the date by which the GPS data must be imported into the database.
- Once the macroplot location data have been imported into the database, the GIS Specialist will notify the Protocol Lead and Data Manager.
- If the GIS Specialist is unable to meet the deadline for importing the data, the Protocol Lead and Data Manager are notified. The Protocol Lead may choose to have the macroplot 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 the original macroplot centroid location as part of Quality Assurance/Quality Control (QA/QC) procedures, 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.

2.2. Data Entry

Data entry consists of transcribing the hard copy field forms. 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 Field Lead and Data Manager will make certain that persons performing data entry are familiar with the database, 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 forms, database software, database structure, and any standard codes for data entry. The Data Manager, in conjunction with the Protocol Lead, will ensure that the SOPs and user guides are 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. Electronic 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 forms.

Data verification immediately follows data entry and involves checking the accuracy and completeness of the computerized records against the hard copy field records; any errors found will be corrected. The following methods will be used to verify IU data.

2.2.1. Visual Review at Data Entry

The person doing data entry verifies each and every record after input and immediately corrects any errors. The best practice is for all records entered during a data entry session to be reviewed 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 Field Lead or Data Manager is confident of the person's use of the database and data entry skills. It may take several data entry sessions for new staff to become proficient with all the upland data entry forms. The review procedure includes:

1. Review field forms for omissions or obvious errors prior to data entry.
2. Following data entry, cross-reference the sample events table with the field forms. Investigate and resolve any discrepancies.
3. Verify 100% of the data entry values with field forms. This can be accomplished by a second data-entry individual.
4. Cross check at least 10% of the data entry values with the field forms. This is performed by the Protocol Lead or Field Lead.
5. Implement MS Access queries to test for generic errors (see section 2.2.3 - *Summary Queries and Tallies*).
6. Verify that 100% of the downloaded geospatial data are using the correct coordinate system, datum, zone, and filenames. This is performed by the Field Lead or GIS Specialist.

2.2.2. Visual Review After Data Entry

All records (or a pre-determined subset of records) entered during a data entry session¹ are compared to the original data source. Each data field on the corresponding electronic data entry form is compared with the original values from the hard copy, preferably by a second person who did not perform the data entry. Any errors that are discovered are corrected in the database as soon after data entry as possible. To achieve the highest possible level of data quality, all records entered during a data entry session would be reviewed by the Field Lead. However, this ideal case may not always be feasible due to limited resources, especially given the amount of data entry required.

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.

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.

2.2.3. Summary Queries and Tallies

Queries are run that detect broad errors such as duplicate or omitted records. Examples of such queries are given below:

- 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/macropoint combination, a listing and count of transects having shrub cover observations recorded.
- d. For each year/park/macropoint combination, a count of the number of photopoints recorded.

2.2.4. Visual Review of Spatial Data

Using GIS, 100 % of monitoring site data are visually inspected for accuracy (i.e. within the boundary of the park and in the approximate area where sampling was completed). This review will take place at the end of each field tour.

3. Data Validation

While many errors are prevented by including validation routines that function during data entry, additional review of the data by the Protocol Lead and Field Lead may be 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 macropoint 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 a way 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 on the *original paper field records* about how and why the data were changed. Modifications to the field records should be clear and concise while preserving the original data entries or notes. Validation efforts should also include a check for the completeness of a dataset since field forms or other sources of data could easily be overlooked.

4. Spatial Data Standards

For data layers to line up properly, the spatial reference (coordinate system and datum) must be completely described. All data managed by MOJN I&M staff will have this information, whether embedded in spatial data through ESRI software (preferred) or documented in tables or metadata. Data will be in the Universal Transverse Mercator (UTM projection), North American Datum of 1983 (NAD83, as both a horizontal and vertical datum), zone 11 or 12 North (depending upon which park), and in meters unless some compelling reason dictates otherwise.

4.1. Mapping Standards

All maps produced by network staff will be checked for compliance with National Map Accuracy Standards (NMAS). When a particular map scale is intended for data collected by GPS, NMAS standards will be used to determine the required on-the-ground accuracy.

4.2. GPS Standards

GPS data will always be collected at the highest accuracy feasible and every effort will be made to consider all uses of the data when designing data dictionaries. Care will be taken to:

1. Maintain Z coordinates from GPS in resulting GIS data.
2. Use appropriate offsets to account for antenna height or when locating features that are difficult to GPS directly.
3. Distinguish true from magnetic north and use up-to-date declination values when applicable.

4.3. Graphical Standards

All geospatial related documents, maps, geodatabases, web sites, and other products will comply with NPS Graphic Identity program standards (part of Director's Order 52A; NPS 2001) to present a consistent look and feel to consumers of these products.

5. Data Quality Review and Communication

MOJN I&M staff involved in IU 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 dataset (see section 9. *Metadata*). An important part of this metadata is data quality documentation, which consists of the verification and validation results. 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 Protocol Lead to indicate that the data are complete, have passed quality assurance checks, and are documented and ready for archiving, posting, and distribution.

6. Data Delivery

After the data are certified by the Protocol Lead, the Data Manager will transfer all data from the annual working database to the master database and deliver the data to the Protocol Lead in a flat file that can be used for data analysis. Following certification of the data, geospatial data will be received and stored in protocol specific geodatabases.

7. Versioning

Version control is the process of managing copies of changing data 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. MOJN I&M uses several techniques to help ensure proper version control: data archiving (refer to section 13. *Data Archiving* details), directory structure conventions (*MOJN I&M DM SOP M13 – Project Deliverables*), backup procedures, and database versioning.

7.1. Directory Structure Conventions

MOJN I&M has adopted directory structure conventions for I&M project folders (refer to *MOJN I&M DM SOP M13 – Project Deliverables*). 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 (refer to section 13. *Data Archiving*). 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 MOJN shared drive (M:).

7.2. Document Versioning

All stand-alone documents associated with a protocol must have a change or revision history log (i.e. user guides, appendices, and SOPs). The change history log is inserted directly after the title page (follow the version guidance described in *SOP 20 – Protocol Revision and Review*).

Revision procedures for the IU protocol and accompanying SOPs are described in *SOP 20 – Protocol Revision and Review*.

7.3. 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. MOJN I&M uses a version numbering scheme to track database modifications, in which modifications are grouped into software releases. Major releases are those involving significant changes to the database and are designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). For releases with only minor database changes (e.g., bug fixes), version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, ...). Database version information is maintained within the database, and can be viewed by choosing the **About** tab on the 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 the archive section and *MOJN I&M DM SOP M5 - Archiving*).

8. Field Photos

A number of field photos and digital images are expected from the field work associated with the IU protocol. All of the photos must adhere to the guidance and specifications provided in the *MOJN I&M DM SOP M11 - Image Management*.

9. Metadata

Data documentation is a critical step toward ensuring that both spatial and tabular datasets are useable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Metadata is required for the following projects, tasks, and deliverables for the IU protocol: database, GIS data, reports, protocol, photos, and field forms. Additionally, metadata provides the means to catalog datasets within intranet and internet systems, making data available to a broad range of potential users.

Metadata can take many different forms, including formal Federal Geographic Data Committee (FGDC) compliant metadata, reference records, and protocol version information. Metadata for all MOJN I&M monitoring data will conform to FGDC and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. Refer to the following for additional guidelines:

1. *MOJN I&M DM SOP M10 - Documentation Spatial*
2. *MOJN I&M DM SOP M9 - Documentation Non-Spatial*

For long-term projects such as this one, metadata creation is most time consuming the first time it is developed; after which, most information remains static from one year to the next. Metadata records in subsequent years only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches, or quality assurance for the project.

The Protocol Lead, with the Data Manager's assistance, will create and update an FGDC- and NPS-compliant metadata record in XML format. The Protocol Lead should update the metadata content as changes to the protocol are implemented and each year as additional data are accumulated. Edits within the document should be tracked so that any changes are obvious to those who will use it. At the conclusion of the field season, the Protocol Lead will be responsible for providing a completed, up-to-date metadata record to the Data Manager and/or GIS Specialist, as appropriate. The Data Manager will facilitate metadata development by assisting with parsing the metadata records and posting the records to national clearinghouses as described under section *12.1 Posting and Distribution*.

To comply with NPS metadata requirements, metadata for datasets will be created following MOJN I&M metadata procedures (see *MOJN I&M DM SOP M10 - Documentation Spatial*, *MOJN I&M DM SOP M9 - Documentation Non-Spatial*, *MOJN I&M DM SOP M6 - Biological Data Profile*, and *MOJN I&M DM SOP M12 - NPS Metadata Tools and Editor* for details):

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

- All other integrated upland datasets and data products will be documented as cross-reference citations in the project level metadata record in IRMA Data Store.

10. Sensitive Information

An element of metadata development includes determining whether or not the data include any sensitive information (e.g., specific locations of rare, threatened, endangered, or commercially valuable species). Prior to completing metadata, MOJN I&M staff and Park Resource Managers should identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager (see *MOJN I&M DM SOP M14 - Sensitive Data* for details). The spatial location of sensitive data will be distorted using GIS applications or the spatial attributes will be removed based upon the data request.

Non-sensitive data with compliant metadata will be distributed as widely as possible via the NPS Data Store. All sensitive GIS data will be stored in a separate directory to minimize confusion over sensitivity levels and ease management of security privileges.

11. Data Certification

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may not have been detected during quality assurance reviews. To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Protocol Lead and Data Manager are responsible for completing certification, with the Program Manager having the final approval and sign-off on the data. Additional details of the certification and delivery processes are included in *MOJN I&M DM SOP M7 - Data Quality*.

12. Data Analyses and Product Development and Delivery

The Protocol Lead is responsible for data analyses, informational product development (reports, presentations, posters, etc.), and delivery of the products to the Data Manager. Analyses, products, and delivery schedules are detailed in *SOP 19 - Data Analysis and Reporting*. All documents associated with analyses and products are delivered to the Data Manager for posting and distribution. The organization and general standards for project deliverables are detailed in *MOJN I&M DM SOP M13 - Project Deliverables*.

12.1. Posting and Distribution

Data and reports are posted on the MOJN I&M SharePoint site, NPS intranet, NPS internet, and the national web-accessible secure databases supported by the NPS Washington Office (WASO) or National I&M program. These include:

IRMA Data Store

This portal is a gateway to NPS natural resource data and information available at <https://irma.nps.gov/App/Reference/Welcome>

MOJN I&M SharePoint Site

This portal is a gateway to MOJN I&M natural resource data and information available at <http://inpniscvsp05:39904/im/networks/MOJN/default.aspx>

MOJN I&M Internet Web Site

This public web site for the MOJN I&M natural resource data and information is available at <http://science.nature.nps.gov/im/units/mojn/index.cfm>

MOJN I&M Intranet Web Site

This internal web site for the MOJN I&M natural resource data and information is available only to employees of the NPS at <http://www1.nrintra.nps.gov/im/units/mojn/>

13. Data Archiving

Archiving is a critical step in ensuring the long-term preservation of data. IU 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. Refer to the following SOPs for archiving procedures:

1. *MOJN I&M DM SOP M5 - Archiving*
2. *MOJN I&M DM SOP M18 - Digitizing Information and Photographs*

14. References

Mojave Network. 2011. Data and information management plan for the Mojave Network. Mojave Inventory and Monitoring Network. National Park Service. Boulder City, Nevada. Available at <http://science.nature.nps.gov/im/units/mojn/index.cfm> (accessed 2 May 2012).

National Park Service. 2001. Director's Order 52A. U.S. Department of Interior, National Park Service, Washington, D.C. Available at <http://www.nps.gov/refdesk/DOrders/DOrder52A.html> (accessed 1 September 2011).

National Park Service. 2008. Data Management Guidelines for Inventory and Monitoring Networks. Natural Resource Report NPS/NRPC/NRR—2008/035. National Park Service. Fort Collins, Colorado. Available at https://science1.nature.nps.gov/naturebib/biodiversity/2008-5-29/National_DM_Plan_1.0.pdf (accessed 1 April 2011).

Standard Operating Procedure (SOP) # 18: Database Design

Version 1.0

Revision History Log:

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

This SOP describes the purpose of the IU protocol database, the data management procedures related to the database, the data fields included in the database, how the database was designed, and how to extract data from the database. The MOJN I&M Data Management Plan (DMP) is an integral component of protocol database management and is referenced throughout this SOP. The DMP can be found online at:

MOJN SharePoint site for NPS only: <http://inpniscvsp05:39904/im/networks/MOJN/default.aspx>

MOJN internet site: <http://science.nature.nps.gov/im/units/mojn/>

MOJN I&M has based the IU protocol database on the Northern Colorado Plateau Network (NCPN) Integrated Upland protocol MS Access database. A number of areas of the database needed to be adjusted to meet the needs of the MOJN I&M IU protocol, including removing the fire-fuels monitoring and adding a number of additional soil parameters.

1. Introduction

MOJN I&M protocol databases are based on the master and working database strategy, each of which are designed to be compliant with the standards set forth by the NPS I&M Program's Natural Resources Database Template (NRDT), version 3.2 (NPS 2007). The working database, or annual or field database, consists of two separate Microsoft Access database files. The front-end of the working database contains forms, linked tables, reports, queries, macros, and Visual Basic code and the back-end contains the data tables (Adams et al. 2009). This organization of the database allows new development and edits of forms and reports (housed in the front-end) to proceed without hindering use of the data (housed in the back-end) (Adams et al. 2009). The two database files are linked using a connect data tables utility built into the database. The purpose of the working database is to facilitate data entry, quality control of data entry, quality assurance reviews following data entry, summaries, and generating annual reporting products. Data in the working database are certified after the quality assurance review and transferred annually to the master database. Working databases are partial or complete mirror images of the master database tables.

The purpose of the master database is to store and facilitate continued access to all protocol data for reporting and analyses throughout the duration of the protocol. The master database lacks the front-end features of the working database and typically has additional data tables. The master database is updated annually and retained with the protocol files for the monitoring project. Source files used to update the master database may include, but are not limited to, the working database, photo links, Global Positioning System (GPS) data, etc. In addition to the master and working database, there will also be a geodatabase for the IU protocol.

1.1. What the Integrated Upland Database is and is not

The Database is/will:

- A relational MS Access database organized by subject-based tables and primary keys
- Compliant with NRDT version 3.2
- Provide quality control of data input
- Provide quality assurance of discrete field data
- Accommodate annual data photo metadata
- Designed for reporting and analyses of the data

The Database will not:

- Accommodate all data photos

1.2. Database Design Considerations

The following items were considered and included in the design of the database:

- Yes/No data types are not used; instead the field is set to Text data type, field size is limited to 4, Display control is Combo Box, Row source Type is set to Value List, and the Row Source is “Yes;No”
 - Reason: Yes/No data types are check boxes in the database tables that may be true/false or binary (e.g. 0 or 1); therefore using text data type limited the data to a consistent value regardless of the software platform
 - Exception to this general rule is the tbl_QA_Tracking which uses the YES/NO data type and the check boxes as the display control. The QA tracking is an internal table that remains with the working database and is not truly considered monitoring protocol data that will be analyzed and or exported.
- Default values for Number data types are set to null to prevent the accidental inclusion of a zero value as data
- Non-integer numerical data are decimal data type, with appropriate scale and precision
- Use of enumeration tables for administrative information, e.g. park unit codes, and vegetation/soils quantity and quality parameters that are not highly variable year to year
- Naming conventions of the database objects and fields followed the standards outlined in *Recommended Naming Standards for Inventory and Monitoring Databases* (WASO 2004), *MOJN I&M Data Management Plan*, and *MOJN I&M DM SOP M8 - Database Naming Conventions*

All decimal numbers that appear in a query output are set as fixed in the property sheet under the format tab. This setting standardizes the number of digits to the right of the decimal regardless of the value, i.e., 2.00 or 2.01, and eliminates calculation and export issues with floating point values.

Numeric values in a table or a query that are not integers are set to a fixed point number, i.e., decimal, and not single or double field size due to the error generated in calculations when floating point values are used (Table 18.1).

Table 18.1. Field size of non-integer numeric values in tables.

Field	Setting
Field size	Decimal
Format	Fixed
Precision	18
Scale	1, 2, 3, or greater if needed
Decimal Places	1, 2, 3, or greater if needed
Default value	null, the default value of zero is deleted

1.3. Database Design Summary

The database is designed around centralized methods of input, specifically:

- Field forms (currently hard copy, potentially soon to be electronic)
- Tracking logs and list (e.g., contacts, equipment)

An additional element is the quality assurance reviews, which results in automated flagging of the data records, a report output for reviewing the data, and importing to Excel/Word for the annual reports.

The following tables and relationships were developed based on the structure and standards of I&M NRDT, version 3.2. The unifying table for most of the IU data is the tbl_Events field data and tbl_Event_Group is the unifying table for the summary data, which is not linked to a single event. Independent tables include tbl_1_Meta and tbl_1_Revisions which are used by the Data Manager to track the changes to and provide metadata for the database.

Photographs associated with the protocol will not be stored in the database with the exception of macroplot overview images that are used for reference. The *MOJN I&M DMP* and *MOJN I&M DM SOP M11 - Image Management* documents procedures for organizing, cataloging, and creating metadata for all protocol photos.

1.3.1. Table Relationships

Relationships between the tables define both how the data relate to one another and controls the quality of the data such that entries are not possible without data in the related table. Relationships occur on the primary key field. The pivotal table, tbl_Events, contains metadata for each sample event and each related table retains an identical field for the sample event identifier, e.g. Event_ID (Figure 18.1).

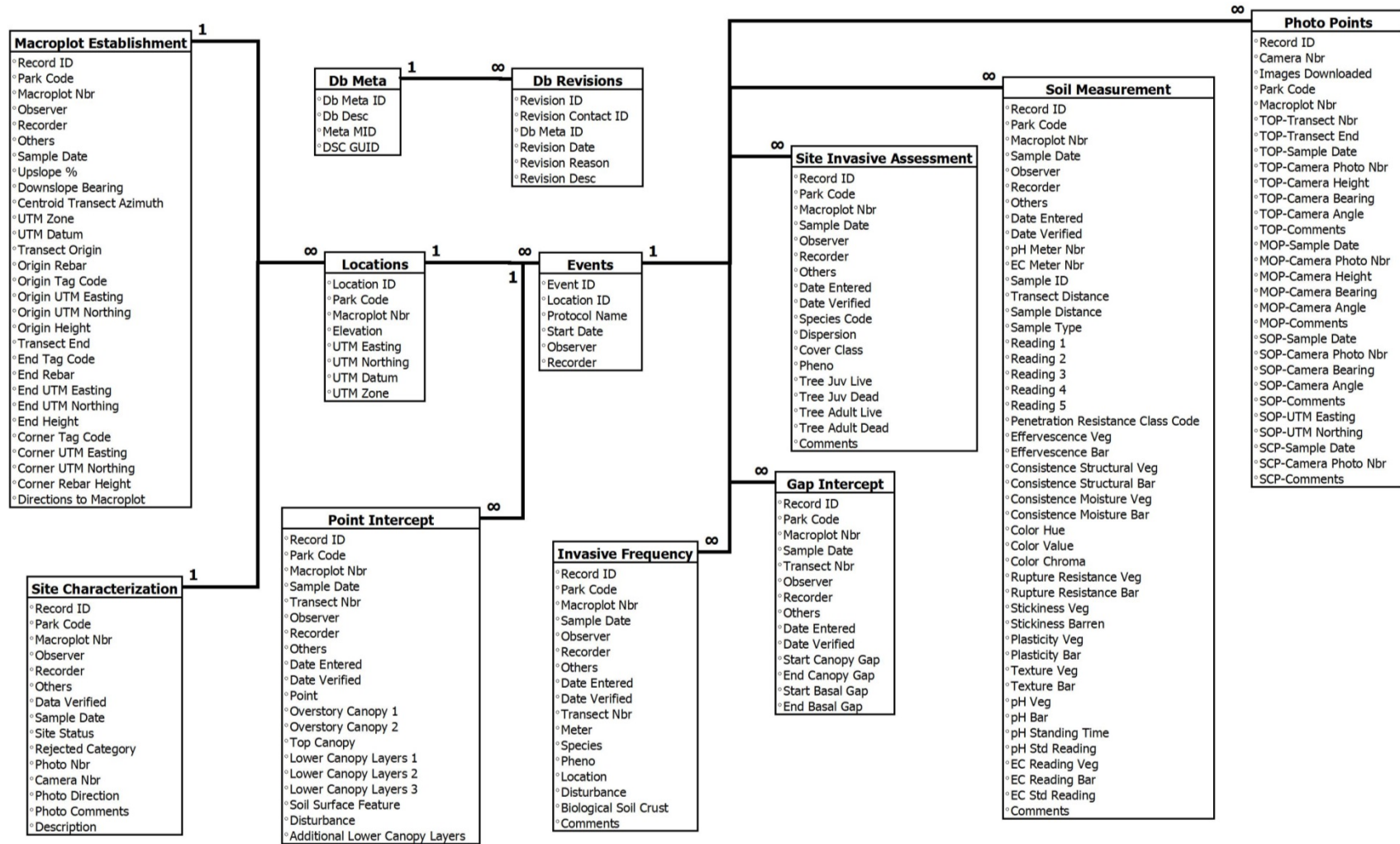


Figure 18.1. Relationships for the IU back-end database. The attribute link is depicted by the line that is drawn between the attributes between tables. The “1” and “∞”, depict a one-to-many relationship between linked tables. The “1” means that one and only one attribute record element can be used (no duplicates allowed) and is linked to many records (“∞”) within a corresponding attribute in a linked table.

1.3.2. Database Structure

All databases and components are in the Microsoft Access application. Tables are a mix of row- and column-major structure depending on the end-user needs. For instance, invasive species parameters are consistently measured each monitoring period, need to be easily accessible and viewable by the Protocol Lead, thus these data are in a column-major table structure. Data that is highly variable annually would be most efficiently contained in a row-major table structure.

All tables include a primary key that will serve to distinguish each record and may be shared with another table to create a 'link' between two or more tables. Primary keys are critical to the stability and long-term integrity of the data. Primary keys are assigned by the database either through the AutoNumber process that MS Access controls or through Visual Basic for Applications (VBA) scripts that automatically invoke during data entry. In most cases where a primary key is a critical component of a relationship between one or more tables, a *meaningful* primary key is used for the field data, such as a combination of a unique feature identifier and date of the sample event, e.g., BAKR1_20010312. A meaningful primary key reduces the potential of worthless data should a table or the data lose its link or be extracted from the database without the appropriate metadata. A meaningful primary key also expands the potential to link currently unlinked data in the future if the data share a common value.

Protocol databases also include a front-end data access database composed primarily of forms, queries, macros, and reports, and a back-end where the critical data tables are stored and accessed. A front-end and back-end combination constitutes the working database that is updated annually. A master database also resides on the server and this database is primarily only tables that are updated annually with all protocol data after the working database has been certified. The master database is also updated as needed and managed by the Data Manager.

1.4. IU Database Structure

1.4.1. Table Structure

The following tables list the IU field forms in a data dictionary format that are integrated into the working database (Tables 18.2-18.9). Tables include those that store field data and calculated data fields, but not the enumeration and look-up tables. Only tables directly related to the IU protocol procedures are included here.

Table 18.2. Data dictionary for fields on Site Characterization Field Form. Characterization of the site to determine whether to accept or reject it for monitoring.

Field Names	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Data Verified	No	Text	5	Enter date that data are verified visually by protocol lead (mm/dd/yyyy)
Sample Date	No	Date	8	Enter date that field data are collected (mm/dd/yyyy)
Site Status	No	Text	10	Site is either accepted or rejected as a permanent macroplot
Rejected Category	No	Text	2	Site was rejected for nonresponse or sample error criteria
Photo Nbr	No	Text	20	Number off of the camera
Camera Nbr	No	Text	3	Number off of the camera
Photo Direction	No	Text	15	Direction that photo was taken
Photo Comments	No	Text	50	Any comments particular to a photo
Description	No	Text	255	Description of why the site was rejected

Table 18.3. Data dictionary for fields on Macroplot Establishment Field Form. Field parameters collected to describe each site where a macroplot will be established.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, 35 per park
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Sample Date	No	Date	8	Enter date that field data are collected (mm/dd/yyyy)
Upslope %	No	Integer	3	Slope of macroplot up, to nearest tenth
Downslope Bearing (aspect)	No	Integer	3	Bearing of the macroplot slope down to nearest tenth of a decimal
Centroid Transect Azimuth	No	Integer	3	Subtract 90 from the down slope bearing
UTM Zone	No	Text	2	11N for all except PARA which is 12N
UTM Datum	No	Text	10	NAD 83 only - default
Transect Origin	No	Text	1	Enter 1, 2, or 3 for transect number
Origin Rebar	No	Text	2	Position of rebar along transect (in meters)
Origin Tag Code	No	Text	30	Code that is marked on the zero meter rebar
Origin UTM Easting	No	Integer	6	X coordinate position transect start point (0 meters)
Origin UTM Northing	No	Integer	7	Y coordinate position transect start point (0 meters)
Origin Height	No	Text	2	Height to top of rebar from ground at zero meter position (in centimeters)
Transect End	No	Text	1	Enter 1, 2, or 3 for transect number
End Tag Code	No	Text	30	Code that is marked on the 50 meter rebar
End Rebar	No	Text	2	Position of rebar along transect (in meters)
End UTM Easting	No	Integer	6	X coordinate position transect end point (50 meters)
End UTM Northing	No	Integer	7	Y coordinate position transect end point (50 meters)
End Height	No	Text	2	Height to top of rebar from ground at 50 meter position (in centimeters)
Corner Tag Code	No	Text	30	Code that is marked on the macroplot corner rebar
Corner UTM Easting	No	Integer	6	X coordinate position for macroplot corner rebar
Corner UTM Northing	No	Integer	7	Y coordinate position transect for macroplot corner rebar
Corner Rebar Height	No	Text	2	Height to top of rebar from ground for macroplot corner rebar
Directions to Macroplot	No	Text	255	Written directions to the macroplot location

Table 18.4. Data dictionary for fields on Point-Intercept Field Form. Data collected on vegetation, soil surface features, and soil disturbances on transects.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
Transect Nbr	No	Integer	1	Enter 1, 2, or 3 for transect number
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Date Entered	No	Date	8	Enter date that data are entered into digital format (mm/dd/yyyy)
Date Verified	No	Date	8	Enter date that data are verified visually by protocol lead (mm/dd/yyyy)
Point	No	Fixed	2.1	Record tape measurement from field form
Overstory Canopy 1	No	Text	10	Record the XXXX letter plant code for the species in top and whether it is alive or dead
Overstory Canopy 2	No	Text	10	Record the XXXX letter plant code for the species in top and whether it is alive or dead
Top Canopy	No	Text	10	Record the XXXX letter plant code for the species in top and whether it is alive or dead
Lower Canopy Layers 1	No	Text	10	Record the XXXX letter plant code for the species and whether it is alive or dead
Lower Canopy Layers 2	No	Text	10	Record the XXXX letter plant code for the species and whether it is alive or dead
Lower Canopy Layers 3	No	Text	10	Record the XXXX letter plant code for the species and whether it is alive or dead
Soil Surface Feature	No	Text	5	Record soil surface feature type
Disturbance	No	Text	10	Record disturbance type
Additional Lower Canopy Layers	No	Text	10	Record the XXXX letter plant code for the species and whether it is alive or dead for additional canopy layers; include measurement along tape in hundredths of a meter

Table 18.5. Data dictionary for fields on Canopy and Basal Gap Field Form. Data collected on the size of gaps between perennial plant canopies and plant bases along transects.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
Transect Nbr	No	Integer	1	Enter 1, 2, or 3 for transect number
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Date Entered	No	Date	8	Enter date that data are entered into digital format (mm/dd/yyyy)
Date Verified	No	Date	8	Enter date that data are verified visually by protocol lead (mm/dd/yyyy)
Start Canopy Gap	No	Fixed	2.2	Meter reading at start of gap in hundredths of a meter
End Canopy Gap	No	Fixed	2.2	Meter reading at end of gap in hundredths of a meter
Start Basal Gap	No	Fixed	2.2	Meter reading at start of gap in hundredths of a meter
End Basal Gap	No	Fixed	2.2	Meter reading at end of gap in hundredths of a meter

Table 18.6. Data dictionary for fields on Invasive Species Quadrat Field Form. Data collected on invasive plant species and soil surface disturbance frequency using quadrats along transects.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Date Entered	No	Date	8	Enter date that data are entered into digital format (mm/dd/yyyy)
Date Verified	No	Date	8	Enter date that data are verified visually by protocol lead (mm/dd/yyyy)
Transect Nbr	No	Integer	1	Enter 1, 2, or 3 for transect number
Meter	No	Integer	2	Enter the meter # along the transect tape that the quadrat is placed
Species	No	Text	10	Record the USDA plant code for the species of invasive species identified
Pheno	No	Text	1	Choose correct phenophase for species
Location	No	Text	2	Choose I (interspace), C (canopy), or CI (both interspace and canopy)
Disturbance	No	Text	10	Record disturbance type
Biological Soil Crust	No	Text	1	Choose A (absence) or P (presence) of biological soil crust
Comments	No	Text	255	Additional comments

Table 18.7. Data dictionary for fields on Soil Measurements Field Form. Measurements taken along edge of macroplot.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
Sample Date	No		8	Enter date that data are collected (mm/dd/yyyy)
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Date Entered	No	Date	8	Enter date that data are entered into digital format (mm/dd/yyyy)
Date Verified	No	Date	8	Enter date that data are verified visually by protocol lead (mm/dd/yyyy)
pH Meter Nbr	No	Text	3	Unique identifying number for this pH meter
EC Meter Nbr	No	Text	3	Unique identifying number for this EC meter
Sample ID	No	Text	2	Enter 1-12 depending upon which sample site within the macroplot
Transect Distance	No	Fixed	2.2	Record the meters along the transect where soil sampling point was found to the nearest hundredth of a meter
Sample Distance	No	Fixed	2.2	Record the distance (meters) from the soil sampling point to where the other (either veg or barren that was not taken at the soil sampling point) sample was taken to the nearest hundredth of a meter
Sample Type	No	Text	1	Record the type of sample V (vegetated) or B (barren) that was collected away from the soil sampling point taken to the nearest hundredth of a meter
Reading 1	No	Fixed	3.2	Record first penetrometer reading
Reading 2	No	Fixed	3.2	Record second penetrometer reading
Reading 3	No	Fixed	3.2	Record third penetrometer reading
Reading 4	No	Fixed	3.2	Record forth penetrometer reading
Reading 5	No	Fixed	3.2	Record last penetrometer reading
Penetration Resistance Class Code	No	Text	3	Record class code from list provided
Effervescence Veg	No	Text	2	Class code for effervescence value-vegetated area
Effervescence Bar	No	Text	2	Class code for effervescence value-barren area
Consistence Structural Veg	No	Text	10	Select aggregate type from list provided – vegetated area
Consistence Structural Bar	No	Text	10	Select aggregate type from list provided – barren area
Consistence Moisture Veg	No	Text	5	Either dry, moist, or wet – vegetated area
Consistence Moisture Bar	No	Text	5	Either dry, moist, or wet – barren area
Color Hue	No	Text	10	Derived from Munsell charts
Color Value	No	Text	2	Derived from Munsell charts
Color Chroma	No	Text	2	Derived from Munsell charts
Rupture Resistance Veg	No	Text	10	Select value based upon determination – vegetated area

Table 18.7. Data dictionary for fields on Soil Measurements Field Form. Measurements taken along edge of macroplot (continued).

Field Name	Primary	Field Type	Field Size	Field Description
Rupture Resistance Bar	No	Text	10	Select value based upon determination – barren area
Stickiness Veg	No	Text	2	Stickiness value codes – vegetated area
Stickiness Barren	No	Text	2	Stickiness value codes - barren area
Plasticity Veg	No	Text		plasticity value codes - vegetated area
Plasticity Bar	No	Text		plasticity value codes - barren area
Texture Veg	No	Text	5	texture value codes - vegetated area
Texture Bar	No	Text	5	texture value codes - barren area
pH Veg	No	Text	2.1	pH sample value - vegetated area
pH Bar	No	Text	2.1	pH sample value - barren area
pH Standing Time	No	Time	hh:mm	Record the amount of time (in hours and minutes) that the sample sits before doing the pH reading
pH Std Reading	No	Text	2.1	Record the pH 7 standard reading
EC Reading Veg	No	Text	4.2	Record the EC soil sample reading – vegetated area
EC Reading Bar	No	Text	4.2	Record the EC soil sample reading – unvegetated area
EC Std Reading	No	Text	4.2	Record the EC standard reading
Comments	No	Text	255	Record any notes related to this sample data collection

Table 18.8. Data dictionary for fields on Site Assessment for Invasive Plant and Target Tree Species Field Form. Data collected on invasive plant species observed within a macroplot during the patterned walk.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
Observer	No	Text	3	3 initials of a person's name
Recorder	No	Text	3	3 initials of a person's name
Others	No	Text	12	3 initials of a person's name
Date Entered	No	Date	8	Enter date that data are entered into digital format (mm/dd/yyyy)
Date Verified	No	Date	8	Enter date that data are verified visually by protocol lead (mm/dd/yyyy)
Species Code	No	Text	10	Record the XXXX letter plant code for the species for invasive species identified
Dispersion	No	Text	2	Dispersion code from pick list
Cover Class	No	Text	2	Cover class code from pick list
Pheno	No	Text	2	Phenophase code from pick list
Tree Juv Live	No	Integer	4	Enter number of juvenile, live trees
Tree Juv Dead	No	Integer	4	Enter number of juvenile, dead trees
Tree Adult Live	No	Integer	4	Enter number of adult, live trees
Tree Adult Dead	No	Integer	4	Enter number of adult, dead trees
Comments	No	Text	255	Record any comments related to this species

Table 18.9. Data dictionary for fields on Repeat Photos Field Form. Information collected for photopoints on a macroplot. TOP refers to transect overview photographs, MOP to macroplot overview photographs, SOP to soil overview photograph, and SCP to soil close-up photographs.

Field Name	Primary	Field Type	Field Size	Field Description
Record ID	Yes	Text	50	GUID, unique identifier
Camera Nbr	No	Text	3	Number off of the camera
Images Downloaded	No	Text	60	Folder path and name where photos are digitally stored
Park Code	No	Text	4	Four letter park acronym
Macroplot Nbr	No	Text	3	Unique macroplot identifier, per park
TOP-Transect Nbr	No	Text	1	Enter 1, 2, or 3 for transect number
TOP-Transect End	No	Integer	2.2	"0" for origin, "50" for 50-m end of tape, or meter reading for placement of camera on transect in hundredths of a meter.
TOP-Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
TOP-Camera Photo Nbr	No	Text	20	Photo number off camera
TOP-Camera Height	No	Text	2.2	Height of camera from ground
TOP-Camera Bearing	No	Text	3	Bearing of camera photo taken
TOP-Camera Angle	No	Text	2	Angle of camera photo taken
TOP-Comments	No	Text	255	Any additional comments about camera placement, images, etc.
MOP-Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
MOP-Camera Photo Nbr	No	Text	20	Photo number off camera
MOP-Camera Height	No	Text	2.2	Height of camera from ground
MOP-Camera Bearing	No	Text	3	Bearing of camera photo taken
MOP-Camera Angle	No	Text	2	Angle of camera photo taken
MOP-Comments	No	Text	255	Any additional comments
SOP-Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
SOP-Camera Photo Nbr	No	Text	20	Photo number off camera
SOP-Camera Bearing	No	Text	3	Bearing of camera photo taken
SOP-Camera Angle	No	Text	2	Angle of camera photo taken
SOP-Comments	No	Text	255	Any additional comments
SOP-UTM Easting	No	Integer	6	X coordinate position of SOP photopoint
SOP-UTM Northing	No	Integer	7	Y coordinate position of SOP photopoint
SCP-Sample Date	No	Date	8	Enter date that data are collected (mm/dd/yyyy)
SCP-Camera Photo Nbr	No	Text	20	Photo number off camera
SCP-Comments	No	Text	255	Any additional comments

1.4.2. Queries

All queries have a prefix of "qry" and a descriptive abbreviated title (*_PurposeOftheQuery*) using Title Case (first letter of word capitalized). The title will typically incorporate the purpose of the query such as data management quality assurance (DMQA), an action such as exporting (Export) a table or updating (Update) a table, or a calculation such as calculating the mean of pH and formatting tables for reporting.

All decimal numbers that appear in a query output are set as fixed in the property sheet for format. This setting standardizes the number of digits to the right of the decimal regardless of the value, i.e., 2.00 or 2.01.

1.5. Updating the Database Design

Lessons learned and updates to the protocol will require adjustments and additions to the master and working databases. The master and working databases changes are tracked using version controls in the tbl_1_Db_Revisions as well as a version number in the file name (see *SOP 17 – Data Management*, section 7.3. *Database Versioning*). Version numbers will be incremented by one (e.g., Version 1.3 to Version 2.0) each time there is a significant change in the structure and/or protocol methods. Version numbers will be incremented by tenths (e.g., Version 1.6 to Version 1.7...1.8....1.10) when there are changes to field names, field structure, data entry tables, queries, and any other minor modifications that do not affect the data.

2. References

Adams, D., D. Press, M. Hester, H. Nevins, D. Roberts, B. Becker, H. Jensen, E. Flynn, M. Koenen, and S. Allen. 2009. San Francisco Bay Area Network pinniped monitoring protocol. Natural Resource Report NPS/SFAN/NRR—2009/170. National Park Service, Fort Collins, Colorado.

National Park Service. 2007. Natural Resource Database Template Version 3.2 documentation. Natural Resource Program Center, Office of Inventory, Monitoring, and Evaluation, Fort Collins, CO. Available at <http://science.nature.nps.gov/im/apps/template/index.cfm> (accessed 1 September 2011).

Washington Support Office, Inventory and Monitoring Program. 2004. Recommended naming standards for inventory and monitoring databases. National Park Service, Fort Collins, CO.

Standard Operating Procedure (SOP) # 19: Data Analysis and Reporting

Version 1.0

Revision History Log:

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

This SOP provides guidance on: 1) methods used to process the data collected for this protocol, 2) methods that will be used to analyze long term trends in the data, and 3) the format and content of the annual reports, annual briefs, and periodic comprehensive reports. This data analysis SOP was developed with R version 2.13.0 and *spsurvey* version 2.2. Quality Assurance/Quality Control (QA/QC) of the data collected in the IU protocol is described in *SOP 17 – Data Management*.

1. Data Analysis

The IU protocol is designed to monitor both status and trend in selected upland plant communities. Status measures provide information on the condition of a resource at a given point in time. Trend describes the change in the resource over time. Outcomes that provide information on the function, composition, and structure of park ecosystems are chosen for long-term monitoring and include cover measurements, species composition, frequency, and density.

Status estimation will occur annually and will incorporate design-based estimation approaches based on a generalized random tessellation stratified (GRTS) sampling design (Stevens and Olsen 2003). Analysis tools from the R package, *spsurvey* (Kincaid et al. 2011), may be used to obtain design-unbiased estimates of population means and totals, cumulative distribution functions, and proportions above/below a threshold for each outcome of interest.

Trend is defined in this protocol as population-level directional change over time (Urquhart and Kincaid 1999). While trend may not be solely linear over time, trend that generates management action will exhibit a substantial linear trend. Trend analysis will be conducted when three cycles of monitoring data are available and then in regular intervals afterward. Trend tests will be conducted using model-based parametric approaches such as linear mixed models (VanLeeuwen et al. 1996, Piepho and Ogutu 2002) and nonparametric approaches such as the Seasonal Kendall Test (Hirsch and Slack 1984). When assumptions of the model-based approaches are met, these techniques for trend estimation and testing have the added benefit of examining relationships between the outcome of interest and related covariates of interest such as environmental covariates, observer effects, and stressors. Tests of association and correlation, graphical tools, and nonparametric ordination

techniques will be used to examine relationship between potential predictors and the outcomes of interest. In modeling approaches, significance of the covariates may be assessed with t-tests or by comparing models with and without the covariate of interest with information criteria such as the AIC or BIS (Gurka 2006).

The three main components of the IU protocol are vegetation, soil, and invasive species. Data collected for each component of this protocol will first be analyzed separately to provide information on the component and, then, analyzed together, where appropriate, to understand how each component influences others. To provide a more comprehensive understanding of upland vegetation communities, we plan to integrate data collected as part of other protocols, such as weather and climate, to explore other potential variables that may be correlated with change in upland communities. Variables that are correlated with change may be the target of future research studies. Likewise, data from this protocol will be used in conjunction with other protocols to understand other vital signs (e.g., birds, fire).

This data analysis SOP will address estimation and issues that are anticipated to arise when the monitoring data are available for analysis. However, all possible data analysis issues cannot be foreseen, and analyses should be conducted by personnel familiar with modeling assumptions, model selection, and exploratory data analysis.

1.1. Data Processing

All of the measured variables collected for this protocol will be calculated to provide a macroplot-level estimate, making the macroplot the unit of replication. All data collected on transects, such as total % vegetation cover, % shrub cover, % biological soil crust, % bare ground, canopy gap size, and basal gap size, will be averaged per transect and then averaged across all three transects to derive a macroplot level measure. For example, for total % vegetation cover, % cover would be determined for each transect and then averaged for the three transects for a macroplot-level measure. This approach will also be used for data that are collected using the transect as a guide, such as the invasive frequency quadrat SOP. Quantitative soils parameters collected along the 12 sample points will be averaged to obtain a macroplot-level estimate. Soil erosion pin data will be averaged across the permanent markers to obtain a macroplot-level estimate of soil erosion.

1.2. Statistical Analysis for Status

Annual status estimation will reflect the properties of GRTS sampling design (Stevens and Olsen 2003). Design-based data analysis tools from the R package, *spsurvey* (Kincaid et al. 2011), will be used to estimate population means and totals, cumulative distribution functions, and proportions above/below a threshold for each outcome of interest. Descriptive measures of status may be obtained for IU measures and may include the calculation of the mean, median, variance, standard deviation, standard error, minimum, maximum, sample size, and range.

These statistics may be estimated with functions available in the *spsurvey* package. When spatial balance of the GRTS design is assumed, the neighborhood variance estimator for the GRTS sample provides more precise estimation than when a simple random sample is assumed (Stevens and Olsen

2003). Note that variance estimation requires the Universal Transverse Mercator (UTM) coordinates of each site and the GRTS design weights generated in the sample draw.

Design weights, or the inverse of the sample inclusion probabilities, are derived from the sampling design and provide the basis for design-unbiased extrapolation to the sampled population (see Thompson (1992) for more on inclusion probabilities). In some cases, the inclusion probabilities (or their inverse, the design weights) must be adjusted for unbiased inference. When non-target sites are included in the sample or sites are inaccessible, these missing sites may warrant inclusion probability adjustment. We assume that these issues have been addressed and the inclusion probabilities adjusted for subsequent calculations.

The status estimators for GRTS samples are based on the form of the Horvitz-Thompson estimator (Horvitz and Thompson 1952). The population mean is computed as:

$$\hat{\mu} = \left(\sum_{s_j \in R} \frac{1}{\pi(s_j)} \right) \sum_{s_j \in R} \frac{z(s_j)}{\pi(s_j)},$$

where $\hat{\mu}$ is the estimator of the population mean, μ , $z(s_j)$ is the indicator of interest measured at site s_j , $\pi(s_j)$ is the inclusion probability of site s_j , and R is the domain of the sampled population defined as a set of points occupied by the population elements. The variance of the mean is calculated using the GRTS neighborhood variance estimator (Stevens and Olsen 2003, Stevens and Olsen 2004):

$$\hat{V}_{NBH}(\hat{\mu}) = \left(\sum_{s_j \in R} \frac{1}{\pi(s_j)} \right)^2 \sum_{s_j \in R} \sum_{s_i \in D(s_j)} w_{ij} \left(\frac{z(s_j)}{\pi(s_j)} - \sum_{s_k \in D(s_i)} w_{ik} \frac{z(s_k)}{\pi(s_k)} \right)^2,$$

where $D(s_i)$ is the local neighborhood for site i , w_{ij} are weights chosen to reflect the behavior of the pairwise inclusion function for GRTS and are constrained so that $\sum_i w_{ij} = \sum_j w_{ij} = 1$. The population total is estimated similarly and the population proportion is estimated as a ratio of two Horvitz-Thompson estimators.

1.2.1. Status Estimation in R

A test data file is provided in *MOJNveg.RData* R workspace called “TotalCover” (SOP 19 Appendix A). This dataset is simulated from variance component estimates of total cover outcomes from pilot data. These data were simulated as test data only and no inference should be made from results. The formatting necessary for data analysis can be obtained from examining this dataset. To see the dataset, type “TotalCover” at the prompt in R after the workspace has been loaded.

1. The dataset may be obtained with one of the following two approaches:
 - a. Import data from a text file. First, go to *File/Change dir...* in the R menu and select the directory where the data set is located. Then, use the following command:

```
TotalCover<-read.table("TotalCover_ParkX.txt", header=T,
sep="\t")
```

If the data are comma-delimited, use *sep*=",".

- b. Copy and paste the data into the workspace from SOP 19 Appendix A.
2. Go to *File/Save* and save the workspace. Load libraries for R (download from <http://www.r-project.org/>):

```
library(lme4)
library(spsurvey)
```

NOTE: These libraries must be loaded at the beginning of every R session for these analyses. Libraries are not saved within R workspaces.

3. Examine the variable names of the data set.

```
names(TotalCover)
[1] "Site" "UTM.X" "UTM.Y" "Year" "WYear" "Visit"
[7] "LogY" "Y" "wgt"
```

Here, Y represents the untransformed transect-within-plot level absolute percent cover measurement. LogY represents the logged absolute percent cover metric.

4. For this example, the 2012 status of total cover will be examined. Obtain a histogram of 2012 total cover, controlling the range and bin size of the histogram with the "breaks" option (Figure 19.1). First, examine the range of the data.

```
range(TotalCover$Y[TotalCover$Year==2012])
# 6.405419 196.437578

# Create subset of data for 2012 only
TotalCover_2012<-TotalCover[TotalCover$Year==2012, ]

# Create histogram
hist(TotalCover_2012$Y, main="2012 Total Percent Cover",
breaks=seq(0,200,10), ylim=c(0,25))
```

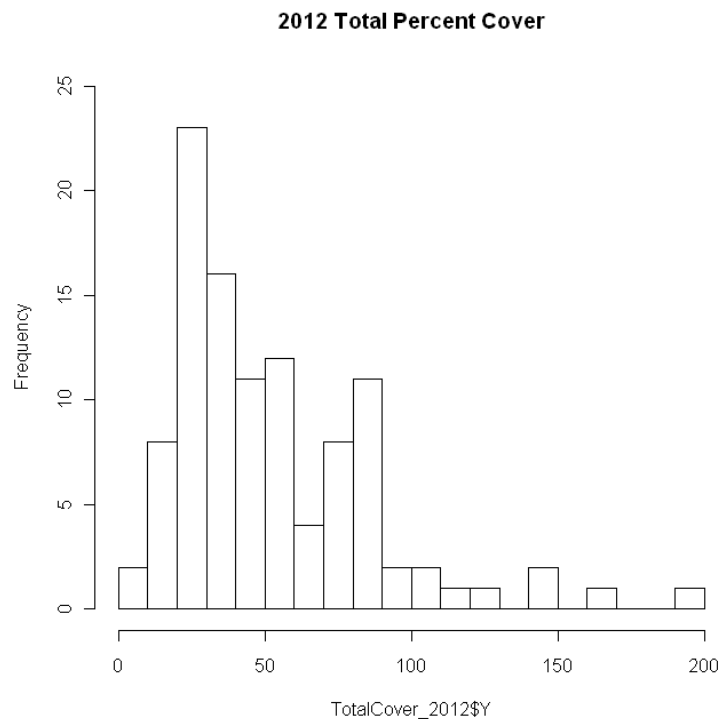


Figure 19.1. Histogram of 2012 total percent cover from simulated example data.

5. Annual descriptive statistics: Use the *total.est* function to obtain estimates of the population mean:

```
StatusEst.TotalCover.2012<- total.est(TotalCover_2012$Y,
TotalCover_2012$wgt,x= TotalCover_2012$UTM.X, y= TotalCover_2012$UTM.Y,
conf=90)
StatusEst.TotalCover.2012
```

Output:

	Statistic	NResp	Estimate	StdError	LCB90Pct	UCB90Pct
1	Total	105	221911.25328	10436.416670	204744.87547	239077.63110
2	Mean	105	52.83601	2.484861	48.74878	56.92325
3	Variance	105	1179.64281	193.151434	861.93697	1497.34864
4	Std. Deviation	105	34.34593	2.811853	29.72084	38.97102

The output is the estimated mean percent cover, the SE of the mean, and the 90%-confidence interval endpoints for the mean.

1.3. Statistical Analysis for Trend

Population-level trend may be expressed as net change over a period of time or annual change. Trend analysis will be conducted when three or more cycles of monitoring data are available. Several methods of estimating trend are available for estimating annual and net trend over time. Parametric approaches (Van Leeuwen et al. 1996, Piepho and Ogutu 2002) allow greater flexibility to

simultaneously estimate trend, variance components, and the effects of covariates but require more rigorous assumptions. Nonparametric approaches such as the seasonal Kendall test (Hirsch and Slack 1984) might produce only a test statistic and p-value for trend, but the robustness of nonparametric tests provides a useful check for parametric test results. We proceed with descriptions of parametric analysis with linear mixed models but suggest that a variety of trend tools be used before using the test results as an argument for management action.

A linear mixed-model is used to test for trend at randomly-selected sites (Van Leeuwen et al. 1996, Piepho and Ogutu 2002). A mixed model allows some effects to be considered fixed and some to be considered random. Fixed effects contribute to the mean of the outcome and random effects contribute to the variance. Random effects are used to estimate variation of linear trends among subjects (sites) and over time (years). Restricted maximum likelihood (REML) is used to obtain the estimates for the variances of the random effects. The linear mixed model is a parametric model, requiring the assumptions of independent and normally distributed errors with equal variance. We will assume that those conducting data analyses are familiar with the assumptions and methods for checking that they are met.

Piepho and Ogutu (2002) improved the estimator proposed by Van Leeuwen et al. (1996) by modeling the random site effect as correlated with the random site-level slope effect. In general, the random intercept for sites is modeled as random if the sample has been chosen using a probability sample, otherwise, it is modeled as a fixed effect. However, modeling the site intercept as fixed may be needed to avoid convergence problems and to optimize test power when residual variance is large (Piepho and Ogutu 2002). For this example, we will assume that the sites were selected randomly and model the intercept as a fixed effect.

The proposed mixed model for trend is:

$$y_{ij} = \mu + w_j\beta + b_j + a_i + w_jt_i + e_{ij},$$

where $i=1,\dots,m_a$; $j=1,\dots,m_b$; and

m_a = the number of sites in the sample;

m_b = the number of consecutive years in the sample;

y_{ij} = outcome of interest for the i^{th} site in the j^{th} year;

w_j = constant representing the j^{th} year (covariate);

μ and β = fixed intercept and slope of the linear time trend;

b_j = random effect of the j^{th} year;

a_i = random intercept of i^{th} site, independent and identically distributed as $N(0, \sigma_a^2)$;

t_i = random slope of i^{th} site, independent and identically distributed as $N(0, \sigma_t^2)$; and

e_{ij} = unexplained error, independent and identically distributed as $N(0, \sigma_e^2)$.

For measuring net trend over time as a percent change, the response must be logged so that exponential change may be estimated. In this case, the response y_{ij} is actually the natural log of the response being modeled, i.e., $\ln(y_{ij})$. Therefore, inference on the original scale is actually made on median trend rather than mean trend.

The null and alternative hypotheses under consideration are that of no trend ($\beta=0$) versus a non-zero trend ($\beta\neq 0$):

$$H_o : \beta = 0 \text{ vs } H_A : \beta \neq 0$$

As defined above, β is the coefficient of the w_j covariate and represents annual trend of the outcome on the log scale. This test is analogous to the test of:

$$H_o : \delta = 0 \text{ vs } H_A : \delta \neq 0$$

where δ is the net change as a proportion. For example, a net change of $\delta = 1.4$ implies a 40% increase of the population parameter over the specified period of time, whereas $\delta = 0.6$ implies a 40% decrease. The test statistic is derived for the two-sided hypothesis and the rejection region is based on a t -distribution Type I error level of $\alpha = 0.10$. Satterthwaite degrees of freedom are recommended (Van Leeuwen et al. 1996, Spilke et al. 2005).

1.3.1. Trend Analysis in R

The linear mixed model is applied in R using the *lme4* package. Residual diagnostics indicate that a logarithmic transformation of the species richness outcome better meets the assumptions of linear modeling.

1. Calculate means by site and year and format for analysis:

```
MeanMatrix<- tapply(TotalCover$Y, list(TotalCover$Site,
TotalCover$Year), mean)
yrs<-as.numeric(colnames(MeanMatrix))
sites<- rownames(MeanMatrix)
ma<- length(sites)
mb<- length(yrs)
TotalCover_SiteMeans<-data.frame(matrix(0, ma*mb, 3))

index<-0
for (i in 1:ma) {
  for (j in 1:mb) {
    index<-index+1
    TotalCover_SiteMeans[index,<-c(sites[i], yrs[j],
    MeanMatrix[i,j])
  }
}

names(TotalCover_SiteMeans)<-c("Site", "Year", "MeanCover")
```

```
TotalCover_SiteMeans$MeanCover<-
as.numeric(TotalCover_SiteMeans$MeanCover)
```

2. Create the WYear (w_j) covariate to be used in the trend analysis. Shifting the year variable to intersect zero allows more stable estimation.

```
TotalCover_SiteMeans$WYear<- as.numeric(TotalCover_SiteMeans$Year) -
min(as.numeric(TotalCover_SiteMeans$Year))
```

3. Plot site-level means over time:

```
plot(TotalCover_SiteMeans$WYear, TotalCover_SiteMeans$MeanCover,
pch="")
for (i in 1:ma) {
  lines(TotalCover_SiteMeans$WYear[TotalCover_SiteMeans$Site==sites
[i]], TotalCover_SiteMeans$MeanCover[TotalCover_SiteMeans
$Site==sites[i]], lty=i)
}
```

4. Obtain the mixed model fit for species richness with fixed effects for the slope and intercept of the regression line and random effects for site, year, and site-level slopes:

```
library(lme4)

# Fit a linear mixed model on the site-level means of total cover
fit1 <- lmer(MeanCover ~ WYear + (1+WYear|Site) + (1|Year), data=
TotalCover_SiteMeans)
summary(fit1)
```

Use the following function to obtain residual diagnostic plots:

```
ResidDiagnostic<-function(fit) {

par(mfrow=c(2,2))
plot(fitted(fit), resid(fit))
qqnorm(resid(fit))
hist(resid(fit))
}

# Examine the residuals from the fit.
ResidDiagnostic(fit1)
```

Notice the funnel-shaped residuals in the first plot, which indicate increasing variance and heteroscedasticity, and the slight right-skewness of the residuals in the histogram. Both suggest that a logarithmic transformation may help meet the assumptions of the mixed model.

```
fit2 <- lmer(log(MeanCover) ~ WYear + (1+WYear|Site) + (1|Year), data=
TotalCover_SiteMeans)
summary(fit2)
ResidDiagnostic(fit2)
```

Now the residual diagnostics indicate normally-distributed residuals with equal variance.

5. These data are balanced so the degrees of freedom for the trend test is the number of years, m_b , minus 2. For unbalanced data, use Satterthwaite (1946) degrees of freedom for the trend test (see SOP 19 Appendix B for R code to calculate the Geisbrecht-Burns approximation to Satterthwaite degrees of freedom).

```
eta <- mb-2
```

6. Conduct the two-sided trend test:

```
VarBeta <- vcov(fit2)[2,2]
t.stat<-fixef(fit2)[2]/sqrt(VarBeta)
p.value<-2*(1-pt(abs(t.stat), eta))
c(t.stat=t.stat, p.value =p.value)
```

```
t.stat.WYear p.value.WYear
      1.7148993      0.1470256
```

The trend test is not significant at the $\alpha = 0.10$ level ($p = 0.1470$), so there is no compelling evidence for net trend in the population over the time frame examined.

1.4. Other Considerations

Inference may be desired for subpopulations not accounted for in the sampling design (e.g., invaded vs. uninvaded). Post-stratification is used to obtain unbiased inference for these subpopulations (Holt and Smith 1979). Post-stratification can be used to obtain estimates within levels of a factor not incorporated into the survey design. Post-strata may be designated after the survey is collected and information on post-strata must be available for both the sample and the sampled population. The estimate of the mean within the g^{th} post-stratum level for $g = 1, 2, \dots, G$ total post-strata is given by:

$$\bar{y}_g = \frac{\sum_{i \in S_g} \frac{y_i}{\pi_i}}{\sum_{i \in S_g} \frac{1}{\pi_i}},$$

where S_g is the sample falling in post-stratum g , y_i is the i^{th} outcome of interest, and π_i is the design weight of the i^{th} outcome. The estimated variance of the mean of the outcome within the g^{th} post-stratum is (Särndal et al. 1992):

$$\hat{Var}(\bar{y}_g) = \sum_{i \in S_g} \sum_{j \in S_g} \frac{\pi_i \pi_j}{\pi_{ij}} \left(\frac{|L_g|}{|\hat{L}_g|} \right)^2 \left(\frac{y_i - \bar{y}_g}{\pi_i} \right) \left(\frac{y_j - \bar{y}_g}{\pi_j} \right),$$

Where $|L_g|$ is the extent of the population within the g^{th} post-stratum and $|\hat{L}_g| = \sum_{i \in S_g} \frac{1}{\pi_i}$.

Because sample sizes are not predetermined in unplanned post-strata, the unconditional variance of post-strata estimators is increased by a variance component that accounts for random sample sizes. The benefits of post-stratification include conditional unbiasedness and gains in efficiency.

Nonsampling errors arise from the imperfect execution of the sampling design and include nonresponse error, frame error, and measurement error (Lessler and Kalsbeek 1992). While these errors often cannot be avoided, precautions may be taken to minimize their impact and adjust for any potential bias of estimates during the analysis phase. Currently, the number of sites that will be physically accessible is unknown. Nonresponse error occurs when an incomplete response is obtained for a sampling unit. If an inaccessible site is not surveyed for a reason that is associated with an outcome of interest, then estimates for that outcome may be biased due to nonresponse error. Obtaining sites from the GRTS oversample may remedy this missingness if the accessible sites from the oversample are not significantly different from the inaccessible sites from the original sample. If full samples cannot be obtained, weighting approaches for nonresponse for surveys in a continuous domain may be used to account for missingness (Munoz and Lesser 2006).

2. Annual Reports, Briefs, and Comprehensive Reports

The MOJN I&M program will provide three primary summary documents (see below) to the network Board of Directors (BoD), technical committee (TC), and relevant park staff: annual reports, annual briefs, and periodic comprehensive reports. Annual reports and annual briefs will be provided to the BoD, TC, and other relevant parties at parks (e.g., resource and interpretation staff) approximately 12-15 months after park monitoring occurs. Comprehensive reports will be produced every 10 years (after ~three monitoring cycles for each park), provided to the BoD, TC, and resource management staff for review, before publication. Annual and comprehensive reports will be submitted for publication in the NPS Natural Resources Report Series or a peer-reviewed scientific journal.

2.1. Annual Reports

MOJN I&M will produce an annual report of protocol activities for each park that is monitored each year. We anticipate a 12-15 month interval between field sampling and report production, with the slightly longer interval needed when reporting is initiated and a subsequent reduction in time interval as procedures and reporting are standardized. The interval between field sampling and report production is necessary because of the time it takes to collect, enter, certify, and analyze the data. Since MOJN I&M is collecting field data at multiple parks each year, we will be producing multiple annual reports each year.

Reports will include the following information:

- Park sampled, numbers of plots sampled per park, and a map of the macroplot locations for each monitored park
- General summary statistics (i.e., mean, variance) for each component of the protocol
- Documentation of any deviations from the protocol, such as missed sites or samples
- Assessment of the sample size and revisit design for the protocol
- Planned activities for the next field season (e.g., modifications to the protocol)

The reports will be prepared according to NPS guidelines for Natural Resource Data Series reports and will likely be published in that series. Annual reports will be posted on the MOJN I&M internet site by protocol (<http://science.nature.nps.gov/im/units/mojn/index.cfm>) and IRMA Data Store (<https://irma.nps.gov/App/Reference/Welcome>). Supporting documentation (e.g., figures and tables) will be made available for park use on the MOJN I&M SharePoint (<http://inpniscvsp05:39904/im/networks/MOJN/default.aspx>) and intranet site (<http://www1.nrintra.nps.gov/im/units/mojn/>).

2.2. Annual Briefs

From each annual report, MOJN I&M will prepare a 1-2 page resource brief for the IU protocol that will provide a brief summary of the status of the protocol and protocol data in the monitored park. These resource briefs will be provided to interpretative staff at parks monitored during the previous field season and written in a style that will allow interpretative staff to directly use relevant sections. Annual briefs, along with supporting documentation, will also be made available for park use on the MOJN I&M SharePoint and intranet site.

2.3. Comprehensive Reports

Comprehensive reports will be produced for each park after all macroplots at a park have been revisited at least three times (approximately 10 years). Comprehensive reports will provide in-depth statistical analyses and interpretation of protocol data, trend analysis to understand how park resources are changing through time, and assessments of whether the monitoring design is meeting protocol goals. Statistical analyses will include integration of data from other relevant protocols (e.g., weather and climate) and the use of data-exploration techniques to evaluate potential explanatory variables and/or covariates to have a more comprehensive understanding of upland community dynamics. The report will also re-evaluate the monitoring protocol and metrics in light of new management concerns and new resource issues, which may lead to some reallocation of effort.

Comprehensive reports will be submitted for publication as a NPS Natural Resources Technical Report or scientific results may be submitted to a peer-reviewed scientific publication. Similar to the other reports, supporting documentation will be available to parks on the MOJN I&M SharePoint site and IRMA Data Store.

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Copy and paste this command into R to obtain the simulated pilot data for the R analysis commands. This command is available as a text file upon request from the Protocol Lead or available for download from: <http://science.nature.nps.gov/im/units/mojn/index.cfm>.

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SOP 19 APPENDIX B: R code for Calculating the Geisbrecht-Burns Approximation to Satterthwaite Degrees of Freedom

```

SatterthwaiteDF_GB<-function(X,Q,gamma,index,limit=0.01) {

# Calculates Satterthwaite df for a trend test (beta indexed by "index")
# for a mixed model (given by fit). X is FE design matrix, Q is a list of
# RE design matrices for each RE, and gamma is the RE vector.
# From Geisbrecht and Burns (1985)
# Leigh Ann Starcevich 04.29.08
# Updated 5.53.10

lambda<-rep(0,dim(X)[2])          # contrast to choose beta for trend
lambda[index]<-1
UUpriime <- Q
d<-length(gamma)
gamma.index<- (1:(d-1))*(gamma[1:(d-1)]>0)
gamma.index<-gamma.index[gamma.index!=0]
m<-length(gamma.index)
if((m==(d-1))&(gamma[d]!=0)) {m<-d; gamma.index<-c(gamma.index,d)}
V<-0
for(i in gamma.index) {V<-V+ (gamma[i]*UUpriime[[i]])}
InvV<-solve(V)
P<-solve(t(X)%*%InvV%*%X)

Q<-InvV-(InvV%*%X%*%solve(t(X)%*%InvV%*%X)%*%t(X)%*%InvV)

# Omit zero rows/cols, user may specify lower limit for variance estimates
nozeroavar<- gamma.index[(gamma[gamma.index]>limit)]
if((m==d)&(gamma[d]<0)) nozeroavar<-c(nozeroavar,d)

mprime<-length(nozeroavar)
InfoSigma<-matrix(0, mprime, mprime)
for (i in 1: mprime) {
  for (j in 1: mprime) {
    InfoSigma[i,j]<-
sum(diag(UUpriime[[nozeroavar[i]]]%*%Q%*%UUpriime[[nozeroavar[j]]]%*%Q))
  }
}

CovSigma <-2*solve(InfoSigma)

VarVarBeta<-0
for (i in 1:mprime) {
  for (j in 1:mprime) {
VarVarBetaij<-(CovSigma[i,j]*(t(lambda)%*%P%*%t(X)%*%InvV%*%
UUpriime[[nozeroavar[i]]] %*%InvV%*%X%*%P%*% lambda) %*%(t(lambda)%*%P%*%t(X)
%*%InvV%*% UUpriime[[nozeroavar[j]]] %*%InvV%*%X%*%P%*% lambda))
    VarVarBeta<- VarVarBeta + VarVarBetaij
  }
}
etaGB<-2*(t(lambda)%*%P%*%lambda)^2/ VarVarBeta
return(as.numeric(etaGB))
}

```

The following code is used to approximate Satterthwaite degrees of freedom for the full mixed model that includes fixed effects for intercept and slope; random effects for sites, years, and site-level slopes; a non-zero covariate between the random site intercept and slope; and residual error. Any reduction of this model will require changes in the R code.

```
VarBeta<- vcov(fit2)[2,2]          # Est. variance of fixed trend est.
sig2a.hat <-VarCorr(fit2)$Site[1,1]      # var(ai)
sig2t.hat <-VarCorr(fit2)$Site[2,2]      # var(ti)
sigat.hat <- VarCorr(fit2)$Site[1,2]     # cov(ai,ti)
sig2e.hat <-attr(VarCorr(fit2),"sc")^2
sig2b.hat <- VarCorr(fit2)$Year[1]
n<-dim(TotalCover_SiteMeans)[1]         # total obs

A<- fit2@Zt[1:ma,]
B<- fit2@Zt[((2*ma)+1):((2*ma)+mb),]
T<- fit2@Zt[(ma+1):(2*ma),]
Q1<- t(B)%*%B
Q2<- t(A)%*%A
Q3<- t(T)%*%T
Q4<-diag(n)
Q5<- (t(A)%*%T)+ (t(T)%*%A)
gamma.vector<- c(sig2b.hat, sig2a.hat, sig2t.hat, sig2e.hat, sigat.hat)

eta<- SatterthwaiteDF_GB(X= cbind(1, TotalCover_SiteMeans$WYear), Q=
list(Q1,Q2,Q3,Q4,Q5),gamma=gamma.vector,index=2,limit=0.00001)
```

Standard Operating Procedure (SOP) # 20: Protocol Revision and Review

Version 1.0

Revision History Log:

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

All protocols require editing as new sampling methodologies, equipment, analysis, and data management information becomes available. Required edits should be made as soon as they are deemed necessary, with appropriate reviews conducted. This SOP describes the revision procedure for monitoring protocols in MOJN I&M. Individuals editing the Protocol Narrative or any one of the SOPs need to follow these procedures in order to eliminate confusion on which documents are the most current version. Changes in the versioning of each section of the protocol must follow the described procedures.

This SOP is adapted from *SOP 20 – Protocol Revision and Review* from the MOJN I&M Surface Water Dynamics and Water Quality in Streams and Lakes of the Mojave Desert Network Protocol and *SOP 20 – Revising the Protocol Narrative and SOPs* from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol.

1. Naming the Versions

Updates and revisions to the Protocol Narrative and individual SOPs can occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs. Thus, each section of the protocol will have its own revision log to allow for independent changes. The procedure for making and documenting changes is described below:

1. Make the necessary changes to the document.
2. Rename the version based on the magnitude of the change:
 - a. If the edits are minor (e.g., fixing typos, formatting changes, grammar/spelling changes), then the new version number will increase incrementally by tenths (e.g. version 1.1, version 1.2, etc.).
 - b. If the edits are major (e.g., changes in methods, sampling design), then the new version number will increase by a whole number (e.g., version 2.0, 3.0, etc.).
3. Record the previous version number, date of revision, author of the revision, and a succinct reason for the changes along with the new version number (if applicable) in the document's revision history log.

For minor edits, it is not necessary to describe the specific edits, just a general description of the type of edits.

4. When all revisions have been made, the document will be reviewed by the appropriate people (see next section).

2. Revision Review

Once a document has been revised, it will need to be reviewed by:

1. *MOJN staff* if the revisions were minor or modifications of existing methods.
2. *MOJN Technical Committee, MOJN Vegetation Working Group, or designated Park representatives, and the Regional I&M Program Manager* if there are substantial changes to the sampling design or methodology.

After the document has been reviewed, provide the Data Manager with the updated document and information on any changes that were made so that he/she can update the reference table for the protocol (Table 20.1).

Updated versions of the Protocol Narrative and SOPs will be posted on the MOJN I&M internet (<http://science.nature.nps.gov/im/units/mojn/index.cfm>), IRMA Data Store (<https://irma.nps.gov/App/Reference/Welcome>), intranet (<http://www1.nrintra.nps.gov/im/units/mojn/>), and SharePoint sites (<http://inpniscvsp05:39904/im/networks/MOJN/default.aspx>). Older versions of the Protocol Narrative and SOPs will be archived in the MOJN I&M IU Protocol Library.

Table 20.1. Reference table for the IU protocol showing the most current versions of each section, including the supplementary materials, and the contact person for the section.

	Document	Current Version	Date	Author/Contact
20-3 MOJN I&M IU SOP	Protocol Narrative	1.0	August 2015	Protocol Lead
	SOP 1 - Preparations and Equipment Setup Prior to the Field Season	1.0	August 2015	Program Manager
	SOP 2 - Training Observers	1.0	August 2015	Program Manager
	SOP 3 – Daily Field Activities	1.0	August 2015	Program Manager
	SOP 4 - Spatial Data Naming Conventions	1.0	August 2015	GIS Specialist
	SOP 5 - Crust-Friendly Field Procedures	1.0	August 2015	Protocol Lead
	SOP 6 - Site Characterization	1.0	August 2015	Protocol Lead
	SOP 7 - Macroplot Establishment and Revisit Set-Up	1.0	August 2015	Protocol Lead
	SOP 8 - Measuring Cover of Vegetation and Soil Surface Features Using Point-Intercept Sampling	1.0	August 2015	Protocol Lead
	SOP 9 - Measuring Basal and Canopy Gaps Using Line-Intercept Sampling	1.0	August 2015	Protocol Lead
	SOP 10 - Assessing Invasive Plant and Disturbance Frequency Using Quadrats	1.0	August 2015	Protocol Lead
	SOP 11 - Soil Measurements	1.0	August 2015	Protocol Lead
	SOP 12 - Site Assessment for Invasive Plant and Target Tree Species	1.0	August 2015	Protocol Lead
	SOP 13 - Repeat Photos	1.0	August 2015	Protocol Lead
	SOP 14 - Unknown Shrub Species	1.0	August 2015	Protocol Lead
	SOP 15 - End of Field Tour and Season Activities	1.0	August 2015	Program Manager
	SOP 16 - Information Management Workflow and Tasks	1.0	August 2015	Data Manager
	SOP 17 - Data Management	1.0	August 2015	Data Manager
	SOP 18 - Database Design	1.0	August 2015	Data Manager
	SOP 19 - Data Analysis and Reporting	1.0	August 2015	Protocol Lead
	SOP 20 - Protocol Revision and Review	1.0	August 2015	Data Manager
	MOJN SOP M1 - Incidental Observations of Incipient Invasive Species	1.0	August 2015	Data Manager
	MOJN SOP M2 - Prioritizing Invasive Species for Status and Trends Monitoring	1.0	August 2015	Data Manager
	MOJN SOP M3 - Global Position System	1.0	August 2015	Data Manager
	MOJN SOP M4 - Field Safety Plan	1.0	August 2015	Data Manager
	MOJN SOP M5 - Archiving	1.0	August 2015	Data Manager
	MOJN SOP M6 - Biological Data Profile	1.0	August 2015	Data Manager

Table 20.1. Reference table for the IU protocol showing the most current versions of each section, including the supplementary materials, and the contact person for the section (continued).

Document	Current Version	Date	Author/Contact
MOJN SOP M7 - Data Quality	1.0	August 2015	Data Manager
MOJN SOP M8 - Database Naming Conventions	1.0	August 2015	Data Manager
MOJN SOP M9 - Documentation Non-spatial	1.0	August 2015	Data Manager
MOJN SOP M10 - Documentation Spatial	1.0	August 2015	Data Manager
MOJN SOP M11 - Image Management	1.0	August 2015	Data Manager
MOJN SOP M12 - NPS Metadata Tools and Editor	1.0	August 2015	Data Manager
MOJN SOP M13 - Project Deliverables	1.0	August 2015	Data Manager
MOJN SOP M14 - Sensitive Data	1.0	August 2015	Data Manager
MOJN SOP M15 - Season Closeout	1.0	August 2015	Data Manager
MOJN SOP M16 - Directory Structure Non-Spatial	1.0	August 2015	Data Manager
MOJN SOP M17 - File Naming Conventions	1.0	August 2015	Data Manager
MOJN SOP M18 - Digitizing Information and Photographs	1.0	August 2015	Data Manager

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