



Integrated Upland Protocol of the Mojave Desert Network

Volume 2.0, Standard Operating Procedures



ON THE COVER

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

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Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Hupp, N.R., J. Ladd, S. Wright, M. Lehman, and L. A. Starcevich. 2020. Integrated Upland Protocol of the Mojave Desert Network: Volume 2.0, Standard Operating Procedures. Mojave Desert Network, National Park Service, Boulder City, Nevada.

Change History

Previous Version	Revision Date	Revised By	Change Description	Justification	New Version Number
			First published version		1.0
1.0	6/1/20	N. Hupp	Revisions to Photo SOP, Replaced Soil Monitoring SOP (former SOP 11), with Vegetation Height (now SOP 11), changed GPS language to Arc Collector, removed datasheets from each SOP, added gap measurement differences that occur in sagebrush communities	Made SOP changes to reflect tweaks to protocol and actual sampling year 2020 in LAKE, datasheets change frequently therefore updating them in the SOPs is redundant	2.0

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 Mojave Desert Network (MOJN) is one of 32 long-term monitoring networks in the National Park Service's (NPS) Inventory & Monitoring Program. MOJN is comprised of nine NPS units: Castle Mountains National Monument (CAMO), 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), Grand Canyon-Parashant National Monument (PARA), and Tule Springs Fossil Beds National Monument (TULE). Collectively, these units encompass over 3.3 million hectares (8.3 million acres), or 9.7%, of the total land area managed by NPS.

MOJN began implementing the Integrated Upland (IU) protocol in 2015 (Pan et al. 2015a and 2015b) to conduct long-term monitoring of upland shrub communities. This document describes the standard operating procedures (SOPs) for the MOJN IU protocol. SOPs describe the steps required to collect, manage, and disseminate the data representing the status and trend of upland communities in MOJN parks. The protocol narrative (Pan et al. 2015a) accompanies these SOPs and provides details on study communities, rationale for monitoring, protocol goals, monitoring objectives, and an estimated budget.

As of 2020 the IU protocol has been implemented in six of the seven parks; IU has not been implemented in DEVA yet. Since the protocol has been implemented, many crewmembers, Protocol Leads, and MOJN staff have had the opportunity to review and test the SOPs. During this time, we tweaked language, edited methods where necessary, and improved the functionality of the SOPs for field staff. The first version of the IU SOPs was published in 2015 (Pan et al. 2015b); this new release of the SOPs is the updated version. 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.

References:

- Pan JJ, D. Craig, D. Robinson, D. A. Soukup, L. A. H. Starcevich, N. Tallent, and R. Truitt. 2015a. Integrated upland protocol of the Mojave Desert Network: Volume 1, protocol narrative. Natural Resource Report. NPS/MOJN/NRR—2015/1010. National Park Service. Fort Collins, Colorado
- Pan JJ, D. Craig, D. Robinson, D. A. Soukup, L. A. H. Starcevich, N. Tallent, and R. Truitt. 2015b. 2015. Integrated upland protocol of the Mojave Desert Network: Volume 2, standard operating procedures. Natural Resource Report. NPS/MOJN/NRR—2015/1010.1. National Park Service. Fort Collins, Colorado

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Service wide Inventory and Monitoring Program. We have based our SOPs on the SOPs from the Northern Colorado Plateau Network and thank them for sharing their SOPs and experiences with implementing the field SOPs. Both MOJN and NCPN protocols are based on the BLM Assessment, Inventory & Monitoring (AIM) protocol (Herrick et al. 2015). These SOPs benefitted from the comments of the park staff, particularly members of the Vegetation Working Group comprised of vegetation leaders at each of the MOJN parks. Technicians over the years including Alex Whalen, Jennifer Bailard, Carolyn Mills, Justin Mills, Logan Combs, Kyle Smith, Nico Meija-Matallana, and Daniel Goldstein provided valuable tweaks and updates that improved these SOPs. Lise Grace (North Coast and Cascades I&M Network) provided significant help preparing this document.

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

Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/11/20	N. Hupp	Removed language that was stated more than once, updated field prep requirements to match newer procedures and technologies	SOP no longer reflected MOJN requirements; MOJN now uses more tech in the field than in 2015	1.1

1. Before the Field Season

1.1. 3-6 Months before field sampling

Well before the field season, the Protocol Lead or Field Lead needs to:

- ✓ Prepare and post position descriptions for seasonal field hires.
- ✓ Depending on the park, determine if research permits are required (this may require contacting the permitting office or the natural resource chief at the park). Permits are submitted on the 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.
- ✓ Even if a permit is filed, contact park natural resource staff and provide them a list of sites to parks for comment (e.g., accessibility, compliance, etc.) before they are 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 Management Team 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.

1.1.1. Gear Checklists

The lists below are the amount of gear needed by one field crew. Multiply the amount by the number of crews that will be in the field. Items marked with an asterisk * are optional and depend on crewmember's preference. Items marked with ** are for multiday trips only.

Table 1.1 Measuring Equipment Checklist:**Measuring Equipment**

Item	Use and notes	# Needed per crew	# Packed
Meter tapes	200 ft (they are longer than 50m which is nice for when rebar is offset therefore the transect is longer than 50m), need 3 for revisits, 5 for establishment	3-5	
Wire pin flags	LPI, invasive quadrats, marking transects; make sure at least 3 are very straight!	~15	
Small tape measure	5m; measuring camera distance, generally helpful	1	
Chaining pins (candy canes)	Anchoring transects	~15	
Compass	Setting tapes along correct bearings; make sure declination is appropriate for the park you are working in	1 per person	
Laser rangefinder	Estimating slopes; with capacity for measuring tree height; tree height and distance; double check batteries are good	1	
Ruler tool for shrub ht.	Custom made for measuring shrub height	1	
Moosehorn	Measuring overstory along LPI line	1	

Table 1.2 Navigation, Electronics, and Recording Equipment

Item	Details
Digital camera	MOJN point-and-shoot
High accuracy GPS and spare battery	Arrow or Bad Elf; needs spare batteries and charger, must be paired with tablet or cell phone
Tablet or MOJN cell phone and charger	Must have arc collector with downloaded maps, and paired with GPS; also preload with SOPs, narrative, and plant ID materials
Pens and clipboards	Pens preferred over pencil for data mgmt. purposes
Spare batteries	AA and AAA's for GPS and laser range finder
Macroplot revisit forms	Forms from previous visits
Revisit photos	Print the old plot photos to match the new photos
Weatherized field data entry forms	1 per plot plus 2 backups; store in plastic tote if possible
Backup battery	For recharging tablet and cell phone

Table 1.3 Plot Monumenting Equipment

Item	Details and purpose	# Needed per crew	#Packed
Rebar (establishment only)	36" inches long, ½ in diameter; Diameter of rebar MUST match the diameter of the rebar caps	7 per plot	
Aluminum rebar caps (May not be necessary, check previous photos/notes per plot)	Make sure they are blank or at least that the right park has been stamped	7 per plot	
Sledgehammer (establishment and capping only)	Installing rebar	1	

Hacksaw	Shortening rebar	1
Gloves (establishment only)	Installing rebar	
Cap imprinting kit (capping only)	For labeling rebar caps	1

Table 1.4 Miscellaneous Field Equipment

Item	Details
Field notebook	<i>One per person required!</i> Each crewmember needs one for writing down plot notes or recording numbers in the field.
Field-relevant SOPs	Need at least one copy per crew; can be on tablet but a hardcopy is nice to have
Daypack and overnight backpack	Depending on hitch schedule.
Trowel or hori-hori	For collecting vegetation samples (and bathroom breaks)

Table 1.5 Plant Identification Materials

Item	Details
Plant ID references	Shrub ID, and for crew curiosity (e.g., regional floras and photographic tree guides)
Target invasive species list	Need info for keying these out as well; is printed on the data sheets
Hand lens	Keying out shrubs
Small plant press	Make sure there is space for new plants and that it has newspaper in it; leave large one in the office and plants can be transferred in the office instead of in the field
Newspaper	For use in pressing plant specimens

Table 1.6 Communication and Safety. Need at least one per vehicle of each item.

Item	Details
Cell phone + charger	Share phone numbers with other drivers or crewmembers
Park radio + charger	Know how to get to park repeaters
Satellite phone + charger	
InReach satellite locator device + charger	<i>Must</i> program in office before use to assign to a person and ensure appropriate contacts are synced
Battery charger + charge cable	Charge ahead of time
Copy of backcountry travel plan	1 per vehicle; Make sure it is accurate and contains safety contact information
Fire extinguisher, shovel, and other park-specific vehicle safety equipment required	
Sunscreen	
Water cube	Make sure it is filled.
First Aid kit	Make sure it is fully stocked and medications are not expired
Handheld 2-way radios + charger*	And charging cable; Necessary for communication within a plot

*Items with a * are optional, they're not necessary for the field work, but some may prefer to use them. This depends on style.

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.
- Create a field schedule:
 - Find location data for macroplots within parks
 - Make a travel schedule to get to each plot in the season
 - Determine potential car camp and backcountry camp sites (consult with parks as needed)
 - Anticipate that roughly one macroplot will be completed per field day, including travel time.
 - When in the field, crews often work eight consecutive 10-hour days, followed by six days off, especially when working in the backcountry (called “8 on, 6 off” or an “8 day hitch”).
 - *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.
 - Ensure schedule meets the objectives for the field season and maintains the integrity of the sampling design. Don’t be an optimist when it comes to planning a field schedule, include flexibility for unforeseen events.
- Create a training schedule:
 - Work with the Protocol Lead to organize and update crew training materials.
 - 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.
 - Training should include plant ID, field safety, detailed training of each SOP, and all field methods.
- Work with the park staff:
 - 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 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.
 - Determine lodging options and contact parks early to determine whether park housing will be available.
 - If camping, reserve camping sites or acquire backcountry camping permits.
 - Work with the park to determine daily and field tour check-in and check-out procedures for the field season at the park.
- Coordinate with Data Management Team:
 - Make sure that Arc Collector apps are updated and ready for navigation and data collection.

- Work with Data Management Team to update field data management procedures to reflect any changes in equipment.
- Coordinate with Program Manager or Protocol Lead:
 - Make sure that research permits have been approved.
 - Prepare Protocol Review Certificate and submit to park superintendent or superintendent designee for signature.
 - Have the field vehicle thoroughly inspected for back country roadworthiness. 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.
- Data collection and gear prep:
 - Review plant species lists for each park unit and update them with any new species detected in the previous field season.
 - Make sure first aid kits are well-stocked, organized, and ready to go for the season.
- Prepare for plot visits and logistics:
 - Prepare site packets for each field site that may be visited, including potential back-ups.
 - Review maps and plot locations in AGOL or Collector to make field plans.
 - Organize materials and review relevant information for each macroplot.
 - *Revisit field forms* – provides directions to the macroplot, coordinates of monuments, and any other specific information from the previous visit.
 - *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.
- Collaborate with the rest of the office about safety:
 - Test that all field communication devices (e.g., radio, InReach, 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.
 - Review and update the Job Hazard Analysis (JHA) and emergency/park contact lists.
- Collaborate with the rest of the office about safety:
 - Test that all field communication devices (e.g., radio, InReach, satellite phone) are working

1.3. Before Beginning a Field Day or Multi-day Hitch

The Field Lead will:

- 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 SOP M4 - Safety* for specific procedures.
- Prepare and provide the following documents for each crew:
 - copies of the protocol (only SOPs and reference table sheets are needed in the field)

- o permits (e.g., research, backcountry camping)
- o emergency contact information and procedures
- o shrub species list for each park
- o target invasive species list and field guides
- o adequate copies of all field forms (Table 1.2)
- o relevant flora, keys, and field herbaria

The field crewmembers will:

- 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).
- Make sure that all batteries and rechargeable equipment are fully charged to start field work.
- Make sure Arc Collector is set up appropriately, basemaps are downloaded, and devices are on airplane mode.
- Take all mandatory trainings in field skills, procedures, and safety (see *SOP 2 – Training Observers*).
- Read and understand the MOJN 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.
- Read the MOJN safety plan, review the JHA and/or GAR with the Field Lead, and sign a copy of the JHA and/or GAR.
- Demonstrate an understanding of the check-in and check-out procedures at the park to be visited.
- Make sure to take the appropriate site packets for the field tour.
- 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
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

Standard Operating Procedure (SOP) # 2: Training Observers

Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/11/20	N. Hupp	Updated SOPs to match new protocols and equipment at MOJN, updated GPS data with Collector info, updated DSLR camera info with "point and shoot" changes	Needed to replace outdated information	1.1

1. Safety Training

All field crew must

- provide emergency contact information to MOJN
- have thoroughly read and understand *MOJN SOP M4 – Safety* and the MOJN Safety Plan
- have reviewed the JHA (SOP 2 Appendix A)
- taken MOJN Safety Training and read the Stocking Lake Incident Report (presentation and discussion) and/or taken the National Park Service Operational Leadership training
- haven taken First Aid and Wilderness First Aid or are signed up to do so in the future at MOJN
- be trained in the proper use of communication devices (e.g., radios, satellite phones, InReach device)
- be trained in check-in/check-out procedures for MOJN, dispatch, and designated contacts at each park

If your supervisor has not talked with you about each of these items *talk to the Protocol Lead*. Take ownership for your safety in the field! Nothing is more important than your safety.

Travel within parks will often be on backcountry roads and require the use of a 4WD vehicle. Crews must be familiar with federal government regulations for Government Services Administration (GSA) vehicles and defensive driving. Field crew are expected to follow all MOJN 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 discuss 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 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 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 – Arc Collector, GPS, Compass and Map Training

The Data Management Team or Field Lead will be the primary instructor for field navigation. Field crews will receive training on traditional navigation techniques, using a compass, and using Collector or other data collection tools. While paper maps are not the primary tool for navigation to plots, park maps should be used in training as well in case of device failure.

Crew members must thoroughly review and understand *MOJN SOP M3 – GPS* and *SOP 4 – Spatial Data Naming Conventions*, as part of GPS training. As part of the training, how to use Collector will be demonstrated, including uploading field sites and waypoints, syncing data, and how to side-load maps. Field crew will use Collector 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, uploading to Arc GIS Online (AGOL), and quality assurance/quality control (QA/QC) of data. Spatial data will be collected using high accuracy GPS devices paired with Arc Collector on MOJN iPhones and iPads.

2.2. Field Procedures Training

Review SOPs 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). The target invasive species vary by park.

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 “point and shoot” camera for different photos. Crews will be trained in the basic features of the camera, how to navigate the camera menus, how to check photos for clarity 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.

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 Management Team, 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 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 parks	SUPERVISOR: MOJN Program Manager DEPARTMENT: MOJN	ANALYSIS BY: MOJN REVIEWED BY:	
REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Refer to relevant protocols and MOJN 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 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).		

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 repellant 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 Safety Plan.		
JHA and Emergency Evacuation Procedures Acknowledgement		
We, the undersigned Supervisor and employees, acknowledge participation in the development of this JHA. We have thoroughly discussed and understand the provisions of this document.		
SUPERVISOR'S SIGNATURE		DATE:
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE	
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE	
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE	
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE	
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EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE	
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	ORGANIZATION: NPS	LOCATION: MOJN parks	SUPERVISOR: MOJN Program Manager	ANALYSIS BY: MOJN
			DEPARTMENT: MOJN	REVIEWED BY:
REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Refer to relevant protocols and MOJN 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 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 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

Emergency Evacuation Instructions	
Reference the MOJN Safety Plan.	
JHA and Emergency Evacuation Procedures Acknowledgement	
We, the undersigned Supervisor and employees, acknowledge participation in the development of this JHA. We have thoroughly discussed and understand the provisions of this document.	
SUPERVISOR'S SIGNATURE	DATE:
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EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
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 <u> </u> REVISED
	EMPLOYEE / OPERATOR: All	SUPERVISOR: MOJN Program Manager	ANALYSIS BY: MOJN	
ORGANIZATION: NPS	LOCATION: MOJN parks	DEPARTMENT: MOJN	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 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 always be worn 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	• 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.
Camp overnight on the beach	• 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 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.

Emergency Evacuation Instructions	
Reference the MOJN Safety Plan.	
JHA and Emergency Evacuation Procedures Acknowledgement	
We, the undersigned Supervisor and employees, acknowledge participation in the development of this JHA. We have thoroughly discussed and understand the provisions of this document.	
SUPERVISOR'S SIGNATURE	DATE:
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
EMPLOYEE SIGNATURE	EMPLOYEE SIGNATURE
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.

1. Before Leaving Base Each Morning

- ✓ Make sure that all equipment on the equipment checklist (see Table 1.1 in *MOJN 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, gas)
- ✓ 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, tablet, 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 camera date and time is set correctly.
- ✓ Make sure that the Tablet/Cell Phone is logged into Arc Collector, GIS data and basemaps are uploaded, device has been recently synced, and Airplane Mode is turned on*
- ✓ 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.
- ✓ 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 office using satellite device (follow *MOJN 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 office on the InReach
- ✓ 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 office by sending an InReach message.
- ✓ 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
- ✓ Store field forms in designated location
- ✓ Perform data management activities, including syncing Collector data
- ✓ 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 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	5/29/2020	N. Hupp	Added information about using Arc Collector	MOJN no longer uses GPS to navigate or store location data, we began using Collector in 2020	1.1

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.

1. Naming Conventions for Field Data

1.1. Waypoints and Tracks

Starting in the 2020 field season, hiking tracks and waypoints will be stored in Arc Collector on MOJN field devices.

1.1.1. Location Names

- Macroplot Location – The original macroplot location (to the origin of transect 1) UTM (Universal Transverse Mercator) coordinates will be provided by MOJN in Collector. 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.
- 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).
- Transect Permanent Marker - There are three 50 meter transects per macroplot. The “ends” (“O” origin at 0 m and “E” end 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.
- 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.

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

1.2. Upload Collector Data

After the field visit, ensure that all field devices are connected to the internet and data sync. Navigate to AGOL on your computer and make sure you can see the data that were collected that day. If there were any issues, notify the Protocol Lead and/or Data Management Team.

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 Management Team 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

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 Management Team 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

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 ARCH	Four to six letter USDA Plants database acronym for invasive plant species. Depending on the plant code, some characters may be blank. 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

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 invasive 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

- a. 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*

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

Name *PlotID_Photos_YYYYMMDD*

- c. 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 Management Team 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

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 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, disturbance *we create* can affect the dynamics of the macroplot which introduces bias and misrepresents 'natural' system dynamics.

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 steppingstones. Tracks in washes should be erased during the next rainstorm. 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).
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.
 - a. If that is not possible, then use rocks (if available) to hold standard lengths of rebar in place.

2. 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 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	5/15/2018	N. Hupp	Added special requirements for PARA site rejections	PARA needs provisions since the GRTS draw is based on LANDFIRE data, not an NPS veg map	1.1
1.1	6/5/2020	N. Hupp	Added language to filling out the top of the field form; updated figures to assist with transect layout	All forms have this at the top so we removed it from each SOP and refer to it here.	2.0

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 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. 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.**

- a. Note: You will monitor the area directly upslope of this point, be careful to not trample the sampling area; approach from downslope.
 - b. Place a pin flag on the ground to mark the origin of transect 1.
2. **Determine the downslope direction for the macroplot:**
 - a. If there is no obvious slope, the nearest drainage will mark the downslope side of the macroplot. Downslope must be representative of the entire macroplot (not just the transect 1 origin); examine the site from the center of the macroplot to determine downslope.
 - b. **Take a compass bearing for the downslope direction** (Figure 6.1). Take your time with this measurement, this bearing will be used for many additional measurements at the plot. 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.
3. **Establish a line to determine the origins of transects 2 and 3:**
 - a. Crew member A will stand downslope of the pin flag, hold the reel end of a 50 m transect tape, and direct crew member B. Crew member B takes the free end of the tape and 2 pin flags and chaining pins (take extra chaining pins to secure the tape on windy days), and slowly moves in the downslope direction for 50 m while constantly checking their bearing to stay on course (Figure 6.1).
 - b. 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.
 - c. When crew member B reaches 50 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 50 m point.
 - d. As crew member B heads back to crew member A, place a pin flag at the 25 m mark to indicate the start of transect 2 (chaining pins can be placed as needed).
4. **Establish transect 1:** Repeat steps 5-6 to establish a line perpendicular (90°) to the first tape. This line will be transect 1 (Figure 6.1, black dotted lines).
5. The crew will set up two additional transect tapes at the 50 m points on the established tapes, following steps 5-7 (Figure 6.1, gray dotted lines). 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.

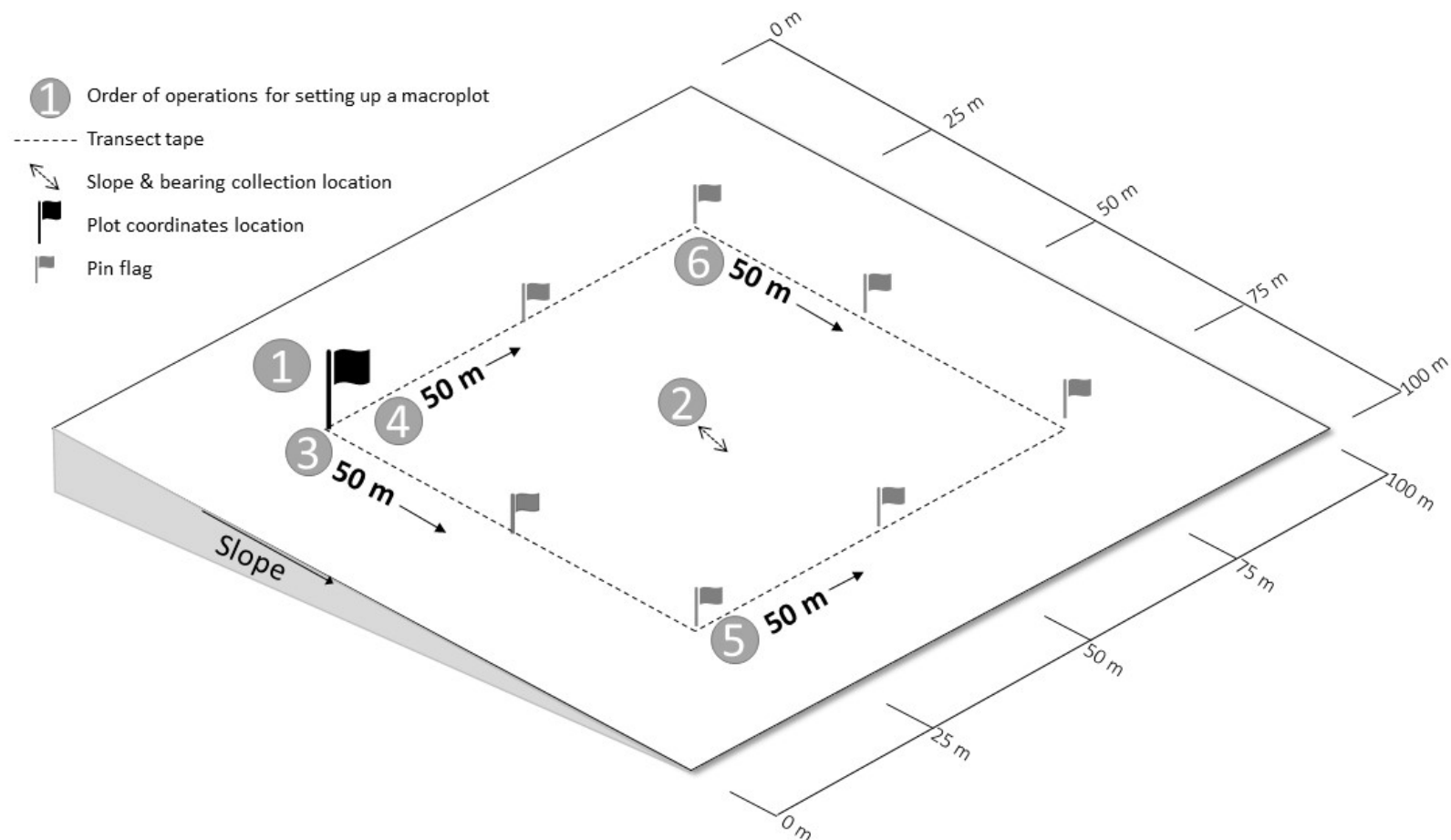


Figure 6.1. Example of how to setup the 100 x 100 m macroplot. The large black flag marks the point used in the plot coordinates (used in hiking directions) and marks the origin of transect 1. Lay meter tapes out to create the dotted square by following the steps numbered 1 to 6: 1. Hike to the plot 2. Measure the slope from roughly the center of the macroplot 3. Pull a meter tape from the plot origin downslope 50 m 4. Pull a meter tape from plot origin perpendicular to the slope 5. Pull a meter tape to make the bottom of the dotted square pictured above. 6. Pull out the last meter tape following the downslope bearing. If the corners do not line up, attempted to restraighten the tapes as much as possible to create an even square. The black dotted lines 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*). Note that PARA has specific guidelines for suitability which are different from other parks (this is because sites on BLM land in PARA were selected with LANDFIRE data which is less accurate than NPS vegetation maps used in other parks).

2.1. Criteria

For each field site, fill out relevant information at the top of the field form (*Site Characterization Field Form*, SOP 6 Appendix A). All IU field forms have at least these fields at the top of the form.

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

Plot Code – A pre-assigned, unique number provided for each site.

Date – Use the format mm/dd/yyyy

Start Time – 24hr hh:mm Time SOP initiated on transect

Stop Time – 24hr hh:mm Time SOP completed on transect

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.

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 degree 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., what should be 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
 - For PARA on BLM land: sagebrush consists of less than 50% cover and/or trees comprise 25% cover of plot
- 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. Note that PARA has specific guidelines for macroplot shifting which are different from other parks (this is because sites on BLM land in PARA were selected with LANDFIRE data which is less accurate than NPS vegetation maps used in other parks).

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
 - ridges: >3 m tall and slopes >10°
- macroplot will include part of paved/unpaved roads
- any of the macroplot area spans safety hazards
 - cliff
 - 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*, for most parks 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. In PARA, the plots on the BLM parts of the park can be shifted up to 150 m radius (this is due to the reality that LANDFIRE data is less accurate than NPS vegetation maps). One hundred meters and 150 m, respectively, 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 an 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.

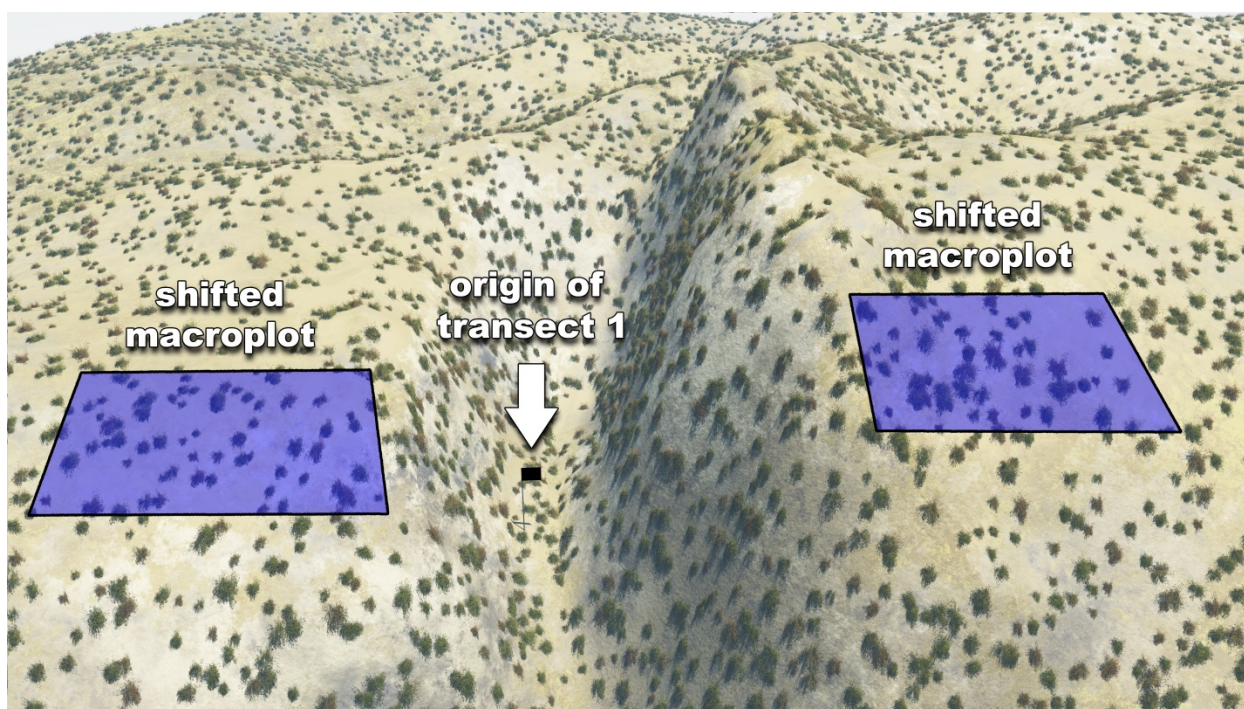
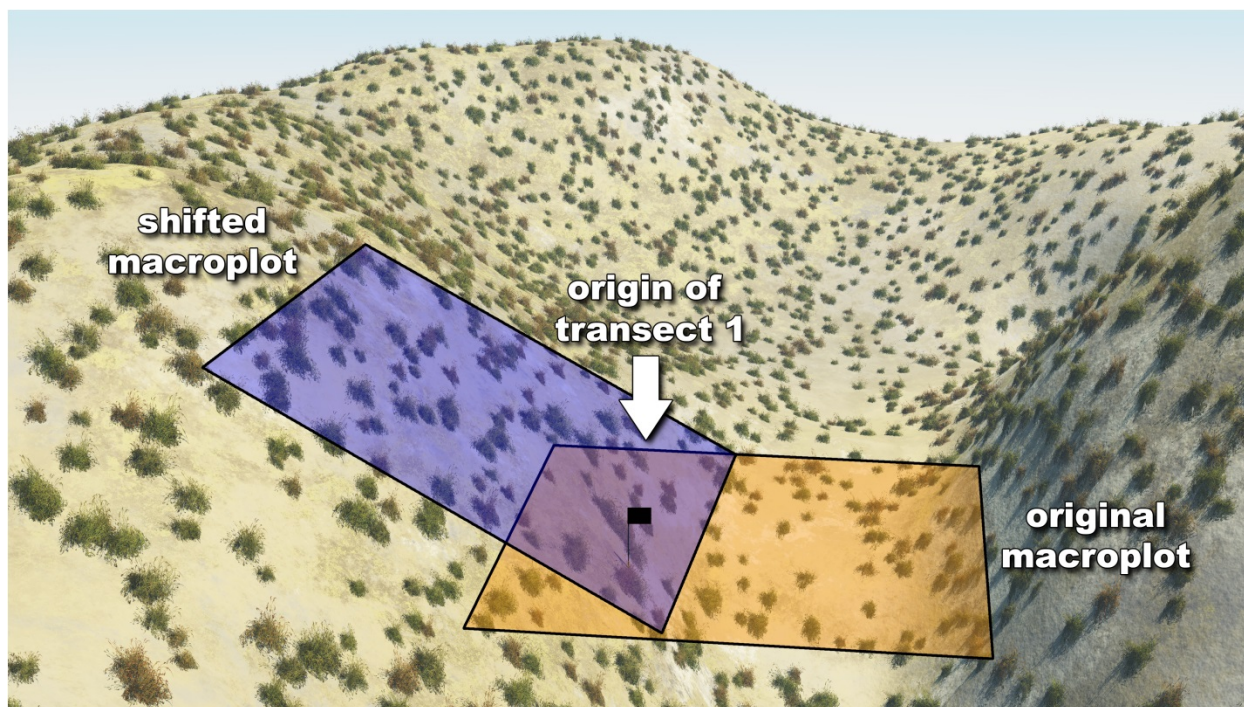


Figure 6.2. Examples of how to shift macroplot placement to have one terrain type or slope. a) shifting the macroplot in the direction that captures the most area from the original macroplot location. b) shifting the macroplot to capture one slope or terrain type. The black flag represents the original 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 comparatively 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 in DEVA, LAKE, AND MOJA: 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.
- Roads in PARA: if a macroplot would include an active road (paved/unpaved), the macroplot should be shifted so that the edge of the macroplot is ~50 m from the center line of unpaved roads and ~50 m 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. From approximately the center of the macroplot, face north and take a picture of what would have been the north part of the macroplot.
 - b. Proceed *clockwise*, taking pictures of each of the remaining cardinal directions.
 - c. If the four cardinal direction photos do not adequately show the criteria for site elimination, take additional photos of the site.
 - d. Record the photo file numbers on the “*Site Characterization Field Form*” and include a brief description of each photo under the “Comments” field.
 - e. To find the photo file numbers, playback the image (see SOP 13).
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 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* ≥1% cover. Go to 250A.

II.3 Go to IIIA.

IIB Tree species not present. Go to IIIA.

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

IIB Shrubs present (≥2%); go to 400A.

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

250A *Yucca brevifolia* ≥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* ≥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* ≥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 spheriocephalus*. *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 spheriocephalus* 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 ≥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 #
1.0	5/28/2020	N. Hupp	Updated text about how plots are established for ease of use	SOP was confusing as written before	1.1

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 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 GPS unit, topographic map, or the Collector app 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 (T1O in figure 7.1).

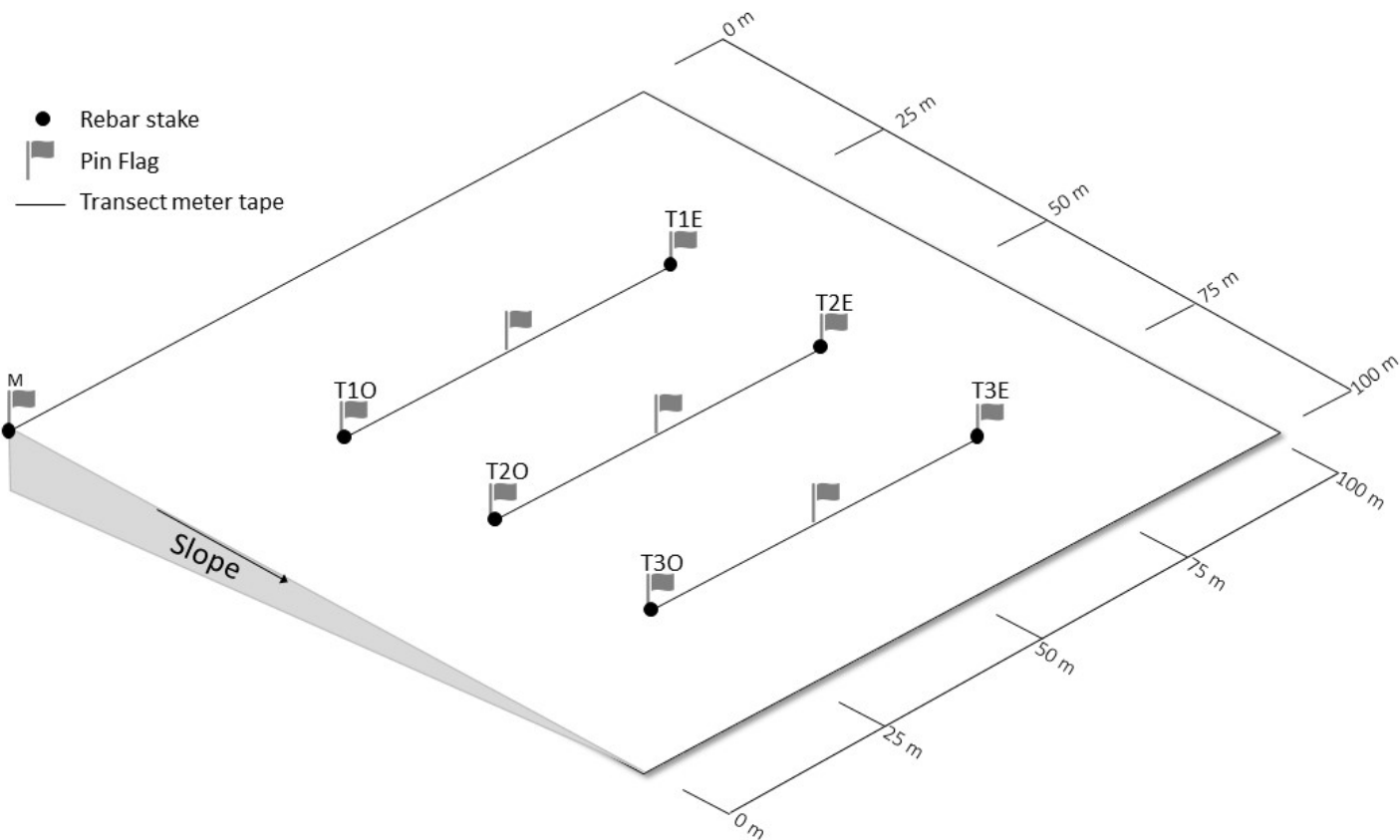


Figure 7.1. Standard macroplot and transect layout for upland monitoring. The filled circles represent rebar stakes, the gray flags represent temporary pin flags used for monitoring, and the black lines are the transect tapes. Transect number, transect origin, and transect endpoints are labeled (e.g. T1O is transect 1 origin, T2E is transect 2 end).

1.2. Establishing the Transects and Macroplot Corner

The upland macroplot consists of three, 50 m long transects running 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 2-6, 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. Establish transect 2 at the center (25 m) of the tapes running perpendicular to transect 1 and 3.

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 or a range finder at a point at eye level on 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 or the digital screen on the range finder and record the degrees 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 macroplot corner 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.

5. Replace the pin flag at the origin of transect 1 with a 36" long, 3/8" diameter rebar stake.
 - a. If there is an obstruction or the rebar stake cannot be securely inserted at the origin or end of each transect, then offset the rebar stake by moving it in-line with, but off the transect (that is, do not put the rebar stake between 0 and 50 meters on the transect since it may affect data collection).

- b. 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 or a hack saw.
6. 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 the transect.
 - a. 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).
 - b. Cap the end of the rebar with a rebar cap using the sledgehammer. Try to hit the cap squarely with the hammer to avoid putting dents in the aluminum. Caps be stamped with the following information:

Above Center: Park code followed by macroplot number

Below Center: Transect number (I.e., 1 = upper, 2 = center, or 3 = lower), transect location (I.e., 0 = origin, E = end)

Outer Right: Stamp the last digit of the year the plot was established.

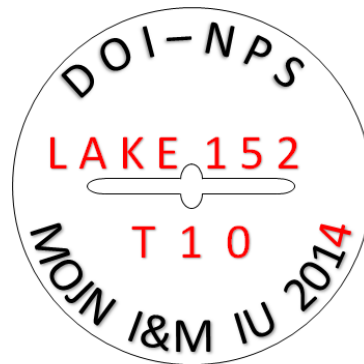


Figure 7.2. Example of aluminum cap used to mark rebar stakes at the transect ends. Writing in black is pre-stamped, writing in red is an example of what the crew would stamp on a cap.

7. Record the date in the appropriate fields on the field form for the rebar marker.
8. In the Collector app, gather the location information using a high accuracy GPS (such as the Arrow or Bad Elf) and fill in each record on the app. If using paper forms, record the UTM coordinates of the rebar using the GPS (*MOJN SOP M3*) and in the appropriate fields on the *Macroplot Establishment Field Form*.
9. Repeat steps 1-5 for the origin and ends of all transects.

10. Make sure that the correct cap is on each rebar marker.
11. For the macroplot corner permanent marker, repeat step 1.
12. 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*.
13. Cap and stamp the macroplot corner rebar like a transect rebar, however, replace the transect number and location with an “M” to indicate macroplot corner.
14. Repeat steps 3-4 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, SOP – 12 Site Assessment for Invasive Plant and Target Tree Species)

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. Top of the form was filed out following SOP 6, section 2.1.
2. Slope for the macroplot and the compass bearing of the transects and macroplot.
3. Location data are collected using Arc Collector.
4. Record directions to the macroplot, with notable details that future crews might not be able to determine from Google Maps or Collector.
5. Begin with road travel from the MOJN 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. 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. At the top of the *Plot Revisit Form* (SOP 7 Appendix A), enter the Park, Plot Code, Date, and Crewmembers information (see SOP 6 section 2.1 for details on each of this data).

2. Record the time it takes to drive and hike to the macroplot and provide navigation details that would be helpful for the next crew. Add additional safety and access notes.
3. Using the Collector App on the iPhone or iPad, navigate by GPS to the edge of the macroplot. Leave personal items in a discrete location (I.e. behind a bush or in a wash, rather than on a hill-top) in order to stay out of photos. Do not walk through the transects. Display a map of the transect endpoints on the Collector App and approach from the downslope side, if possible, to avoid trampling the transects.
4. Locate the rebar marking the origin of transect 1 using the GPS (UTM coordinates).
5. Check the metal tag/rebar cap to make sure it is marked with the code for the origin of transect 1.
6. 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.
7. 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. 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 the transect tape is pulled such that the 54 m mark is at 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 tape to a chaining pin so that the 0 m mark falls over the rebar at the origin end of the transect.
4. Locate the bearing from the transect origin to the transect end (found on *Plot Revisit Form SOP 7*) Take the reel end of the tape and follow the bearing 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. If it is windy or the plot is undulating, we cure the tape in place with chaining pins as you walk along the transect toward the other end.

6. Secure the end of the tape by wrapping the tape around transect end rebar or anchoring the reel with a chaining pin. Make sure the rebar is at the correct meter along the tape (refer to step 1).
7. Repeat steps 1-6 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.
2. Make any necessary updates to macroplot directions, rebar locations, or macroplot side slopes.
3. 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.

Standard Operating Procedure (SOP) # 8: Measuring Cover of Vegetation and Soil Surface Features Using Point Intercept Sampling, and Shrub Height Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/17/2020	N. Hupp	Added vegetation height to this SOP, updated codes in table 8.5 to match datasheets	Since vegetation height was added in 2020 it needs to be included in the SOPs. Veg. ht. is measured at the same time as LPI and makes the most sense to enter here	1.1

Line- Point Intercept: 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).

Vegetation height: Since vegetation height is recorded at the same time as point-intercept and is recorded on the same datasheet, shrub height methods are also included here in SOP 8. Vegetation height is measured as the height of the tallest plant part within a 30 cm (12 in) diameter cylinder projected tangent to the transect. It is measured vertically from the soil surface at the center of the cylinder (Figure 17). Vegetation height provides plot-level vertical structure information necessary to predict soil erosion from wind and characterize wildlife habitat. Vegetation height is usually measured at the same time as line-point intercept because it is more efficient but can be measured separately.

This SOP was adapted from the Northern Colorado Plateau Inventory and Monitoring Network (NCPN) Integrated Upland protocol (which was based on Herrick et al. 2005). Vegetation height methods are adapted directly from Herrick et al. 2005.

1. Point-Intercept for Cover Estimates

Point-intercept is used to sample vegetation on three separate 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). Follow instructions on SOP 6, section 2.1 for how to fill out most of the data, additional fields include:

Sky Condition – Circle appropriate sky description

Weather Notes – Record any additional weather notes

Wind Scale – Record wind condition based on Beaufort Wind Scale 1-10

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.
 - a. Do not bias placement of the flag by trying to intercept or hit vegetation.
 - b. Do not force the pin flag into the ground, as this will bias placement of the pin flag on impenetrable materials.
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 highest layer.
5. Then record the soil surface code and any appropriate disturbance code following the steps below.

For each point, record the following information for the overstory, canopy, soil surface type and disturbance:

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

- a. To project the pin flag upwards, use a meterstick to extend the point up. Or use a moosehorn densitometer to more accurately determine if the overstory is intercepted.
- b. 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).
 - i. If the intercepted plant is dead, indicate with a “-D” after the species code.
 - ii. Unknown shrub species should be recorded as described in *SOP 14*.
 - iii. If there is no overstory, then enter a “0” in the first “Overstory” column and proceed to top canopy.
- c. Record the next tallest species >2 m tall in the “Overstory 2” column. If there is no overstory, then enter a “0”.
 - i. Only two overstory hits will be recorded for each point. If there are more species >2 m tall, they will be recorded under “canopy”.

B. **Canopy**

- a. Beginning at the top of the pin-flag and moving downwards, record plants that directly touch the pin flag. From the top canopy species, move down the pin flag and record species intercepted in the order that they occur. The level of the different canopies is relative to each other.
- b. Record the canopy layers in order as they hit the pin flag

- i. For shrubs, succulents, and target invasive plants, record the species using the USDA Plants Database code
- ii. For annual and perennial grasses and forbs, record the life form (Tables 8.1-8.2; Figure 8.1)
- iii. For other items, record the canopy cover type (Table 8.3).
- c. If no plants are intercepted, enter a “0” in this column.
- d. If a plant is encountered more than once along the pin flag, record only the first (top) occurrence along the pin flag.
- e. If the intercepted plant is dead, indicate with a “-D” after the species code.
- f. Unknown shrub species should be recorded as described in *SOP 14*.
- g. If a dead shrub is intercepted and it is difficult or impossible to determine which species of shrub is dead, record that species as “UNKS-D”. Use this same code for any unidentifiable dead shrub. In other words, even if there are multiple dead shrubs that are likely not the same species, they still get the same code “UNKS-D”.
- h. 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).
- i. If you hit more canopy layers than the number of columns available on the field form, record data for those layers in the SOP 8 – Point Intercept (Extra) form.
- j. Enter a 0 in the next column after your last recorded canopy layer.

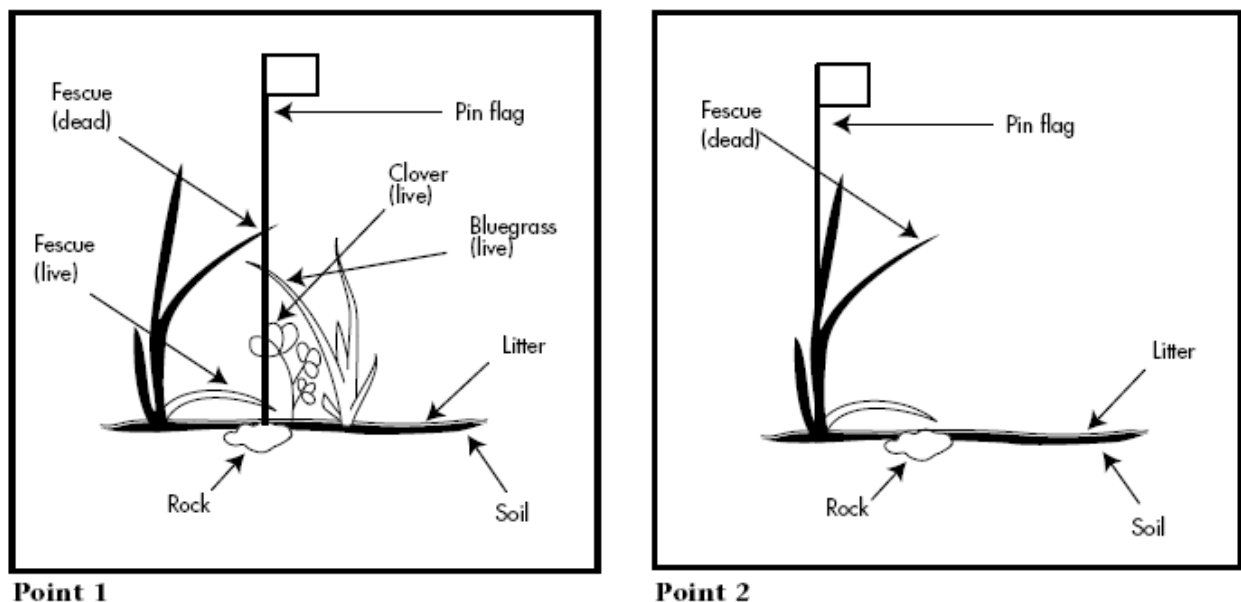


Figure 8.1. Points along a transect associated with the example shown in Table 8.2 (from Herrick et al. 2005).

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

Life form	Plant Code
Annual Forb	2FA

Life form	Plant Code
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 was 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	Ø		2GA	2GP	2FA	L	SR	0
2	Ø		2GA	L	Ø		2GA	0
3	Ø		ATCA2-D	2GA	L	Ø	S	ANT
etc.								

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.

C. 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 “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 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 sand, soil, and crust.
- If the pin flag lands on a rock that overhangs a section of soil surface, project the pin flag through the rock and record what the pin flag would land on if the rock wasn’t obstructing its path.

D. Soil surface disturbance

- a. 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).
- b. Enter a “0” in this column if there is no disturbance.
- c. 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.
- d. Use only abbreviations from Table 8.5 to label the type of disturbance.
- e. 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.

Important Point Intercept Rules to Note:

- Only count plants that directly touch the pin flag. Plants that are very close do not count.
- If the pin flag lands at a plant base, record the USDA species code for the plant as the soil surface type.
- If you encounter a dead shrub and cannot determine what species it is, record the species as “UNKS-D”. This code is used any time an unknown shrub or cactus species is encountered, even if it is used for two different species which are clearly not the same species, but undiscernible.

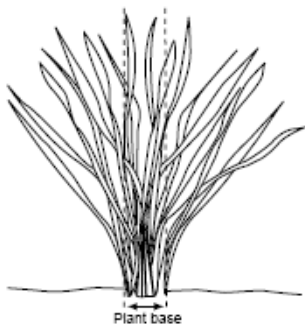


Figure 8.2. Area defined as a plant base (from Herrick et al. 2005).

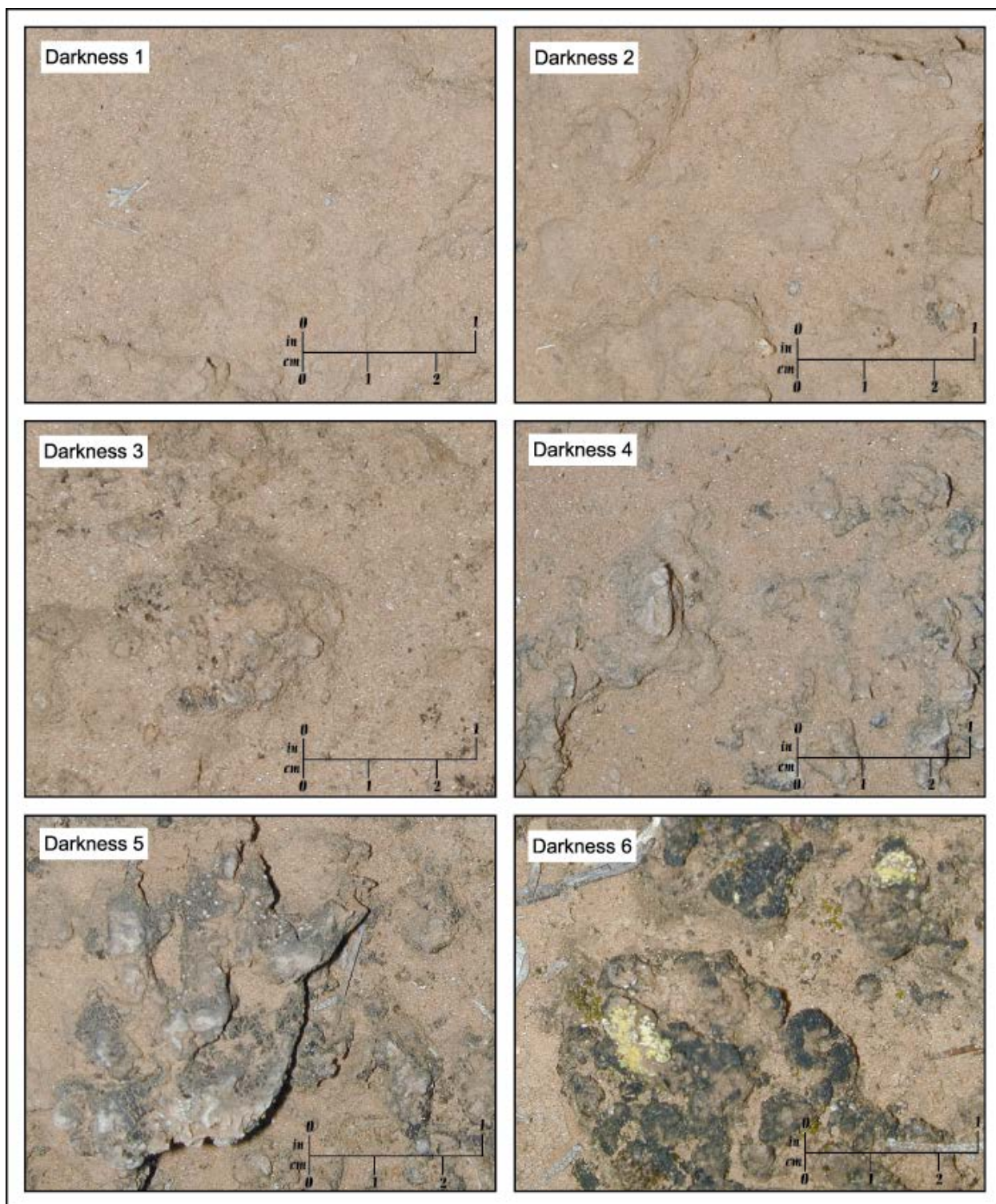


Figure 8.3. Photographic key to a six-class scheme for describing degrees of biological soil crust development (Belnap et al. 2008). Darkness 1-3 show mainly undifferentiated crust while Darkness 4-6 contain substantial areas of dark cyanobacteria. Darkness 6 also includes lichens.

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 particles that are rich with decomposing organic matter and small litter debris (<2 mm)
SA	Sand	Loose soil particles (0-2 mm diameter) not protected from wind erosion by any type of crust or any other soil surface feature
C	Crust	Anything from physical crust to weak biological crust (weak cyanobacteria)
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
P	Playa	Dried lakebed
W	Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and in direct contact with soil. Also includes fibrous plant material such as pieces of yucca.
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
BK	Bicycle	Disturbances caused by non-motorized bicycles
HMT	Human track/trail	Tracks or trails created by humans
LT	Livestock track/trail	Tracks, marks, or trails created by livestock
MV	Motor vehicle	Disturbances caused by any motorized vehicle
WSH	Wash	Small to large eroded areas caused by (temporary) flowing water; plants and soil are displaced
WLE	Wildlife excavation	Holes and mounds created by wildlife
WLT	Wildlife track	Tracks, marks, or trails created by wildlife
HMO	Other anthropogenic	Any human disturbance other than tracks and trails
UNK	Unknown	Any disturbance of indeterminate origin or not classified as one of the other categories

2. Measuring Vegetation Height

Measure plant heights along transect lines every 5 meters for a total of 10 readings per transect and 30 per plot. Vegetation height is measured in a 30 cm diameter circle. The circle is estimated by lowering a circle down a pin flag or measuring stick over the vegetation, and the tallest woody vegetation that the circles touches is recorded on the field form. This method can be completed using other tools such as a ruler (either 15 cm for radius, or 30 cm for diameter) lowered over a pin flag, or other creative tools if they estimate a 30 cm diameter circle accurately. Measure vegetation height every 5 m along the transect line (specifically 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 m along the transect tape),

1. Starting at 0 m hold the edge of the disc on the uphill side of the tape. Using the disc as a guide, determine the tallest living or dead woody (including succulents) plant parts intersecting a projected 30 cm diameter cylinder tangent to the line (Figure 2.1).
2. Record the USDA plant species code and the height on the data form. Repeat each measure along the meter tape for all 10 points.
3. If no woody plant parts are intersected record “0” in the height and species column.

Important Vegetation Height Rules to Note:

- All woody plant materials existing inside the projected cylinder are considered, whether they are rooted inside or outside the 30 cm (12 in) circular area (Figure 18). It does not matter where plants are rooted, only plant materials within the cylinder are observed.
- Plants count whether they are dead or alive, but record “[USDA code]-D” for dead individuals.
- Do not stretch or move any plant parts.
- Ignore any part of the plant that is outside the cylinder.
- Record the height of plants 0-2 m (6 ft) tall to the nearest centimeter (1 in). Record the height of plants that exceed 2 m (6 ft) in height to the nearest 30 cm (~1 ft). Plants greater than 18 m (60 ft) should be recorded as 18 m (60 ft) tall.

If vegetation is taller than 3 m (~10 ft), a range finder, clinometer, phone application, or geometric technique can be used to estimate height. For a ranger finder, step back from the tree far enough so that you are at least as far away from the tree as the tree is all (e.g. if the tree is 5 m tall, stand at least 5 m away from the tree to get an accurate reading).

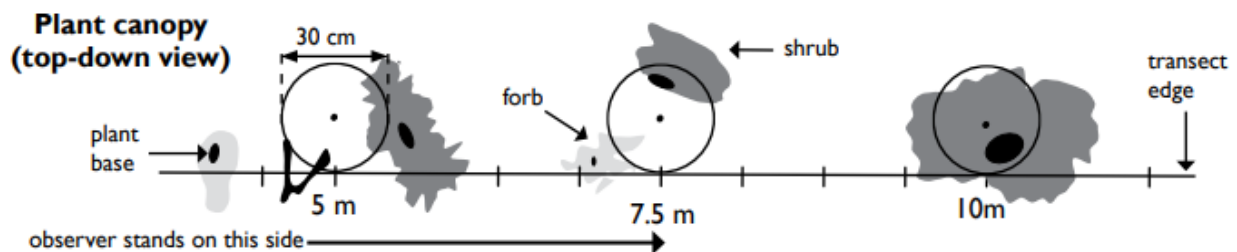


Figure 8.4 Example of vegetation height measurement intervals and the area tangent to the line in which the tallest woody and herbaceous plant elements are measured.

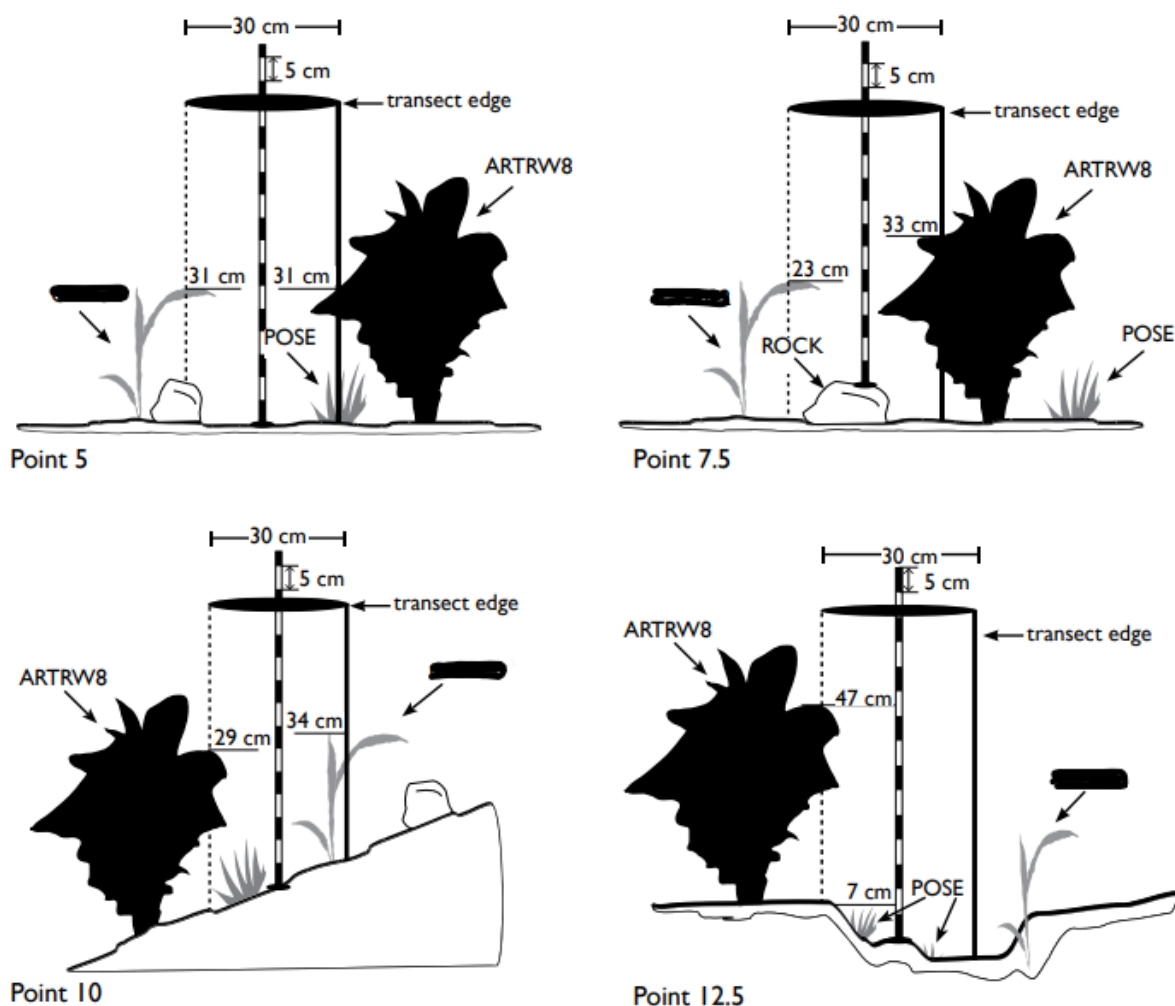


Figure 11.2.2 Example of woody height measurements at 4 points along a transect. Height is measured from the surface center point of the cylinder even if the point is on a slope (Point 10), a rock (Point 7.5), or in a furrow or hummock (Point 12.5). Where no woody or herbaceous vegetation are present, mark "0" on the data sheet (from Herrick et al. 2005).

3. 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.

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

Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	5/29/20	N. Hupp	Updated text to make easier to follow, polished language, added an "important rules" subheading for canopy and basal gaps; included GRBA specific rules for basal gaps	SOPs were too wordy to follow and at times ambiguous; GRBA basal gap rules were edited in 2017, the SOPs now reflect that change	1.1

Gap intercept measurements provide information about the proportion of the line covered by large gaps between plants. Large gaps between plant canopies are important indicators of potential wind erosion, weed invasion, and wildlife habitat, including wildlife hiding cover and thermal environment. Together with vegetation height, canopy gap measurement can be used to characterize vegetation structure. Large gaps between plant bases are important indicators of runoff and water erosion.

This SOP was adapted from "Gap Intercept" SOPs in the BLM AIM monitoring protocol (Herrick et al. 2005).

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) following SOP 6, section 2.1. Additional fields include:

Sky Condition – Circle appropriate sky description

Weather Notes – Record any additional weather notes

Wind Scale – Record wind condition based on Beaufort Wind Scale 1-10

A crew of two is expected to conduct this SOP, with one member the observer and the other the recorder. Experienced field technicians can consider conducting this SOP alone.

2. Canopy Gaps

A canopy is the aboveground portion of the plant and extends beyond the base of a plant (Figure 9.1). In this SOP, we measure canopies of live or dead **perennial shrubs, trees, grasses, and forbs**; we do not count annual vegetation in canopy gaps. For this protocol, perennial plants growing close together may form one continuous canopy.

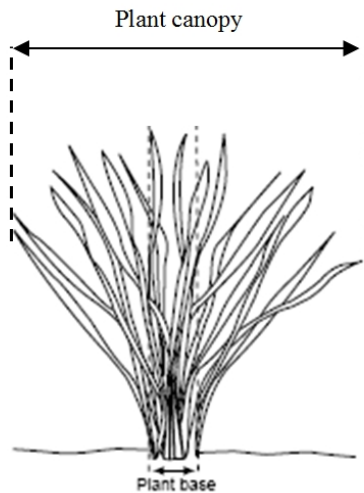


Figure 9.1. Canopy and base of a grass plant (from Herrick et al. 2005).

1. Stand on the downhill side of the transect tape.
2. Start at the transect origin (0 m) and work from left to right towards the 50 m end.
3. Walk along the downslope side of the transect and go to the first perennial plant with a canopy overhanging the transect tape (canopies can be live or dead). Stand downslope of the tape and collect data on the uphill side of the meter tape. Use a straight pin flag to project a line vertically to the ground (Figures 9.2, 9.3, 9.4). The pin flag should barely touch the uphill side of the meter tape.
 - a. You may need to project the pin flag from the canopy edge onto the ground if the vegetation is tall.
4. Determine if the encountered plant constitutes a plant canopy. If it meets the criteria (i.e. a perennial plant that is $> 50\%$ of 3 cm, refer to rules below), then this point is the start of a canopy gap. Record the gap start point on the data sheet (Table 9.1).
5. Move along the transect projecting a vertical line to the ground looking for the next plant canopy, when it is detected, record the gap end point (m) on the datasheet. Note that gaps must be > 20 cm to be considered a “gap”, distances shorter than this are not gaps and should not be recorded.
6. Apply the same method from gap to gap along the transect line, recording where the gaps begin and end on the data sheet.

Important Canopy Gap Rules to Note:

- 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 0 cm mark and the 3 cm mark (or greater) both must intercept plant canopy; a 1.5cm section of plant canopy with 100% density does not count. The only exception to this rule occurs when you have a space between canopies < 20 cm.
- 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. In other words, 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.

- Record the start and end of each canopy gap to the nearest hundredth 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.
- If there is a shrub canopy that covers the end of the 50 m tape, the canopy gap can end at a number before 50 m. For example, if a shrub is present from 49.10 m through 50.00 m with no gaps, the last gap of the line ends at 49.10. Record dashes in the next row to emphasize a gap ended before 50 m.

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	

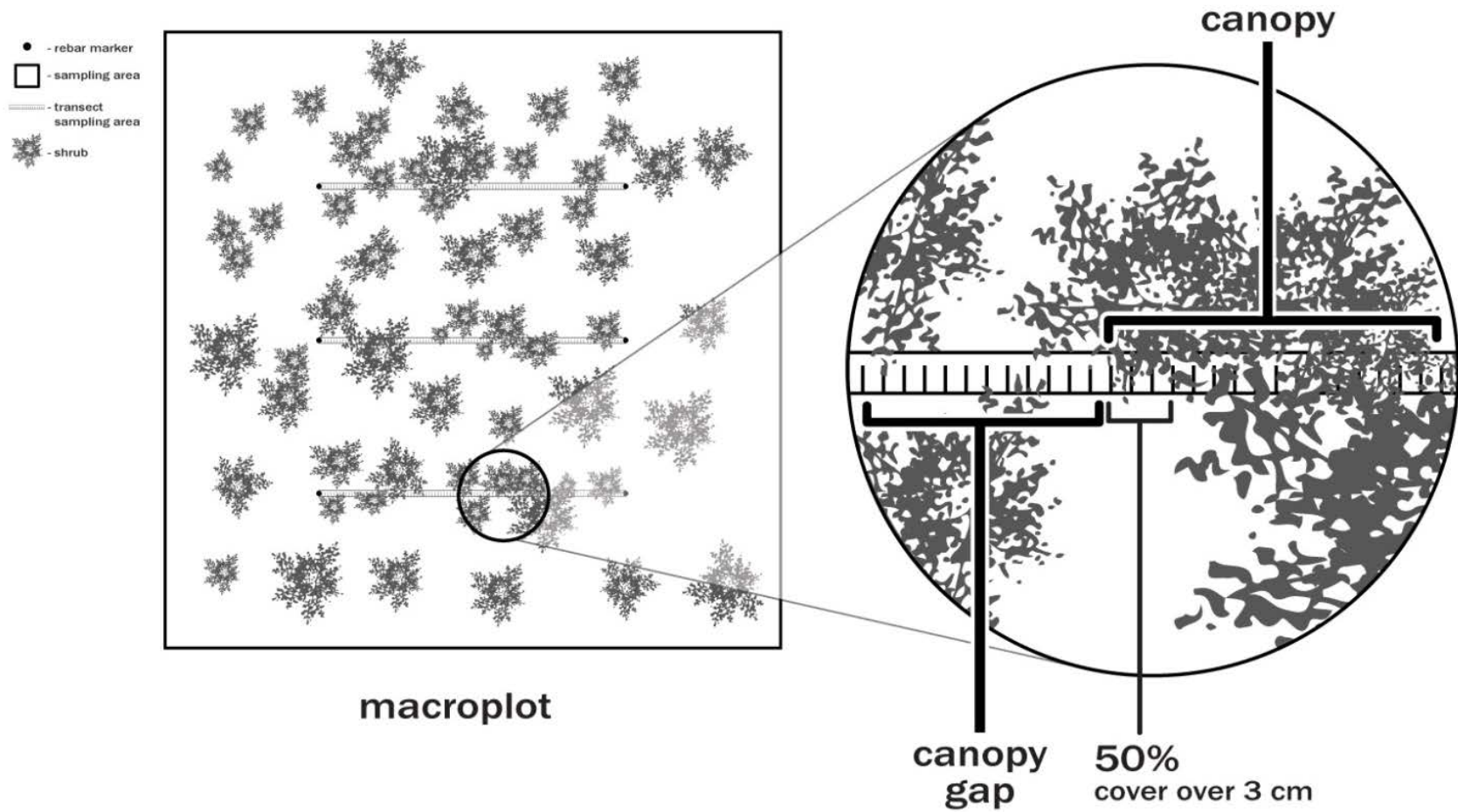


Figure 9.2. Example of 50% canopy cover over a 3 cm segment of the transect. Tick marks are in cm.

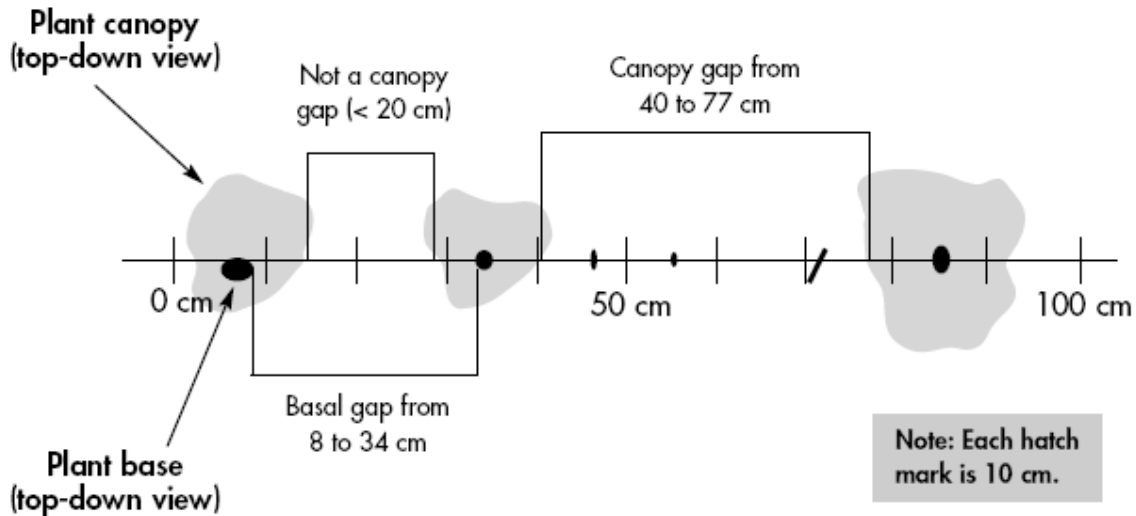


Figure 9.3. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 1 m (100 cm) of a 50-m transect. Canopy gaps: There is a gap between 40 cm (0.40 m) and 77 cm (0.77 m) because the plant canopies do not cover more than 50% of any 3 cm segment. Though the first 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.)

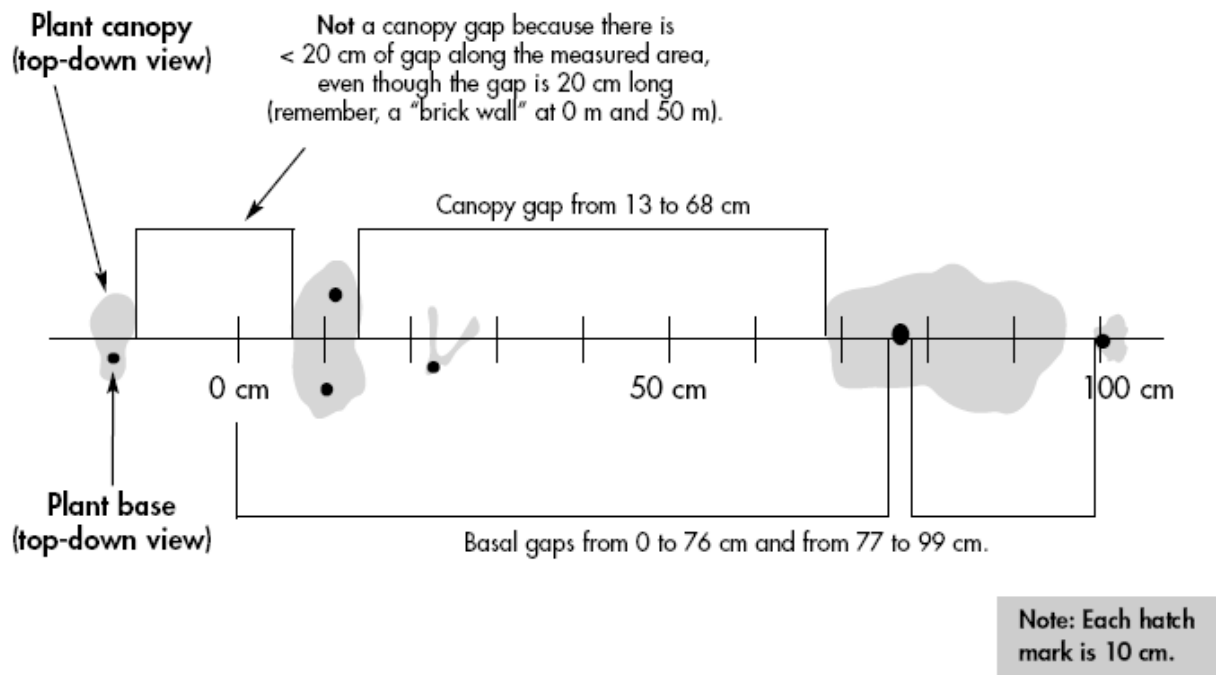


Figure 9.4. Example of canopy gap intercepts (above the line) and basal gap intercepts (below the line) for 1 m (100 cm) of a 50-m transect. Canopy gaps: Shrub canopy starts at 6 cm (0.06 m) since the space from 0 to 6 cm (0.06 m) is not large enough to be considered a canopy gap. Look at the plant canopy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

Begin sampling basal gaps from the 0 m origin of the tape and work towards the 50 m end of the tape. If the transect is sparse, basal gaps *may* be measured from end to origin (50m to 0 m); beware this can be challenging mental math if there are many gaps. A plant base is any **perennial** plant stem emerging from the soil surface, along the graduated edge of the tape, that when disregarding bumps in the soil surface itself, would disrupt a straight line of light emitting from a laser pointer shooting in a horizontal direction (minimum diameter of stem = 1 mm or ~1/25 in; or in sagebrush plots, minimum diameter of a stem = 3 cm). Plant bases must be anchored to the ground and can be either live or dead (Figure 9.1). Record the start and end of a gap to the nearest centimeter.

1. Remain on the downhill side of the transect.
2. Work from left to right if starting at 0 m, or right to left if starting at the 50 m end of the line and move to the first piece of perennial vegetation encountered along the line.
3. Look straight down on the uphill side of the tape. Use a straight pin flag to project a line vertically to the ground.
4. Determine if the encountered plant constitutes a plant base. If it meets the criteria (i.e. is perennial vegetation at least 1mm or 3 cm, depending on the park, in length along the meter tape), then this point is the end of a basal gap.
5. Walk along downslope side of the transect projecting a vertical line to the ground on the upslope edge of the tape looking for the end of the plant base. When it is detected, record the gap start point (m) on the datasheet. Note that gaps must be >20 cm to be considered a “gap”, distances shorter than this are not gaps and should not be recorded. NOTE: For the first gap on the transect, the gap begins at 0 and ends at the first qualifying base if the gap is at least 20 cm.
6. Apply the same method from gap to gap along the transect line, recording where the gaps begin and end on the data sheet.

Important Basal Gap Rules to Note:

- Do not consider gaps or vegetation that occur off the ends of the tape; do not record numbers less than "0" or greater than the maximum length of the tape. In other words, if a basal gap of <20 cm occurs on either end of the transect, do not count this as a gap.
- 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.
- Only measure basal gaps formed by **perennial shrubs, trees, grasses, and forbs**.
- The minimum diameter of a plant base is 1 mm (0.001 m) in LAKE, MOJA, DEVA, JOTR, and MANZ.
 - Since gaps are recorded to the nearest centimeter, a gap can end and the next gap begin at the same number. For example, if a gap ends at 2.55 m when a plant stem 2 mm long is encountered, the next gap could begin at 2.55 m.

- The minimum diameter of a plant base is 3 cm (0.03 m) in GRBA and PARA, the two parks that monitor sagebrush.

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.

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

Version 2.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/11/20	N. Hupp	Updated language to reflect changes to datasheets, make text easier to follow for field crews, added clarifications	Protocol was difficult to follow	1.1
1.1	6/8/20	N. Hupp	Added "Trash" as quadrat disturbance code, this was functionally added to data collection on 6/11/18 and now the SOPs reflect the reality	Trash has been encountered frequently in the field and no other code is suitable to record those data	2.0

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 line point intercept did a poor job of detecting it (Pan and Tallent 2013). A list of targeted invasive plants for each park is presented in Appendix A of the Integrated Upland Protocol of the Mojave Desert Network, Volume 1: Protocol Narrative. A crew of two is expected to conduct this SOP, with one member the observer and the other the recorder.

This SOP was adapted from BLM AIM monitoring protocol (Herrick et al. (2005). Complete this SOP 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). These fields are described in detail in SOP 6, section 2.1.

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 (Figure 10.1). There will be a total of 50 quadrats along each transect. For ease of use and carrying in the field, we do not use a PVC quadrat as is common. Instead, use two-meter sticks or pin flags 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.

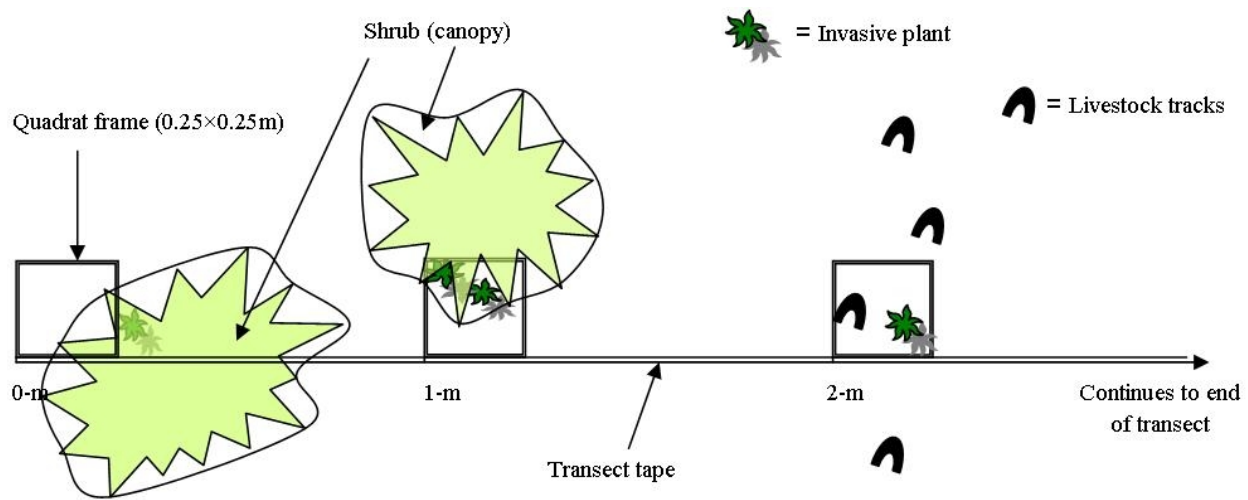


Figure 10.1. Diagram of invasive plant and disturbance frequency quadrat placement showing the first three sample points on a transect. Invasive species are absent from the quadrat at the 0 m mark because the invasive species is not located within the quadrat. Invasive species are present in the quadrat 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”).

1. Start at the origin (0-m mark) of transect 1 (Figure 10.1). Hold the meter sticks or pin flags at 0.0 m and 0.25 m extending 0.25 m on the uphill side of the meter tape. The area in this 0.25 x 0.25 m zone is the first frame.
2. Determine whether targeted invasive species (dead or alive) are present within the quadrat. Plants can be rooted outside the quadrat but overhanging into the search area 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 4.
3. 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 most of them are in. Circle the most common phenological stage of the species (Table 10.1).
 - b. Circle “C” to indicate plants are primarily located under canopies or fall within an area influenced by canopy (see Figure 10.1), or “I” for interspaces between plants. If target species appear equally under both canopies and interspaces, then indicate with a “CI”. For a species to be considered under both areas, between 40% and 60% of individuals must occur under canopy (and likewise for individuals in interspaces). Only perennial plants are considered canopy.
4. If any disturbances are found in the quadrat, 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.

5. If any developed biological crusts are found in the quadrat, then circle the “Y” (yes, crust is present) under BSC. If no developed crusts are found, then circle the “N” for (no crust, or not present).
6. When all data has been recorded, move the quadrat frame to the next meter. 50 quadrat frames are recorded from 0-49 m. for each point along that transect in increments of 1 m. The last point will be at 49 m; do not measure the 50 m mark.

Important Invasive Quadrat Rules to Note:

- Focus search energy on the predetermined list of invasive species of interest. If other invaders are detected, record them. However, there are 100+ non-native plants detected in most MOJN parks, having an accurate search image for each of these is beyond the scope of this protocol.
- Start at 0 and end at 49 m. Quadrats can be read “backwards” by going from 49 m to 0. Make sure to record data in the correct location on the datasheet in either case.
- Any invasive plant rooted in or overhanging the quadrat is counted. Uprooted plants are considered litter and not counted in the quadrat.

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
BK	Bicycle	Disturbances caused by non-motorized bicycles
HMT	Human track/trail	Tracks or trails created by humans
LT	Livestock track/trail	Tracks, marks, or trails created by livestock
MV	Motor vehicle	Disturbances caused by any motorized vehicle
WSH	Water erosion	Small to large eroded channels caused by (temporary) flowing water where obvious soil and vegetation displacement occurs with some regularity.
WLE	Wildlife excavation	Holes and mounds created by wildlife (e.g. rodents)
WLT	Wildlife track	Tracks, marks, or trails created by wildlife
HMO	Other anthropogenic	Any human disturbance other than tracks and trails
UNK	Undifferentiated	Any disturbance of indeterminate origin or not classified as one of the other categories
TR	Trash	Human trash including balloons, tires, or other human-related debris (code added on 6/11/2018)

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.

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

Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/11/20	N. Hupp	Updated info about collecting data in Collector instead of on hand drawn map	We have changed how these data are stored so that EPMT can use the information readily	1.1

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 (LPI or invasive quadrats) and for counting target tree species. Target trees include pinus species in GRBA and PARA, and any occurrence of Joshua trees (*Yucca brevifolia*) in any park. 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.

Some of these data are collected on the field form, the rest are collected in Arc Collector so that data are made readily available to park managers.

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). These fields are described in SOP 6, section 2.1.

To ensure 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.

Search only for invasive plants that are specified on the data sheet. Fill out the table at the top of the *Site Assessment for Invasive Plant and Target Tree Species Field Form* (SOP 12 Appendix A). If any

invasive plants were detected on all three transects during LPI or Invasive Quadrats, they will not be searched for on the invasive species walk.

At sites with significant coverage of physical and/or biological soil crusts, it is important not to impact soil stability more than is 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.
3. Each crew member will keep individual notes on what they observe.
4. When both crew members should walk at the same time and confer when needed. As they walk, they can 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) and in Arc Collector:
 - 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. Collect location data as Infestation Points or Infestation Polygons in Arc Collector based on the findings of the invasive species walk.
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.

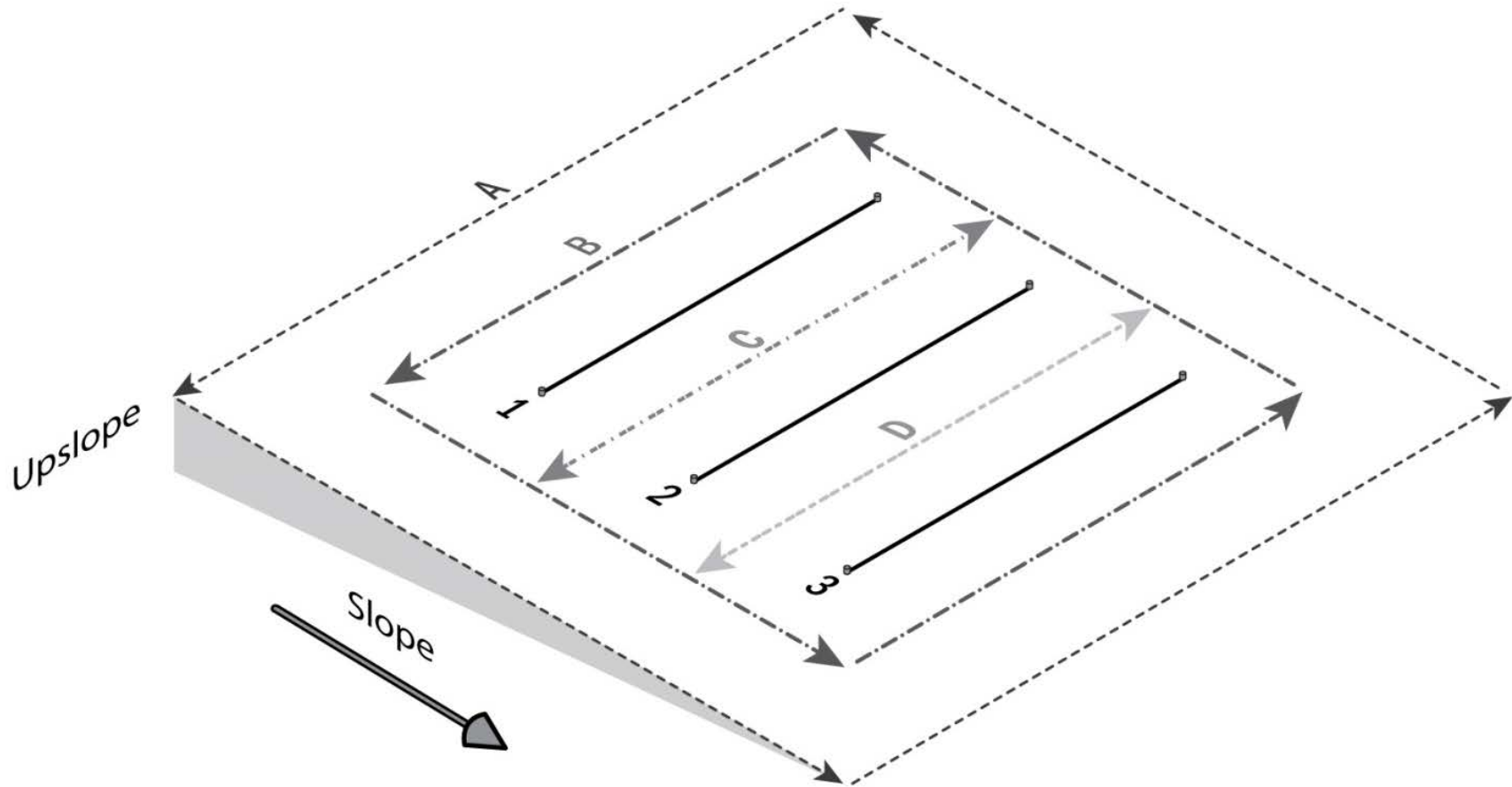


Figure 12.1. Macroplot diagram showing the search pattern for target invasive plant species. The numbered lines correspond to transects 1, 2 and 3 whereas the lettered and arrowed lines correspond to the search pattern. Letter A indicates the macroplot perimeter walk, B indicates the box-pattern walk 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.

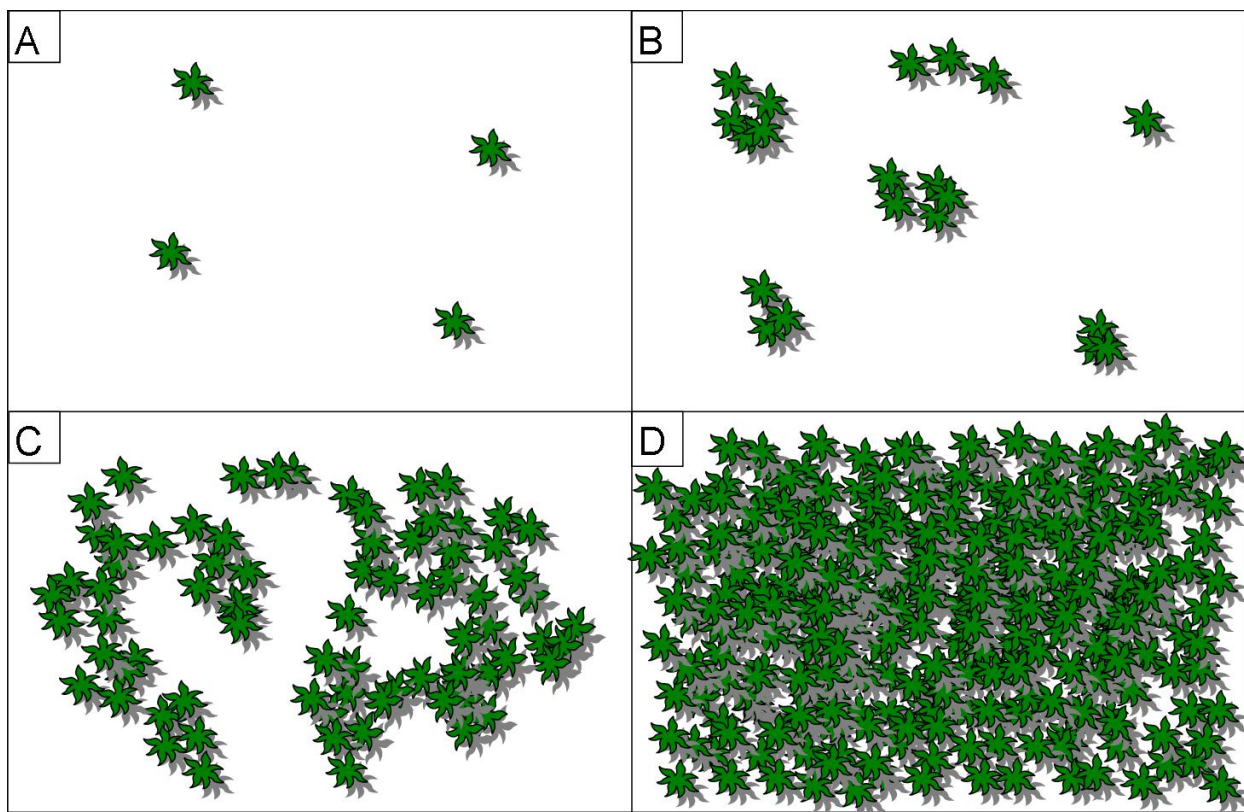


Figure 12.2. Dispersion types of invasive plant populations: A) scattered individuals, B) scattered patches, C) clumped, and D) continuous cover of plants.

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. Description of codes for cover classes of the area infested within the macroplot.

Cover Class code	% cover classes
1	>0-2%
2	3%-25%
3	26%-50%
4	51%-74%
5	>75%

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.
- 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.
- Pan, J. J., and N. Tallent. 2014. Mojave Desert Network integrated upland monitoring: 2012 pilot study for Joshua Tree National Park. Natural Resource Technical Report NPS/MOJN/NRTR—2014/850. National Park Service, Fort Collins, Colorado.

Standard Operating Procedure (SOP) # 13: Repeat Photos

Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	12/23/19	J. Ladd	Removal of tripod from methods; implement use of new digital cameras	Streamline methods and decrease time commitment of SOP	1.1

Repeat photos are used to show vegetation change along transects and provide one overview photo of 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 are based on the **Olympus TG-4 Digital Camera** but may be implemented with any digital camera with slight modifications. *SOP 5 - Crust-Friendly Field Procedures* should be reviewed before starting this SOP.

1. Transect Overview Photos

Photos are used to provide qualitative documentation of vegetation change along transects through time. One photo is taken per transect. See Figure 13.1 for an overview of default photo positions and orientations.

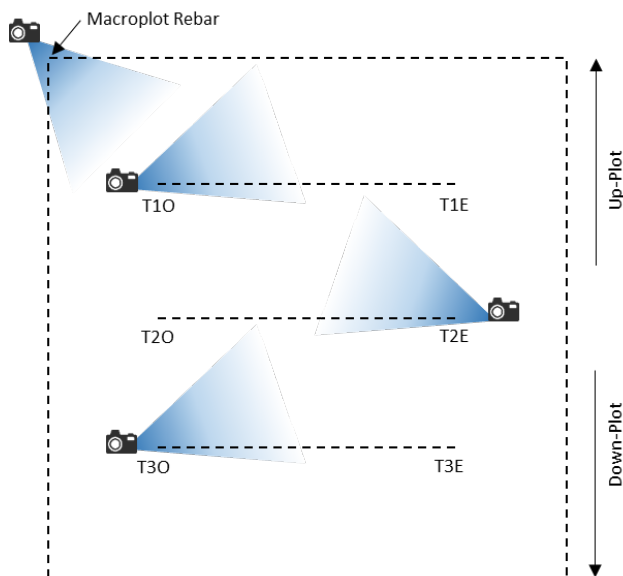


Figure 13.1 Diagram of camera location (camera icon) and field of view (blue cone) for each standardized Plot Repeat Photo

1. Label field form “SOP 13 – Repeat Photos” with the park code, date, photographer, macroplot code, camera number (last 5 digits of the NPS inventory tracking tag), and memory card number. Fill in the part of *Repeat Photos Field Form* under “Transect Overview” from the steps below.
2. Transect Overview Photos are taken at different views along the tape to provide documentation on multiple sides of the macroplot. A total of three Overview Photos are taken at the macroplot (Figure 13.1).
 - a. For transects 1 & 3, take the photo from the origin of the tape.
 - b. For transect 2, take the photo from the 50 m end of the tape.
3. Stand at the appropriate location (origin/end) of the transect tape for transect being photographed. Record “1, 2, or 3” under the “Transect #” column and circle “O” for origin or “E” for end under the “Transect End” column on the field form.
4. Use a measuring tape or rod to measure 3 meters directly back (in-line with the transect) from the rebar stake marking the end of the transect. Mark the spot with a pin flag; this will be the photopoint location. Record the position of the photo location in the “Position” column on the field form. (T0 default will be -3m; TE default will be 53m)
5. Make sure that the image resolution is set to the highest setting by scrolling through the camera menu. To do this, press the “Menu” button on the camera and navigate to Camera Menu > Compression > Select “Fine”. Using the setting wheel on the camera, ensure the camera is on the “iAUTO” setting.
6. Use a measuring tape or rod to position the camera 1.5m above the placed pin flag.
7. Position the camera so that the image will be in the Landscape (horizontal) view.
8. Observe the digital display of the camera and frame the photo using the following criteria:
 - a. The rebar is visible and the transect tape is toward the “down-plot” edge of the image (photo is angled slightly “up-plot”). To ensure repeatability, enable gridlines on the camera display by pressing the “SOMETHING” button. Align the transect tape with the appropriate gridline on the camera display (right gridline for photos taken from T0, left gridline for photos taken from T50). The image should clearly capture as much of the vegetation along the transect as possible. The photo should have no more than 20% sky in the field of view (but include some sky to help with orientation).
 - b. The photo is framed along true horizontal, not tilted to conform to the landscape.
 - c. 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.

- d. 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.

NOTE: *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 detailed information for this photo, especially the location along the transect.

9. When the above criteria have been met, take the photo. Press the shutter button halfway down to focus. To take the photo, gently press the shutter button all the way down while being careful not to shake the camera.
10. Check the image for clarity by pressing the Playback button. Review the following:
 - a. Zoom in on the image (use the zoom lever to zoom in/out) 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 viewed on a large screen. Zooming in on the image will allow you to identify if the photo is out of focus.
 - b. If necessary, re-take photo to ensure photo is framed properly and image is in focus.
 - c. 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 13).
11. When the desired photo has been captured, record that image file number under “Photo #” on the field form.

NOTE: The photo number can be found on the review screen and is the last four digits of the number listed below the photo size. This always begins with “100-“ followed by the photo number, NOT the index number at the top right of the screen (Figure 13.2).

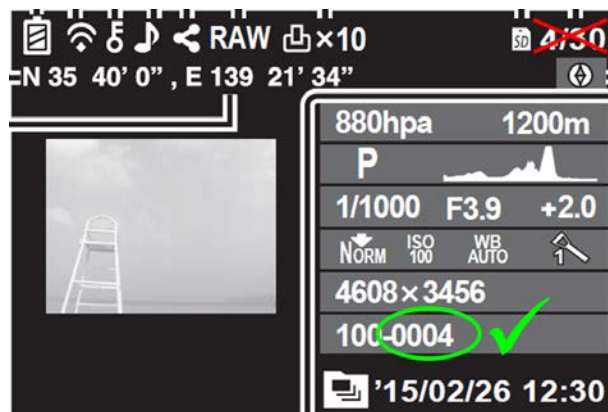


Figure 13.2 Olympus T-4 Digital Camera photo review menu showing the location of photo number to be recorded on field data sheet.

12. In order to help with relocating the field of view during repeat visits, camera height and compass bearing of the camera need to be determined. Record the following on the field form:
 - a. Camera Height: Measure the height of the camera off the ground to the base of the camera where the photo was taken (default is 1.5m) using a measuring tape or rod. Record the information on the appropriate line in the field form.
 - b. Camera Bearing: Take a compass bearing for the camera in degrees. Identify an object that is in the exact middle of the photo horizontally and determine the azimuth from the camera to that object. Record the information on the appropriate line in the field form.
13. If additional photos need to be taken of the transect, start by taking an image at the other end of the transect (following steps 2-12). 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 “Position” column. 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 2-12 and make sure to record on the field form the distance along the transect where the camera is placed for the image under the “Position” 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).
14. When all photos have been taken, take the pin flag, measuring tape or rod, and camera to the next transect
15. Repeat steps 2-12 for the remaining transects
16. When all transects are completed, collect the pin flag, measuring tape or rod, and camera 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. See Figure 13.1 for an overview of default photo positions and orientations.

1. Ensure field form *SOP 13 – Repeat Photos* has been filled out with the appropriate information. Fill in the part of *Repeat Photos Field Form* under “Macroplot Overview” from the steps below.
2. Go to the rebar stake marking a corner of the macroplot.

3. Use a measuring tape or rod to measure 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.
4. Use a measuring tape or rod to position the camera 1.5m above the placed pin flag
5. Position the camera so that the image will be in the Landscape (horizontal) view.
6. Observe the digital display of the camera and frame the photo using the following criteria:
 - a. The Macroplot rebar is horizontal center of the image. The image should capture as much of the macroplot as possible. 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* under the “Macroplot Overview” section, that you have moved the photopoint and provide information on how to relocate
 - b. The photo should have no more than 20% sky in the field of view (but include some sky to help with orientation).
 - c. The photo is framed along true horizontal, not tilted to conform to the landscape.
 - d. 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.
 - e. 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.
7. Follow steps 9-12 from section 1. *Transect Overview Photos*.

3. Revisiting the Photopoints

For sections 1. *Transect Overview Photos* and 2. *Macroplot Overview Photos*, it is imperative to bring 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.

1. After setting up the plot and transects, navigate to the photopoint site.
2. When you are in the general vicinity of the photopoint, use the location notes and previous overview/transect photo to find the photopoint.
3. Follow the steps in sections 1 and 2 while referencing the data recorded on the previous visit’s *Repeat Photos Field Form* to take as exact repeat photo as possible.

4. Be sure to reference the printed photo from the previous visit in order to create the exact same frame, angle, and orientation for the repeat photo.
5. Record any deviation in Position, Height, Bearing, or Angle from the previous visit on the field form.

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).

a. 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. If you choose to photograph an unidentifiable shrub, record these photos on the Photo Log Field Form.

b. 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 =
4 letter park code + macroplot number + ‘-’ + date (YYYYMMDD) + collection letter (use letters starting with ‘A’ in each macroplot)
For example, if we came across an unknown shrub in Mojave National Preserve on macroplot B001, it would be named “MOJAB001-20150923A”.
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 *Unknown Shrub Species Field Form* (SOP 14 Appendix A).
Be sure to take a photo that shows the whole plant.
4. Label a blank 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).
Place the specimen in a zip-lock bag or place it in a plant press.
7. Use the unknown species code on the monitoring field forms. If you find multiple unknown shrubs of the same species in the same macroplot, you may use the same code for each occurrence of this species, but when in doubt, treat them as separate unknowns.
Try to ID the collected material as soon as possible.

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

Version 1.1

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	5/29/2020	N. Hupp	Updated season close-out requirements; updated GIS data to include Collector	More detailed procedures are in place; we now collect location data using Arc Collector	1.1

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 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 Management Team, 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 Management Team and Protocol Lead for next season needs
Data certification (data received from Data Management Team)	Protocol Lead
Field forms and data	Protocol Lead, GIS Specialist, and Data Management Team
Images/Photographs processing	Field Lead and Data Management Team
Images/Photographs metadata and catalog	Protocol Lead and Data Management Team
Species (IRMA NPSpecies)	Data Management Team
References (IRMA Data Store)	Data Management Team
Geospatial data organization and metadata	GIS Specialist and Protocol Lead
Archiving	Data Management Team

2. Relevant SOPs

For this SOP, please refer to the following associated SOPs (those listed as MOJN SOPs are MOJN 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 SOPs are MOJN 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 DM SOP M13 – Project Deliverables* - for creating a directory structure and organizing files, for photograph organization
- *MOJN DM SOP M17 – Naming Conventions* - for file naming conventions
- For metadata, consult:
 - MOJN DM SOP M12 - NPS Metadata Tools and Editor* - for how to create metadata and what is required
 - MOJN DM SOP M9 - Documentation Non-Spatial* - for tabular metadata
 - MOJN DM SOP M10 - Documentation Spatial* - for geospatial data metadata
 - MOJN 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 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., invasive species, infectious agents) between parks.

1. ID any collected specimens of unknown shrubs.
 - a. 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.
 - a. Spray the outside of the field vehicle, particularly areas where biological material may have accumulated (e.g., undercarriage, tires, truck bed).
 - b. Sweep out or vacuum the inside of the vehicle.

- c. 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. Clean any seeds from all gear used during the field season
 - a. Check all camping gear, equipment, and personal belongings for seeds or insects.
 - b. Brush all clothing, particularly socks and shoes, to remove plant material; be especially aware of seeds that are stuck to clothing.
 - c. Clean brush before leaving park-do not leave the brush filled with accumulated plant material.
 - d. Any items that can be rinsed (e.g., camping gear, muddy equipment, shoes) should be hosed down.
 - e. All camping gear, equipment, and personal belongings should be washed or vacuumed.

3.2. General Tasks

- 1. Complete documentation for unknown plants.
 - a. The Field Lead is responsible for ensuring complete resolution of all unknown plants.
 - b. Annotate the field forms with the correct identifications and ensure that species are entered correctly in the database.
 - c. Label and mount the appropriate specimens for the field herbarium.
 - d. Update park plant species lists, species list in the database, and submit for updates in Integrated Resource Management Applications (IRMA) NPSpecies.
- 2. 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.

4. After the Field Season

4.1. Season close out meeting

The Protocol Lead and Field Lead should 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. Look for previously used templates for this meeting. Have the meeting with seasonal employees before their positions end! Major points to discuss during the meeting include:

- 1. Have an open conversation with the crew about details of the field season including:
 - a. Did our data collection tools work as needed?
 - b. Were there any deviations from the protocol that need to be documented?
 - c. What gear needs to be fixed or replaced?
 - d. How can we improve future field seasons?
- 2. Organize and properly pack equipment into bins for storage.
 - a. Electronic equipment should have the batteries removed to prevent corrosion and leaking.

- b. Equipment should be organized by function, stored together (e.g., camping gear), and clearly labeled.
- 3. Assign someone to manage 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 DM SOP M17 - Naming Conventions*).
 - c. Place files into appropriate folders (see *MOJN DM SOP M13 – Project Deliverables*) and archive (see *MOJN DM SOP M5 - Archiving*).
 - d. Manage the hard copy forms according to the *MOJN DM SOP M5 - Archiving*.
 - e. After returning to the office, store site packet and field forms in designated location.
- f. Discuss who will manage geospatial data
 - a. Make sure all data from GPS devices or Collector has uploaded properly
- b. Determine who will manage images.
 - a. All images downloaded from cameras to appropriate project folder within “Originals” folder

4.2. Data Management

During the season close-out meeting, discuss what data management tasks need to be completed. Here are some tasks that must be done, however, talk with the Data Management Team to ensure there are no additional steps to complete:

- 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 Management Team ($\geq 95\%$ confidence), with final approval from the Program Manager.
 - d. The Data Management Team 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 DM SOP M12 - NPS Metadata Tools and Editor* and *MOJN 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 and Collector data
 - All GPS Waypoints/Tracks/Routes located in appropriate folders
 - GPS data dictionaries provided, if applicable
 - All GPS data loaded into geodatabases or kept in the cloud

- All GPS data post-processed, if applicable
- 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 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 DM SOP M11 - Image Management*)
 - b. All images processed, organized, and images located in appropriate folder structure (see *MOJN DM SOP M11 - Image Management* and *MOJN 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 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 DM SOP M12 - NPS Metadata Tools and Editor* and *MOJN 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 and 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, apart from 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 Management Team, 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 Management Team is responsible for training MOJN 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.

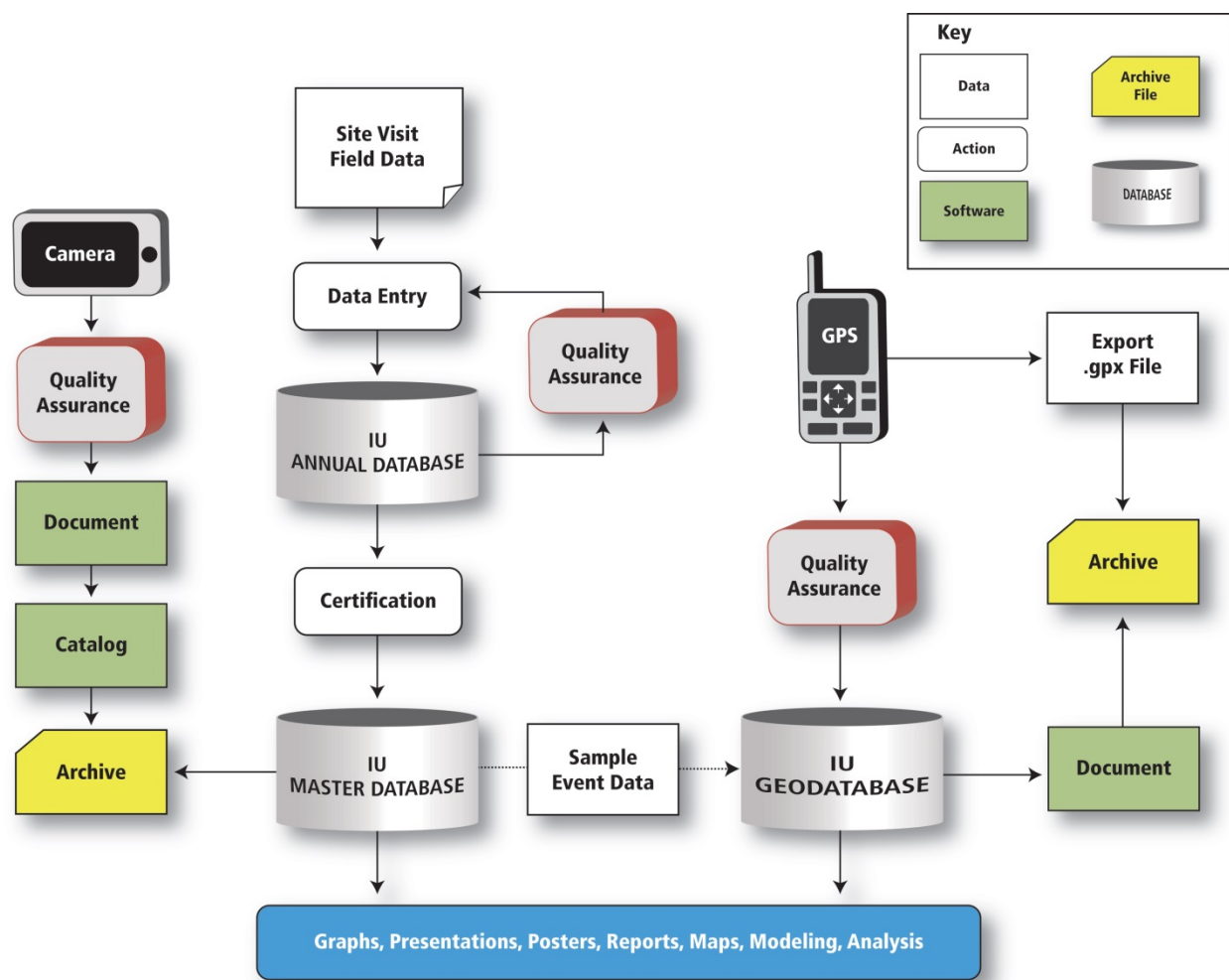


Figure 16.1. Overview of data collection, analyses, archiving, processing, and storing IU data.

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

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 Disturbance

NOTE: Soils data were collected in LAKE, MOJA, and MANZ in the years prior to 2017. After those years, many soils methods were removed from this protocol (described in now-deleted *SOP 11 – Soil Measurements*).

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 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 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 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 offices. Detailed procedures for hard copy data archiving, including roles and responsibilities, are provided in the following SOPs:

1. *MOJN DM SOP M5 – Archiving*

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 Management Team (DM), GIS Specialist (G), and Data Technician (DT) and a frequency for which this task is carried out. Other MOJN staff will assist on the various data management tasks.

3. Project Records Management

MOJN records management is legally mandated per NPS Director’s Orders #19 (NPS 2001). Records management ensures all items pertaining to the operation of MOJN 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 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 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 SharePoint site. Project deliverables may include field forms, camera images, master databases, and geospatial data. *MOJN 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 SharePoint site, and all project deliverables are verified as received (refer to *MOJN DM SOP M15 - Season Closeout*). The entire set of annual project deliverables is compiled within a single folder directory on the MOJN SharePoint site and Integrated Resource Management Applications (IRMA) Data Store for dissemination and access by the parks and archived according to *MOJN 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 Management Team 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

Revision History Log:

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

This SOP describes data management procedures for all data collected for the MOJN IU protocol. The procedures for data management given in this SOP follow guidelines and standards that are described in the MOJN 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 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 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 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 Management Team 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 Management Team.
- If the GIS Specialist is unable to meet the deadline for importing the data, the Protocol Lead and Data Management Team 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 Management Team 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 Management Team, 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 Management Team 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 session are compared to the original data source (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). 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.

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/macropLOT combination, a listing and count of transects having shrub cover observations recorded.
- d. For each year/park/macropLOT 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 macropLOT 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 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 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 Management Team 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 uses several techniques to help ensure proper version control: data archiving (refer to section 13. *Data Archiving* details), directory structure conventions (*MOJN DM SOP M13 – Project Deliverables*), backup procedures, and database versioning.

7.1. Directory Structure Conventions

MOJN has adopted directory structure conventions for I&M project folders (refer to *MOJN 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 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 DM SOP M5 - Archiving*).

8. Field Photos

Several field photos and digital images are expected from the field work associated with the IU protocol. All photos must adhere to the guidance and specifications provided in the *MOJN 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 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 DM SOP M10 - Documentation Spatial*
2. *MOJN 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 Management Team'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 Management Team and/or GIS Specialist, as appropriate. The Data Management Team 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 metadata procedures (see *MOJN DM SOP M10 - Documentation Spatial*, *MOJN DM SOP M9 - Documentation Non-Spatial*, *MOJN DM SOP M6 - Biological Data Profile*, and *MOJN 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 staff and Park Resource Managers should identify any sensitive information in the data. Refer to the sensitive records documents created for each park to determine which data are considered sensitive by the park. 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 Management Team 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 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 Management Team. 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 Management Team for posting and distribution. The organization and general standards for project deliverables are detailed in *MOJN DM SOP M13 - Project Deliverables*.

12.1. Posting and Distribution

Data and reports are posted on the MOJN 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 SharePoint Site

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

MOJN Internet Web Site

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

MOJN Intranet Web Site

This internal web site for the MOJN 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 DM SOP M5 - Archiving*
2. *MOJN 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 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 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 IU protocol, including removing the fire-fuels monitoring and adding a number of additional soil parameters.

1. Introduction

MOJN 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 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 Management Team 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 DMP* and *MOJN 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).

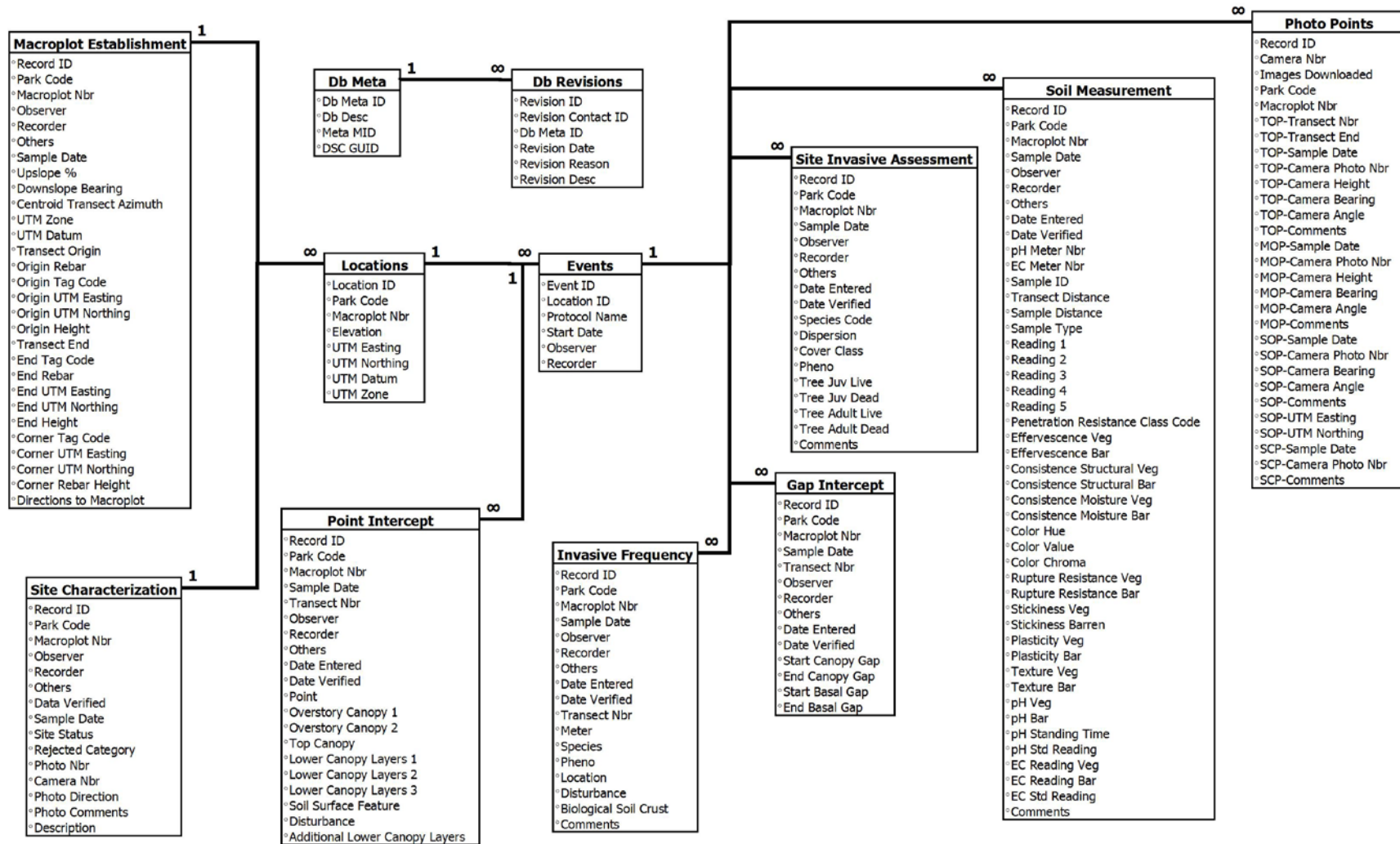


Figure 18.1. Relationships for the IU back-end database. The attribute link is depicted by the line that is drawn between the attributes between tables. The “1” and “∞”, depict a one-to-many relationship between linked tables. The “1” means that one and only one attribute record element can be used (no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

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	No	Text	3	Record class code from list provided
Resistance Class Code				
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
Rupture Resistance Bar	No	Text	10	Select value based upon determination – barren 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
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 #
1.0	6/8/20	N. Hupp	Added information about tech tools such as rmarkdown scripts and automated QC checks	These tools were created in 2020 and will be used into the future	2.0

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 potential analytical issues that may occur once monitoring data are available. 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 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))
```

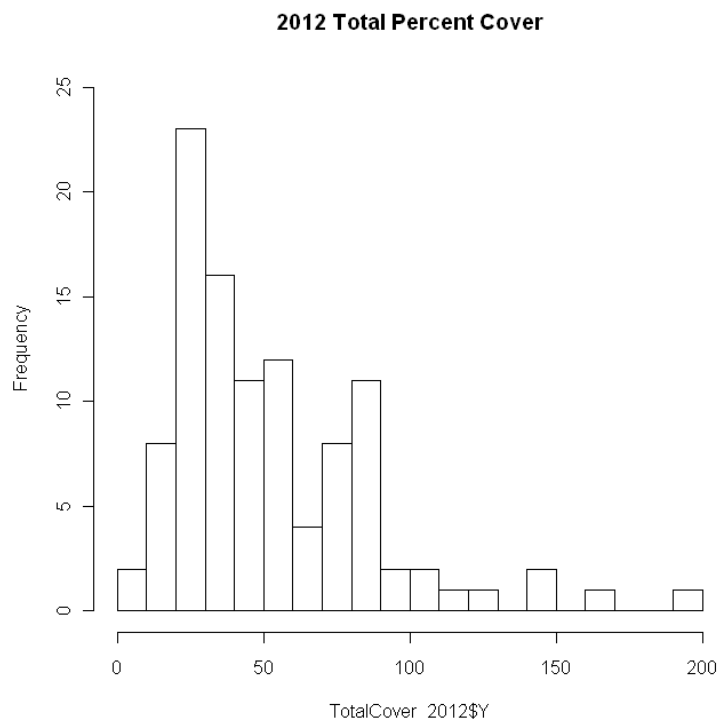


Figure 19.1. Histogram of 2012 total percent cover from simulated example data.

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 $i=1,...,m_a$; $j=1,...,m_b$; 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):

$$\hat{Var}(\bar{y}_g) = \sum_{i \in S_g} \sum_{j \in S_g} \frac{\pi_i \pi_j}{\pi_{ij}} \left(\frac{|L_g|}{|\hat{L}_g|} \right)^2 \left(\frac{y_i - \bar{y}_g}{\pi_i} \right) \left(\frac{y_j - \bar{y}_g}{\pi_j} \right) \cdot,$$

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, & Comprehensive Reports

The MOJN 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 will produce automated annual reports 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.

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 may 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 internet site by protocol and IRMA Data Store. Supporting documentation (e.g., figures and tables) will be made available for park use using the most up-to-date platform

2.2. Annual Briefs

From each annual report, MOJN may also 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 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. 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 an 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 IRMA Data Store.

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SOP 19 APPENDIX A: Simulated Pilot Data

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>.

[illegible]

19A-2

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[illegible]

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 2.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	6/19/20	N. Hupp	Removed redundant language and table stating who should be consulted at MOJN for each protocol change.	Since the ecologist and data managers work closely together, they should each be notified for any changes to SOPs	2.0

All protocols require editing as new sampling methodologies, equipment, analysis, and data management information becomes available. Make edits as soon as they are deemed necessary, or at the end of each field season. This SOP describes the revision procedure for monitoring protocols in MOJN. 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.

1. Naming Versions

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. After revising, consult the appropriate reviewers (below).

2. Revision Review

Once a document has been revised, it will need to be reviewed by MOJN staff if the revisions were minor or modifications of existing methods. In some cases, the MOJN Technical Committee, MOJN Vegetation Working Group, or designated Park representatives, and the Regional I&M Program Manager should review updates if there are substantial changes to the sampling design or methodology. After the document has been reviewed, discuss with the Protocol Lead and Data Management Team how to post the revised versions to the NPS [IRMA Data Store](#).

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U.S. Department of the Interior



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