



Wetlands Ecological Integrity Monitoring Protocol for Sierra Nevada Network

Standard Operating Procedures Version 2.1



ON THE COVER

Porcupine Flat, Yosemite National Park, California (NPS photo courtesy S. Haultain)

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NOTE: SOPs will be published separately in final version and authors will be associated with individual SOPs.

This report is available in digital format from the Sierra Nevada Network
(<http://science.nature.nps.gov/im/units/sien/>). Please cite this publication as:

Gage, E. A., J. C. B. Nesmith, L. Chow, A. Chung-MacCoubrey, D. J. Cooper, S. A. Haultain, J. G. Holmquist, J. R. Jones, S. T. McKinney, P. E. Moore, L. S. Mutch, L. A. H. Starcevich, and H. Werner. 2017. Wetlands ecological integrity monitoring protocol for Sierra Nevada Network: Standard operating procedures version 2.1. National Park Service, Sierra Nevada Network, California.

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	1/15/2014	J. Nesmith	Multiple	Revisions were required to address peer review comments and adjust to the modified sample design and methods.	2.0
2.0	Mar. 2017	J. Nesmith	Multiple	Revisions were required to address peer review comments and adjust to changes in the WEI Database	2.1

1. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
2. Notify the Network Data Manager of any changes to the Protocol Narrative or SOPs so that the new version number can be incorporated in the Metadata of the project database.
3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOPs. A list will be maintained in an appendix at the end of this document.

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SOP 1. Sample Event Preparation

Version 2.1

Jonathan C. B. Nesmith and Edward A. Gage

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	2013-12-03	J. Nesmith	Included many additional details on pre-season preparation requirements	Earlier version was incomplete	2.0
2.0	Mar. 2017	J. Nesmith	Updated field equipment list	Adjusted to reflect recommendations from field crews.	2.1

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Introduction

The Sierra Nevada Network comprises four federally managed units (Figure SOP 1.1), much of which is within designated wilderness and present significant challenges to ecological monitoring due to their size and remoteness. This SOP provides an overview of the steps that must be taken prior to field sampling to ensure efficient, high quality data collection. The emphasis in this SOP is on tasks that must be undertaken by field crews or the Project Lead for field preparation, rather than larger statistical or sampling design elements. Equipment lists and procedures for specific field sampling techniques are included in individual SOPs later in this document.

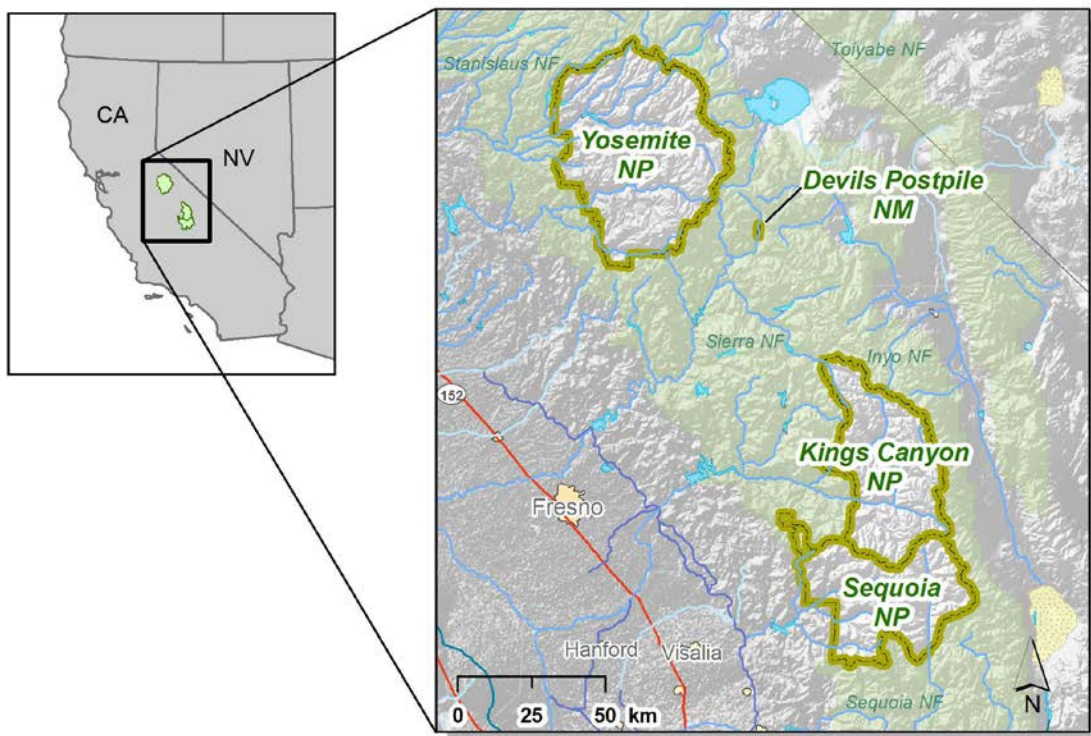


Figure SOP 1.1. The four NPS units in the Sierra Nevada Network and the surrounding region.

Annual Pre-Season Planning

Prior to the field season each year, beginning in December and January, the Project Lead should review the entire protocol, including SOPs, and should plan the field season. Annual planning includes:

- Hiring qualified field technicians
- Arranging overnight facilities and other logistical support such as food storage and access to showers
- Preparing for any required backcountry travel

- Reviewing the list of sampling locations
- Scheduling sampling
- Preparing field equipment
- Applying for research permits and submitting other required compliance documents such as MRAs

Hiring Qualified Field Technicians

Hiring of field technicians should begin in December of the preceding year. Network Project Leads should work with the Network Program Manager to advertise for field technicians through NPS and other channels. It is important to recruit from advanced undergraduate or post-baccalaureate students with training and experience in field botany from the Sierra Nevada. A minimum of three (though four is recommended) dedicated field technicians are required each season to complete sampling. Positions need to be advertised by March of each year and filled by April or at the latest May. Review of technician training including plant identification and macroinvertebrate sampling techniques is particularly important. Training is covered in SOP 21.

Field technicians must be capable of quickly learning the sampling methods. At least the crew lead must already have extensive knowledge of common wetland plants found in the Sierra Nevada and be able to quickly learn or key unknown species. A basic understanding of soils, hydrology, and entomology are also highly desirable skills. Field technicians must also have experience and be comfortable working independently outdoors all day in remote and sometimes arduous conditions. They should be comfortable with traveling in steep and rugged terrain that is often encountered enroute to sampling sites and be prepared to carry field equipment and personal gear long distances while travelling on foot. The field technicians must have a mind for safety and exercise safe actions while working in the field.

The Network wetland monitoring Project Leads should seek technicians with the following capabilities:

- College-level training in plant taxonomy or systematic botany
- Previous experience working at least seasonally under rugged field conditions and in group living situations
- Evidence of personal initiative and an independent, self-starter work ethic
- Meticulous attention to details and demonstrated interest in natural resource conservation

Additional details of required and desired qualifications are available from past job announcements and descriptions in Network personnel directories.

Arranging Overnight Facilities

Preparation for extensive backcountry travel in SIEN should be well planned and is described in a separate section at the end of this SOP. Lodging and camping sites for field crews will need to be reserved with the separate parks or other local facilities as early as possible preceding the field

season. Campsite or other overnight facilities should be optimized in terms of convenience ahead of time based on the field schedule for plot sampling. When possible, access to proper food storage facilities and showers should be arranged if the crew will be staying at the same location for a prolonged period of time.

Research Permits, Field Readiness Review, and other Compliance Requirements

It is also important to check that research permits and other necessary compliance documents are up to date. Research permits can be requested through the NPS research permit and reporting system (<https://science.nature.nps.gov/research/ac/ResearchIndex>). Requests are coordinated through the Network Program Manager.

The Pacific West Region requires the Network to conduct an annual Protocol Field Readiness Review at each park where the protocol is to be conducted. This review entails an integrated examination of field readiness by Park Management, the I&M Program Manager, and the I&M Project Lead before the park Superintendent approves monitoring in the park that season. The Protocol Field Readiness Review ensures that the following elements have been addressed by park and network staff in preparation for the project field season:

- Operations planning and field logistics
- Training requirements
- Risk management
- Awareness of and consistency with park safety protocols and emergency procedures
- Supervisory oversight
- Communications

To facilitate this review, SIEN developed a Field Readiness Review Checklist template that articulates specific actions to be completed by park and network staff prior to certification of field readiness. This form can be found in the Safety Plan for the Sierra Nevada Inventory and Monitoring Network (Chung-MacCoubrey et al. 2012). As part of the Field Readiness Review, the Project Lead will provide an overview to the designated park point-of-contact (field season objectives, sampling plan, and schedule), seek assistance as needed on logistics, and consult on any potential impediments such as trail, road, or campsite closures, or other inconveniences.

Other compliance documents that may be required include a Minimum Requirements Analysis (MRA). A Minimum Requirements Analysis is required for all administrative actions in wilderness that propose a Section 4(c) generally prohibited use, or may have an effect on Wilderness Character. Refer to the Minimum Requirement Instructions for directions and background materials to assist you in completing this analysis. Additional instructions may be found at: <http://www.wilderness.net/mrdg/>.

Review the List of Spatially-Balanced Sampling Locations

Wetland ecological integrity sampling locations have been drawn using the Generalized Random Tessellation Stratified (GRTS) spatially-balanced sampling algorithm (Stevens and Olsen 2004, Theobald et al. 2007, Kincaid 2011). In order for the spatial balance of the sample to be maintained, the suite of sites included in the sample must follow the GRTS ordered list (SOP 6). Each panel (i.e., yearly collection of sample locations to be visited) will be an ordered subset of the GRTS list, and panel membership is noted for each sample location. The most recent and up-to-date location of sampling plot locations is provided in annual reports and the WEI Database. These lists should be consulted before going in to the field in subsequent years. Once all permanent plots have been established, tables will be included in a revised version of this SOP for future reference. To view the maps and coordinates of sampling locations, stored as shapefiles, use the Network wetlands ecological integrity project GIS. The *spsurvey* package (Kincaid et al. 2011, available on-line at <https://archive.epa.gov/nheerl/arm/web/html/>) or in the R statistical software and environment (R Development Core Team, Vienna, Austria, available on-line at <http://www.R-project.org>) was used to generate GRTS sampling locations. Example R code for drawing GRTS samples is available for each park (see Appendix 3 of the protocol narrative).

Well in advance of field work, review each site within the target panel to determine *a priori* if sites need to be replaced. Criteria for dropping sites are listed in SOP 6. Use the project GIS with high resolution imagery (e.g., NAIP imagery) to evaluate wetland polygon boundaries and to identify other potential problems. Figure SOP 1.2 provides an example illustration of this procedure for SEKI. Replacement sites for any rejected sites will be drawn, in GRTS list order, from the list of oversamples provided for each park. Track the evaluation status of each site so that inclusion probabilities can be recalculated to support the use of design-based status estimators and properly weighted trend analyses (Kincaid 2011).

Prior to start-up, survey planning should include careful review of fixed sampling locations, retiring sites that can no longer be sampled and replacing as necessary. Plan visits to sampling locations by grouping visits into hitches based on geographic proximity. Hitches refer to time spent in the field collecting data at multiple sampling locations and usually include several overnights. Load waypoints for the final evaluated list of target sites within the selected panel and oversample locations into project GPS units following instructions in SOP 3.

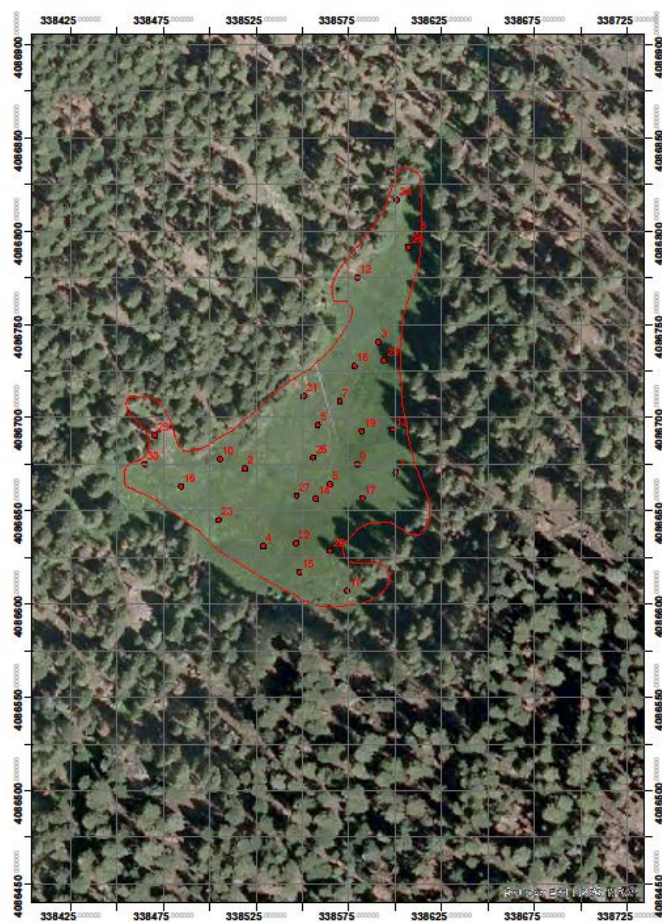


Figure SOP 1.2. Map illustrating an individual sample site from the GRTS list in SEKI. Base imagery is 2012 0.3m resolution National Agricultural Imagery Project (NAIP) aerial photography, providing a means to identify wetland boundaries and examine if sites need replacement before going into the field. The map also illustrates the 30 GRTS points that will be examined to determine the random plot location within the wetland polygon.

Scheduling and Organizing Field Work

Surveys will begin no sooner than early June in the lower elevations and proceed upward as the season progresses. Scheduling of fieldwork and planning of hitches also needs to begin as early as possible, no later than March of the sampling event year. The SIEN Project Lead has primary responsibility for ensuring that all hiring, schedules, and logistical details are addressed. Close coordination with park resource staff is absolutely essential. Prior to the field season, the entire schedule of locations that will be sampled should be organized so as to avoid unnecessary travel time.

During the start-up period (installation phase), new sample sites within one panel will be visited, following the ordered GRTS lists. Review this list carefully and prepare hitches that enable proximal sites to be visited as efficiently as possible. Spatially proximal sites are not necessarily in GRTS order. Therefore, care should be taken to ensure that the complete suite of sites within each panel can be accomplished during the season; otherwise a spatially unbalanced hole in the sample will result. If it is unclear whether the full panel can be visited, then a smaller subset of panel sites, following GRTS order, should be targeted first, thereby ensuring spatial balance. In subsequent years, field routes for hitches will be established based on past experience traversing park terrain and the particular arrangement of sample locations to minimize total travel time.

Sampling period plans must include a sufficiently flexible window of dates to accommodate unusual weather events, fire activity, snowmelt, and other complications such as trail and park road maintenance. When planning field season schedules, the Project Lead should allow a generous margin of time to accommodate unplanned travel delays and other workflow challenges such as weather or fire activity and road and trail closures. Access roads and other important location information may need to be loaded into GPS units to aid in efficient orientation to sample sites. Camping sites should be planned and reserved to avoid unnecessary and unproductive travel to and from areas to be sampled. Despite efforts to screen sampling locations during pre-season planning, expect that some sites will be dropped, particularly during the first few years of implementation. Allow time at the end of each sampling session to sample replacement points. Because of the GRTS spatially-balanced design, replacement points will not necessarily be near dropped sites; consequently it is critical to perform a thorough office evaluation *before* going into the field. SOP 6 describes procedures for replacing sites during field work.

Target sample sizes are three sites per panel per wetland type per park in SIEN, where a panel refers to a collection of plots measured in a given year for a total of 60 unique sites across the network. Pilot work conducted in each park indicates that one plot can be completed per day, although remote plots that require extensive travel should be allocated extra travel time. Expect that some sites will be dropped, and allow time at the end of each sampling session to sample their replacement sites.

Equipment Preparation

Equipment List: Each independent field team will need a full set of equipment. An inventory of existing equipment, needed repairs, and construction or purchases of additional equipment must be made well in advance of the approaching field season. The required equipment is as follows and may differ slightly between parks. Equipment required to conduct laboratory based tasks

such as processing plant vouchers and macroinvertebrate sorting and identification are listed individually by task in SOPs 16, 17, 18 & 19.

Table SOP 1.1 Field Equipment.

Handheld computer with Microsoft Access 10 and applicable plot information pre-loaded
Digital camera and storage media with sufficient memory for field tour and extra batteries
GPS receiver
Compass, with declination properly set
Knife or similar collecting tool (e.g. Leatherman)
Black indelible marking pens (e.g. Sharpie)
Random number table or electronic equivalent
Mechanical pencils with replacement lead and erasers
Data sheets, including a few Rite-in-the-Rain sheets
D-frame aquatic net with a 30.5cm diameter aperture and 178cm two-piece handle (BioQuip #7512D)
Collapsible 11.4 liter bucket with handle (e.g., Seattle Sports Pocket Bucket; REI #685002)
Dry bleach (this should be in pre-measured, labeled packages for each sample site)
Featherweight sorting forceps (e.g., Fine Science Tools #26029-10)
Small tape measure (e.g., 3' Stanley Powerlock #33-115)
Small aquarium dipnet (approx. 10x8cm) with an approximately 30cm handle and mesh size of 0.5x0.5mm
Thirty ml (1 oz.) glass jars with polypropylene lid with Teflon liner (e.g., Qorpak #2S01QEDC)
Lexan or Nalgene container (~200ml) containing supplemental alcohol
Collapsible sweep net with a 30.5cm diameter aperture and 70cm handle (BioQuip #7112CP)
Cotton balls, approximately 3cm, one ball per sample
Ethyl acetate, 99%, (e.g., BioQuip #1185A) in a 30 ml (1 oz.) glass jar with polypropylene lid with Teflon liner (e.g., Qorpak #2S01QEDC)
One or more Rubbermaid 4022 (2.7 liter; 30x20x7cm) container depending on the planned number of site visits (A container will hold six typical sweep samples)
Honey, transferred to an approximately 25ml plastic container
Tuna packed in oil, transferred to an approximately 25ml plastic container
Heavy weight, green construction paper. Two 8x16cm sheets per site
Watch with alarm
One-dram vials with polyethylene-lined caps (4.5ml; 15x45mm; e.g., BioQuip #8801P) pre-filled with non-denatured, 70% ethanol. Two vials per site, pre-sealed with electrical tape.
Quaternary ammonium compound in bottle sealed with electrical tape
One 100- meter field tape and two 30-meter field tapes (with gradations in cm)
Reinforcing bar: 30 cm (12 inch) lengths of 1.6 cm (5/8 inch) diameter (4 pieces)
Caps for the top of rebar, pre-stamped with each cardinal direction (N, S, E, W) (1 each = 4 total)
Metal washers greater than 6 cm outside diameter with opening greater than 1.6 cm diameter (4 pieces)

Table SOP 1.1 Field Equipment (continued).

Internal tooth lock washers (8 pieces)
Landscape staples or large diameter nails to temporarily fix tapes
Pin flags to temporarily mark macroplot, subplot and microplot corners (12x)
Current National wetland plant list (USFWS, NWI)
Field key to wetland types
Plant identification guide(s)
Field Indicators of Hydric Soils in the U.S. (USDA NRCS 2006)
1 m ² plot frame
Plant press with newsprint and blotters and cardboard ventilators
Non-vascular voucher envelopes with pre-printed labels
Hand lens
Groundwater level Datalogger
Appropriate cable for data download and calibration
Munsell Soil Color Chart
Work gloves
3 in. diameter bucket auger
Plastic tarp to temporarily hold excavated soils
Bailer or small pump to clear wells
Hack saw, extra hack saw blades
1.25 in. diameter schedule 40 PVC pipe, machine slotted or slotted by hand using hack saw
1.25 in. diameter PVC cap (top cap), notches cut into side to facilitate cap removal and hole predrilled to accommodate attachment of aluminum tag
Teflon coated stainless steel cable or similar non-reactive, non-stretching cable
Bolt that is ½ inch longer than the outside diameter of the well casing; wingnut to fit bolt, drill, and drill bit
Cable ties

Preparation of Navigation and Field Data Management Equipment

The sampling point locations must be uploaded to each GPS unit following procedures outlined in SOP 3. GPS preplanning also includes review of satellite availability for the duration of the scheduled sampling window, and is described in SOP 3. Some sites near cliffs can have poor satellite coverage as well and making schedule changes if an unusually poor arrangement of satellites is scheduled during the sampling window is recommended. Digital data entry tools (handheld computers and Tablet PCs) should be checked and preloaded with software and files. At least one back-up GPS unit should also be available and have all necessary files pre-loaded. Access roads and other important location information may need to be loaded into GPS units to aid in efficient navigation to sample sites. Be sure to completely charge all GPS units, data entry units, radios, and digital cameras, as well as backup batteries, prior to departure for the field. Provide back-up batteries to each field crew.

Paper data sheets should be prepared and at least 25% of the copies printed to Rite-in-the-Rain paper for each field team. Field reference maps of park sampling areas and plot locations must be prepared in advance of field work with sample points organized into hitches to guide efficient field travel. Reference maps should be printed on Rite-in-the-Rain paper. Data entry forms should be revised and printed, with extra copies available for each team. Note that paper data sheets are only provided for back-up in case of tablet PC failure.

Driving Directions

Sequoia and Kings Canyon National Parks

SEKI is made up of two large adjoining parks (Sequoia National Park and Kings Canyon National Park) that are managed as one unit. SEKI is large, rugged, and mostly roadless wilderness. Monitoring crews will need to carry previously obtained research permits with them at all times. There is not a specific road or entrance that will lead crews to all field sites. Instead, hitches will be determined prior to the sampling season and will include specific directions for driving, trail routes, and direction of cross-country travel along with associated maps. For example, some sites will be accessed from the west side of the Sierra Nevada crest, while others will be accessed from the east side. Monitoring crews may or may not drive through a park entrance for trips originating from the west side, and will not enter through a park entrance for east side trips as no roads penetrate the park from the east side. Therefore each hitch will be unique with respect to directions for accessing sites.

Yosemite National Park

Like SEKI, YOSE is large, rugged, and mostly roadless wilderness. Monitoring crews will need to carry previously obtained research permits with them at all times. There is not a specific road or entrance that will lead crews to all field sites. However, Tioga Pass Road will be a primary corridor for accessing high elevation sites in YOSE as it is the only road through the park that penetrates the high-country. Hitches will be determined prior to the sampling season and will include specific directions for driving, trail routes, and direction of cross-country travel along with associated maps.

Preparation for Backcountry Travel

The Project lead should be familiar with all rules and regulations pertaining to working and camping in the backcountry of each park. If field sampling is expected to occur in the backcountry, it is the Project lead's responsibility to make certain all crew members are aware of the rules and regulations. Check with each park to learn about their backcountry rules. Links to park website information on backcountry and wilderness regulations are listed below.

SEKI – <http://www.nps.gov/seki/planyourvisit/wilderness.htm>

YOSE – <http://www.nps.gov/yose/planyourvisit/wildregs.htm>

DEPO – <http://www.nps.gov/depo/planyourvisit/permits.htm>

Miscellaneous Preparatory Notes

Analysis and reporting of previous year's data is necessary before starting a new field effort. This is covered in SOP 28. It is particularly important that sampling frame errors, hitch information, and other accumulated experience from previous years be documented *prior* to

season close-out the previous year. A table of GRTS plot locations annotated with plot status (e.g., dropped, established and measured, etc.) will be included in each annual report. This information must be incorporated into pre-season planning in subsequent years. This is particularly true during the first few years of testing and implementation. Changes to sampling frames or other design features are complex decisions with potentially serious statistical implications. Consult with a statistician before making any changes.

Safety is critical consideration in all field work planning. Each year, the project Job Hazard Analysis will be reviewed and updated if necessary. All crew members must review and sign the Job Hazard Analysis during staff training. The WEI safety SOP (SOP 22) along with the SIEN Safety Plan (Cheng-MacCoubrey et al. 2012) should be reviewed during training, and specific park hazards, emergency contact information and procedures should be reviewed with park staff at the start of each park sampling session. A park debriefing will occur with park or network contacts at this time to review any emerging developments, such as fire hazard conditions. Park safety protocols must be reviewed and adhered to. A park-issued radio will be provided in order for backcountry emergencies to be reported via radio repeater towers. Park radios should contain relevant external frequencies (i.e. nearby NFS or BLM contacts). Radio training must include competency on scrolling/using alternate channels.

GeoPro satellite devices will be provided to crews for use in emergencies. These beacons must be pre-programmed to include non-emergency and emergency signal options. Crews must be carefully trained in the use and programming of these beacons based on information contained within individual Network Safety Plans. In the Sierra Nevada Network, a GeoPro device will be used as an additional means of communication between the field crew and the Project Lead or other SIEN staff, via texting capabilities.

Cell phones can be used but coverage is spotty at best. The team must check in with park contacts periodically during park sampling sessions to keep abreast of developing safety information, and to provide park staff with locations of operation. Provide two-way radios to each team. Make sure each team member knows where vehicle keys are to be stored during field operations, the location of the nearest pay phone and/or cellular phone coverage opportunity, and emergency contact and operation procedures for each park.

SIEN parks are large, rugged, and remote. Toilets will be unavailable during the day. Personal effects carried in daypacks should include toilet paper, hand trowel, and a Ziploc plastic bag for packing out garbage. All field crew members adopt a “leave no trace” ethic during park visits.

After the field season, be sure to clean and organize all non-electronic equipment and store in well labeled plastic bins in Network headquarters. Some of this equipment will be used by other Network monitoring projects; so a well-organized and well-stored collection of equipment is essential. Remove batteries from GPS units, cameras, and data entry tools requiring long-term winter storage. Handheld computers need to remain charged to prevent loss of software programs; so these are typically stored according to guidance from the Network Data Manager. All equipment should be checked in with the Network staff person responsible for equipment inventories.

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SOP 2. Compass Use

Version 1.0

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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP presents procedures for compass use during plot lay out as well as for route finding and navigation. It also includes instructions for setting the declination of a compass at the start of the field season. A compass allows users to determine direction, take bearings, plot travel routes, and sight landmarks for navigation; although GPS units replace many of these functions, a compass is required for plot layout and provides a critical backup in the event of GPS failure. These instructions are for the Silva Ranger or similar model compass equipped with a sighting mirror and declination adjustment screw.

Setting Declination

A compass does not point to true north, rather the compass needle aligns itself to the Earth's magnetic field (i.e., magnetic or compass north). Magnetic declination, also called magnetic variation, is the angle between magnetic north and true north (Figure SOP 2.1). Declination varies over time and with location and by convention is considered positive east of true north and negative when west. For example, one's location could be represented as a Westerly declination of 15 degrees, or as a declination value of -15 degrees. As an example, the declination for Yosemite in May of 2009 was approximately 13 deg 50 min E, moving 6 min to the west per year (NOAA). Declination must be accounted for to achieve accurate readings using a magnetic compass. You will need to set the declination on your compass specifically for each network park and the current year. Do not use the declination indicated on a topographic map; this will not be accurate for the current year. The Silva Ranger compass is equipped with a small set screw on the compass dial which allows the user to set the declination, using the screwdriver tool attached to the compass lanyard.

Steps

- Obtain current declination value from NOAA website (<http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp>)
- Insert the attached metal screwdriver into the small brass screw on the front or the back of the compass dial (Figure SOP 2.2) and adjust until the north arrow points to the appropriate degrees. To do this most accurately, check that the south tail points to the correct degrees on the clinometer part of the compass.

Simultaneously sighting and reading the needle can be challenging and requires practice. Lensatic compasses use a lens and rear sight, while with a mirror compass, the reflected view of the compass dial is used to align the needle and dial.

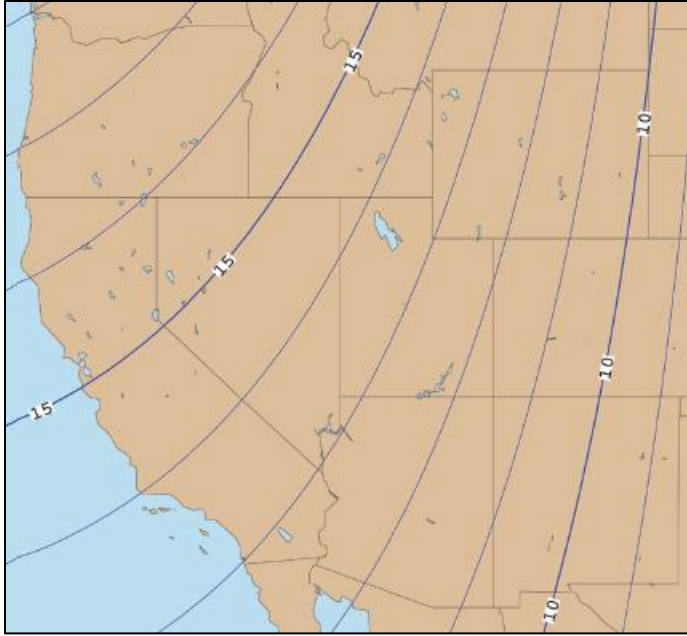


Figure SOP 2.1. Contours of declination (degrees) of the earth's magnetic field in 2004 (source: NOAA NGDC). Current declination can be obtained from <http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp>

Reading Azimuths and Determining Bearing for Navigation

- In land navigation, an azimuth is defined as a horizontal angle measured [clockwise](#) from a north base line.
- To measure azimuth, point the compass body toward the feature or direction of interest.
- Keep compass level, and away from metal.
- Holding the compass at eye level, adjust the mirrored lid so that the face of the compass is visible in the reflection.
- Use the sighting notch to position the compass.
- Turn the dial until the magnetic needle is within the arrow on the dial, aligning other lines and center points to increase accuracy (Figure SOP2.2).
- Read the degrees. It is important to practice proper positioning and alignment of the compass for accurate azimuth measurements.

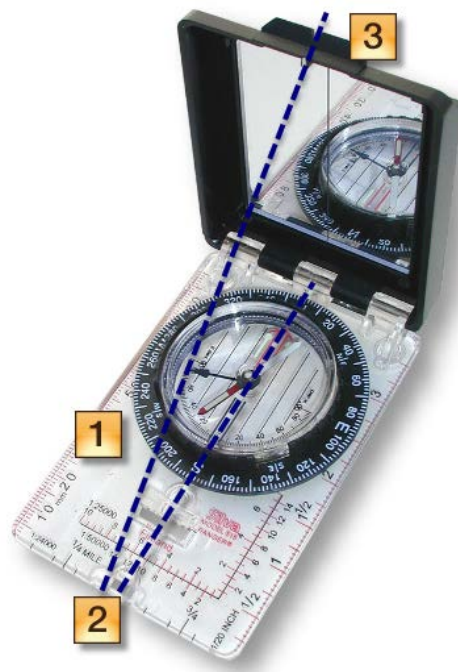


Figure SOP 2.2. Setting compass declination. For many compasses (Silva Ranger pictured), declination is set using a small screw located on the compass dial (1). Sighting is accomplished pointing the compass towards the target direction, lining up the centerline (2–3) and rotating the dial until red portion of the compass needle (pointing towards magnetic north) is fully contained in the red arrow on the compass dial.

Taking a Bearing from a Map

- Lay the map down on a flat stable surface using the compass to orient the map N–S.
- Place the compass on the map with the edge of the compass along the desired line of travel between your present location and the target location. This can be visualized or penciled in. Rotate the compass dial until N on the dial points North on the map. Check that the compass housing red/black north/south lines are parallel with the maps meridians.
- With the compass in hand, turn until the red end of the compass needle is centered on the arrow on the dial - the front of the compass is now pointing towards your destination. Your bearing can be read directly from the compass.

SOP 3. GPS Use: Navigation, Data Collection, and Downloading

Version 1.0

Les Chow

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP explains the methods for using a GPS receiver to navigate to SIEN Wetland Ecological Integrity Monitoring plots and determine geographic coordinates at permanent plots. It provides standards and guidelines for maximizing the accuracy of location coordinates calculated by a GPS receiver.

General Practices for GPS Data Collection

Regardless of GPS receiver brand or model, certain data collection standards must be met. The most critical standard is that all WEI GPS data is collected in the Universal Transverse Mercator (UTM) coordinate system, Zone 11 North, North American Datum of 1983 (NAD83). Ensure that the GPS is set to UTM, Zone 11 North and NAD83 by checking the GPS settings prior to use.

The remaining quality control measures described below can be employed by the user and should be followed whenever possible to ensure that the most accurate data are produced. These are general guidelines applicable to most GPS receivers. As technology improves and the available features and accuracy of GPS receivers increase, the GPS brand and model we use are likely to change. To accommodate these changes, the User's Guide for GPS used by this protocol should be readily available to the field crews. This User's Guide should be consulted for specific instructions on implementing the recommended quality control measures.

Satellite Availability and Satellite Geometry (PDOP)

A minimum of four satellites are required to obtain an accurate coordinate location. Acquiring at least four satellites will also enable you to calculate a reasonably accurate 3D position (elevation). The combination of earth's rotation and orbiting satellites means the availability and relative position of satellites within view is constantly changing. Satellites evenly distributed across the sky will yield a more accurate reading than satellites that are clustered. GPS users can increase mapping accuracy by using planning charts and targeting their data collection for the times of day when satellite availability and geometry are optimal. Because such timing does not always work in the field, however, PDOP (Positional Dilution of Precision) is an option on some GPS receivers. PDOP can be adjusted to allow the inclusion of points with different levels of accuracy, but it should be set to no higher than 8 (PDOP of 6 is preferred). The user should not increase the allowable PDOP value to higher than 8 unless collecting a position overrides accuracy concerns.

Maximize the Length of Time a GPS Data File is Open

Once a GPS has determined which satellites are available it continuously recalculates its position, averaging repeated readings from multiple satellites to improve the accuracy of the estimated position. Positional accuracy will be better the longer a file is open and the more GPS positions are collected and averaged. Trimble® recommends a minimum of 60 positions for each point or feature to attain a high degree of accuracy.

Multipath Error or Signal Interference

Multipath error can occur when the receiver does not have a direct line-of sight to a satellite and reflected signals from surrounding rocks or trees produce erroneous results or a GPS location with low accuracy. Although mostly beyond a user's control, some adjustments can be made to minimize multipath error. These include positioning the GPS with an unobstructed view of the

sky and using an external antenna. Signal strength and accuracy can most easily be improved by simply orienting the built-in antenna in a vertical position above the ground; the higher the better. Because the wetland plots sampled by the WEI protocol are typically in open areas, tree cover is generally not expected to interfere with the incoming satellite signals. However, users should note the location of nearby rocks and trees and be alert to potential inconsistencies in GPS location estimates.

Signal to Noise Ratio (SNR)

This is out of a user's control, although Trimble© units allow a minimum ratio value to be set in the configuration such that positions with SNR below that value are not logged. A value of 4 is recommended for SNR values in Trimble© units.

Recording GPS Coordinates

GPS field coordinates (coordinates shown on a GPS receiver while a GPS is receiving satellite signals), and datum should be recorded either on the handheld computer or hardcopy datasheets. In the event a GPS file is lost or corrupted, the coordinates recorded in the field from the GPS unit display window will become the best measure of location. Be aware that these coordinates cannot be differentially corrected and are in the coordinate system and datum that were chosen for the unit's display.

Training

It is the responsibility of the Project Lead to ensure that GPS training is conducted prior to the start of field data collection.

Data Collection

During reconnaissance and the establishment of permanent monitoring plots, the field crew obtains a GPS reading of plot center. To obtain the most accurate location possible, coordinates are collected using the guidelines recommended above in conjunction with specific instructions for the available GPS receiver. These data are later downloaded to the project computer, differentially corrected if the GPS receiver provides this capability, and entered into the database.

Strategy for Locating Plot Center

Target coordinates with associated plot ID numbers will be loaded onto each GPS receiver and handheld computer prior to the start of the field season.

1. Examine a hardcopy map marked with the plot location and determine your route.
2. Turn on the GPS receiver when leaving camp or the trail to verify your location and the target location. Mark a navigation point.
3. Navigate to the vicinity of the target point or plot center using a map and compass.
4. Use the GPS to confirm your location. Established plots may have rebar, flagging, and/or tagged trees as additional clues.
5. If you are establishing a new plot, turn on the GPS as you near the plot. Continue to move toward plot center, getting as close as you can.

6. When within a few meters of plot center you will find that the UTM coordinates displayed by the GPS unit change continuously preventing you from getting an exact location. This is probably due to multi-path error or interference with the incoming satellite signal. To resolve the problem, assign plot center to the location where you first record the designated plot location (i.e., the GPS indicates you are 0 m from plot center). Begin averaging points. This will give you more accurate UTM coordinates for your location and you can determine whether you need to move closer to plot center.
7. Open a GPS job and/or file to record your current location as outlined in Data Collection: Logging a point. Using the data dictionary prompt you will name each location “PlotCtr” and give it a number (1,2...) to identify each subsequent attempt to locate plot center. The highest number recorded will later be interpreted as plot center.
8. If the current UTM coordinates are within 10 meters of target UTM coordinates you may consider this “plot center.”
9. Record this file # on the data sheet.
10. Record coordinates from the GPS display screen as “field UTM coordinates” on the data sheet.
11. If you are greater than 10 meters off, you may calculate the distance and direction to plot center, move to this location, and log another point [return to step (8)].

Navigation

Waypoints are a quick navigational tool because there is no need to open a job file. They are also less accurate, because they are not averaged over time, nor differentially corrected. Waypoints can aid in navigation by allowing you to record where your camp site or vehicle is located, or where you leave the trail. This can be helpful for return trips and for writing directions on the data sheet. However, the GPS should not be exclusively relied upon for navigation. It gives straight line azimuth and distance to targets but may not indicate the safest navigation route. At times the GPS receiver may not function due to location (for example, in a canyon), low satellite coverage, low power, or forgotten batteries. Always carry and use a map, and compass (and altimeter if available), with GPS as an adjunct.

Downloading and Processing GPS Files

Refer to owner’s manuals for appropriate GPS for downloading GPS files.

Processing differentially correctable GPS rover files requires a computer, a data transfer cable, GPS software, and internet access. GPS receivers typically come with manufacturer-specific software and data transfer cables. Each software package operates differently, but the basic process is the same.

It is extremely important that whenever field crews return from the field, GPS files are transferred from GPS receivers to computers or network folders that are routinely backed-up. Files should be transferred to an appropriately-named folder (such as “Raw” or “Backup”). Communicate with the Data Manager and Project Lead to determine how these files should be stored, differentially corrected, and entered into the database.

SOP 4. Electronic Data Entry

Version 1.0

Elizabeth Edson, Les Chow, Jonathan Nesmith

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	7/20/2016	J. Nesmith	Field form screen captures have been updated and paper datasheets have been included to accurately reflect most current structure of the WEI database and data collection procedures.	Modifications to the database and associated forms meant the old screen captures were out of date.	2.0
2.0	1/3/2017	A. Eddy	Update screen captures and descriptions to accurately reflect the most current structure of the WEI database and data entry procedures.	Previous screen captures were out of date due to recent database debugging.	2.1

Figures

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Introduction

This SOP describes the general steps for entering data in electronic forms stored on the handheld computer. Detailed, step by step instructions can be found in the handheld computer user guide. Project staff will be trained to operate and use a handheld computer prior to commencing fieldwork. Training is intended to familiarize crew members with handheld computer operation, electronic forms, and the layout of paper forms. It also provides an opportunity to answer questions that may arise before the start of fieldwork. Project staff should read the handheld computer documentation and practice entering data into the device prior to commencing fieldwork.

This SOP also describes steps for transcribing data from paper field forms into the working copy of the WEI database. Although most WEI data are intended to be entered in the field into electronic forms on a handheld computer, paper forms are used in instances where drawings or lengthy text narratives are required, or when electronic forms do not accurately capture all necessary information. Descriptions of all electronic field forms are provided below. Back up paper datasheets used by this protocol are included at the end of this SOP (SOP 4 Appendix A).

Equipment

- 1 handheld computer (Trimble Yuma 2) with electronic data entry forms and applicable plot information pre-loaded
- Spare batteries
- Pencil
- Permanent marker
- Clipboard
- Paper copies of datasheets for use as backups in case of hardware failure

Data Entry

The SIEN Wetland monitoring protocol uses the Yuma 2 by Trimble for field data entry (Figure SOP4.1). The basic process for accessing the electronic forms and entering or editing data is described below.

Basic Yuma navigation:

Turn on Yuma using green power button (Figure SOP 4.1).



Figure SOP4.1: Front of Yuma, showing the power button

To log in, use the stylus attached to the back of the Yuma to tap the Trimble. The stylus is used in a similar way as a left mouse button on a desktop. You can click and double click by tapping and double tapping the stylus. Tap and hold the stylus to perform the equivalent of a right click: a circle will appear around the tip, and the right click menu will appear when you release the stylus from the screen. You can also navigate around the Yuma by using directional keys just as you would on a keyboard. The OK button acts as an enter button.

Yuma is similar to a standard Windows desktop, with a few differences. A QWERTY keypad is hidden at the upper left corner of the screen. The keypad can be toggled on and off using the Fn and F1 keys on the right side of the unit. This can also be accessed by gently tapping the edge of the screen twice until it appears. Alternatively, when using a database form, you can tap on the field where you wish to enter text and the keypad will appear.

The Yuma comes with a built in camera which can be activated by clicking on the desktop shortcut, or by going to the windows button on the task bar, and selecting Camera. Any pictures taken will be stored in WEI-01/ My Pictures folder.

The Yuma has 2 batteries which enable low batteries to be hot swapped, i.e. change one battery and then the other without loss of power to the device. This helps to prevent loss of data as the Yuma does not need to be turned off to change the batteries. Please refer to the Yuma manual for the correct procedure to change the batteries. Each battery has its own push-button activated status check that shows via four LEDs how much charge is left. This can be found on the sides of the batteries on the back of the Yuma (red circles in Figure SOP4.2). Alternatively tap the battery icon on the bottom right hand side of the screen to bring up detailed battery information.

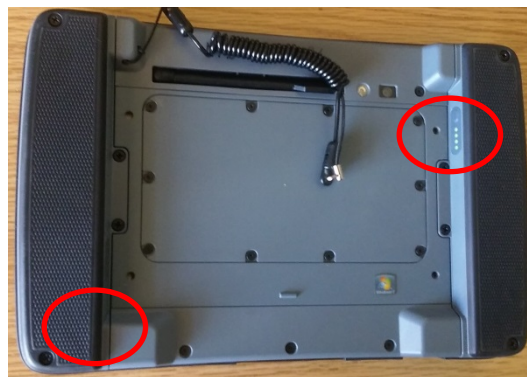


Figure SOP4.2: Back of Yuma showing batter status button

Opening the SIEN wetland database

The wetland database is split into a front end and back end, both of which are on the Yuma. The front-end provides the user interface, with forms for entering data, queries for facilitating QA/QC, and tools for exporting data. The back-end of the database holds the core data tables and data, and should not need to be opened by the field crew.

The front end icon sits on the Yuma desktop and can be launched by either double tapping with the stylus, or highlighting then pressing OK. This will launch the database and bring up the main menu form (Figure SOP4.3).

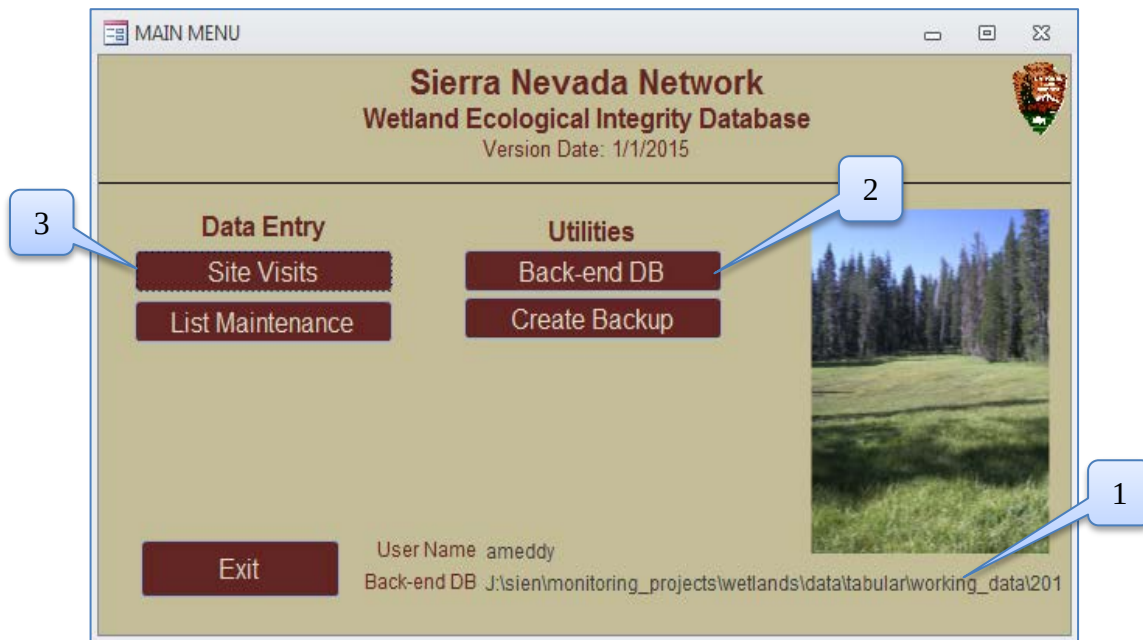


Figure SOP4.3: Database main menu form

Database connections

Check the current backend file connection (Figure SOP4.3, number 1). The file path should be something like:

C:\Users\WEI-01\Desktop\SIENWetlandProjectFolder\Database\SIEN_WEI_BE_CURRENT.mdb.

The database will only prompt you to connect a back end if there has been a break in file path connection. For instance, this can happen when a new front end has been copied onto the Yuma, existing front or back end moved, or if file names have been changed. If the database has a valid connection it will not prompt to reconnect. However you can manually check and connect a back end at any time by clicking on the **Back-end DB** button on the Main Menu tab (Figure SOP4.3, number 2), to bring up a window that allows you to browse to the back end file that you want. Highlight the file and click **Open** to connect the back end. It takes several seconds to connect to the back end. A popup will appear to let you know this has happened successfully. Click **OK**.

Adding a new installation

The **New Installation** form should be populated after any new site is established. Click the **Site Visits** button on the main menu (Figure SOP4.3, number 3) to open the **Site Visit Summary** form (Figure SOP4.4). Click the **New Installation** button at the upper right of the form. This will open a blank **Wetland** form intended for new installations.

Double-click an underlined field to open the corresponding form

New Installation **Re-Visit**

Park	Wetland	Site Name	Site Current Wetland Type	Year	Visit Date	Purpose Code	
DEPO	<u>DEPO-100</u>	<u>DEPO index 1</u>	Wet Meadow	2015	<u>8/5/2015</u>	VegResample	Delete
DEPO	<u>DEPO-100</u>	<u>DEPO index 1</u>	Wet Meadow	2016	<u>8/22/2016</u>	VegResample	Delete
DEPO	<u>DEPO-100</u>	<u>DEPO index 1</u>	Wet Meadow	2014	<u>8/29/2014</u>	VegResample	Delete
SEKI	<u>UNEQUAL-01</u>	<u>SEKI extent-008</u>	Wet Meadow	2015	<u>7/13/2015</u>	VegResample	Delete
SEKI	<u>UNEQUAL-01</u>	<u>SEKI extent-008</u>	Wet Meadow	2014	<u>8/30/2014</u>	Install	Delete
SEKI	<u>UNEQUAL-01</u>	<u>SEKI extent-008</u>	Wet Meadow	2016	<u>9/5/2016</u>	VegResample	Delete

Figure SOP4.4: Site Visit Summary form, showing the New Installation button

Select the appropriate Wetland name from the dropdown menu to automatically populate the details (Figure SOP4.5). Note that none of the information on this form is entered in the field and is provided as “read only” as reference for the field crew for the selected wetland.

For New Installation Only: Select Wetland Name UNEQUAL-50

Wetland Name UNEQUAL-50 Meadow Name Lower Conness Creek

Wetland GRTS Order 141 Meadow Complex Type Meadow

Unit Code YOSE Polygon ID 524

Panel OverSamp Meadow Area (sm) 18044.075593

mdcaty Meadow Meadow Perimeter (m) 670.017200385

Weight 74.133333 Meadow UTM East 292865.326083058

Watershed ID Meadow UTM North 4206768.17425229

Meadow Mapping Notes Sparse. Good view in Google Earth and Esri basemap.

Record Site GRTS Point Wetland **Enter Site Data**

Figure SOP4.5: New installation (WETLAND) entry form, showing dropdown menu.

Click the **Record Site GRTS Point Wetland** button to enter information about each site within the wetland (Figure SOP4.6). The form is automatically populated with the Wetland name. Enter the data and click **Close** to save the record and return to the **Wetland** form.

SITE WETLAND TYPES

Wetland Name

Field Wetland Type

Wetland Notes

Close

Point	Wet Meadow	Fen	Upland	Other	Total %	Site GRTS Point Notes
1					0	
2					0	
3					0	
4					0	
5					0	
6					0	
7					0	
8					0	
9					0	
10					0	
11					0	
12					0	
13					0	

Figure SOP4.6: Site Wetland Type form.

Adding site visit data

After you have filled out the **Site Wetland Types** form, you can enter site visit data related to the new installation. Click the **Enter Site Data** button on the **Wetland** form (Figure SOP4.5). The form is automatically populated with the Wetland name and Panel Type. Select the GRTS number for the selected plot location. This will autofill any details about the GRTS point, including the site name. You can then enter well details for that plot (Figure SOP 4.7).

Figure SOP4.7: Site form.

Click the **Site Visit** button to open a blank site visit form (Figure SOP4.8). The form requires you to fill in the information at the top first (Figure SOP4.8, number 1), as this creates the necessary databases joins that allow the data to be stored correctly. Select the **Site Name** from the drop down menu before choosing a date, protocol version, currently wetland type, etc.

If you miss a required field or forget one, an error popup will appear directing you to the field that needs to be filled in before you can progress through the form. Drop down menus are indicated with a small triangle on the right hand side of a field. These contain a pick list of valid values for that field. You should make your choice from one of these and avoid typing data in yourself. Fields without pick lists, such as the Site Visit Notes field, are text boxes for free form text. Taping on a text field with the stylus will bring up a little keyboard icon. Tap again to bring up the full QWERTY keypad, where you can use the stylus to type. Press enter on the keypad to enter text.

Categories down the left hand side of the **Site Visit** form are buttons (Figure SOP4.8, number 2) which open up their associated sub-form when clicked. The default is the seedling tallies sub-form. Each sub-form is displayed in SOP4 Appendix B. Follow the SIEN wetland monitoring protocol for the correct procedure and order for data collection (WEI Narrative Figure 11), and data entry in to the sub-forms. The **Site** button will take you back to the **Site** form, retaining the wetland name from the **Site Visit** form. Close all forms and return to the main menu using the x in the upper right corner (Figure SOP 4.8, red circle).

The screenshot shows the 'SITE VISIT' form. At the top, there are fields for Site Name, Date, Purpose, Contact, and Role. Below these are Site Visit and Notes fields. On the left, a list of sub-forms is visible, including Terres Sampling, Aquatic Sampling, Ant Sampling, Assessment Area, Buffer Info, Hydrogeomorphic, Special Status, Photos, Macro/Micro, Seedling Tallies, Ground Cover, Plant Collections, Water Depths, and Data Logger. The main area of the form contains a table for 'Height Classes (cm)' with columns for Tree, Common Name, Height Class, Tally, and Notes. The table has rows for height classes: < 10, 11 - 25, 26 - 50, 51 - 75, 76 - 100, and 101 - 137.

Figure SOP4.8: Site Visit form showing top information and list of associated sub-forms.

Editing data in an existing record

You can return to a particular site visit at a later date, either to edit existing data or finish entering data. This is an extremely useful feature but does require that care be taken to not accidentally create duplicate records, or erroneously overwrite data.

From the main menu, click on the **Site Visits** button (Figure SOP4.3, number 3) to launch the Site Visit Summary form (Figure SOP4.6). This form shows all the records for site visits, ordered by site name.

Exiting the database and backing up

It is extremely important to make a backup copy of the database onto the Yuma after every session of data entry, or day of data entry in the field, to help prevent against accidental data loss. The database has been designed that it will prompt you for a backup on exit when you click on the **Exit** button from the main menu, so you should always close the database using this button. You can always make a backup of the database at any time from **Create Backup** button on the main menu as well.

Backups should be stored in a folder called backup within the SEIN Wetland Project Folder on the Yuma desktop (Figure SOP4.9). Storing them all in this folder makes it easy to search for a particular backup or copy to an external drive.

It is also important to put a copy of the backup database on an external memory device daily to make sure that a backup is stored in two places.

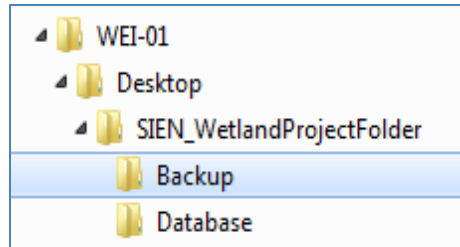


Figure SOP 4.9: Folder structure in the Yuma, showing backup folder location.

Making a backup:

1. Once all the data have been added or updated and you want to leave the database, close all forms except the Main menu, and click on **Exit** button.
2. You should get a popup asking if you want to make a backup copy of the data. Make sure you click **Yes**.
3. The windows explorer window should default to the last place a backup was made. Browse to the backup folder in the SIEN Wetland project folder, if this is not the location seen.
4. A default filename has been chosen, which includes the date of backup. Leave this as is and click **Save**.
5. A message will appear saying the backup was successful. Click **OK**.
6. The database will close.

In the Office

1. Data entry and import should occur as soon as possible after data collection, so that field crews can catch errors or problems as close to the time of data collection as possible.
2. The working database application front end can be found in the project workspace. This front-end copy may be considered “disposable” because it does not contain any data, but rather acts as an interface with data residing in the back-end working database. The Data Manager can provide assistance on copying and using the front-end database.
3. Data entry and import forms have built-in quality assurance components, such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged only to use the pre-built forms as a way of ensuring the maximum level of quality assurance.
4. As data are being imported, the person importing the data should visually review each data file being imported to make sure that the data is logical and falls within quality constraints. This should be done for each record prior to importing the next data file.
5. At regular intervals and at the end of the field season, the Field Crew Leader should inspect the data that have been entered to check for completeness and perhaps catch avoidable errors.

The first action to be taken is to make sure the data entry workspace is set up properly either on a networked drive or the user’s computer if networked server connections are too slow for efficient

data entry. If you are unclear about where this should be or how to do this, contact the Data Manager.

- Store the back-end database file in the database folder in the project workspace. The back-end file has “_be_” as part of its name.
- The crew’s copy of the front-end database may also be stored in the same folder.
- If it doesn’t already exist, also create a folder in the same network folder named “backups” or “backup_copies” for storing daily backups of the back-end database file.

SOP 4 Appendix A. Paper Datasheets

SIEN Wetland Monitoring Protocol Version 2.0

[illegible]

Stage 3 GRTS Point Sampling: Sequentially visit each sample point on the 3 rd stage GRTS list and record the relative percent of each cover type in circular 100m ² assessment area centered on the point						
Point	Wet Meadow	Fen	Marsh	Open Water	Upland	Notes
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Figure SOP 4.A1. Stage 3 GRTS Point Sampling Form

Wetland ID:	Date:
Observers:	

Instructions: After establishing the 10mx10m grid of 100 points, record one pin hit cover class for each point, using the following cover classes and abbreviations:
live Vegétation, Rock (>6.4 cm), Gravel (2 mm – 6.4 cm), Bare ground, Standing water, bare Peat, Litter, standing Dead, or Wood (>1 cm)

Groundcover Grid Sampling							
Point	Cover	Point	Cover	Point	Cover	Point	Cover
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	

Well Installation and Soil Information			
Well ID		Organic Horizon Depth	
Installation date		Peat Humification Rat.	
Plot Type		Gleyed	
UTM E		Mottled	
UTM N		Organic Horizon	
GPS Error		Sulfuric Odor	
Casing length (cm)		Other	
Stick-up height (cm)		Notes:	
Top of well to WT (dm)			
Time of Well Measurement			
Witness Feature	1	2	
Distance (m)			
Azimuth (°)			
Photo #			
Photo #'s: 0-50cm			
51-100 cm			
100-150 cm			
150-200 cm			

Logger ID	
Log start time (24 hour format)	
Download unit ID	
Well visit ID	
Download date	
Logger data file name	
Cable length	
Notes:	

Peat Depths (cm)					
Point					
Depth					

Soil Profile Sketch	
Depth (cm)	
0-20	
20-40	
40-60	
60-80	
80-100	
100-120	
120-140	
140-160	
160-180	
180-200	

Figure SOP 4.A2. Plot Location, Soil Data, Ground Cover, Data logger, and Well Installation Data Form.

SIEN Wetland Monitoring Protocol Version 2.0

Wetland ID:	Visit ID:	Date:
Observers:		

Special Status Plants				
Species	Area (m ²)	# of patches	UTMs of largest patch	Notes/Type

Buffer information		
Distance (0-25, 25-50, 50-100m)	Δ Elevation(m)	
NE quadrant		
SE quadrant		
NW quadrant		
SW quadrant		
Notes:		

Plot Photos		
Code	Photo #	Description/Notes
Sign		
C		
0		
45		
90		
135		
180		
225		
270		
315		
MN		
ME		
MS		
MW		
P-LM		
LM-P		

Hydrogeomorphic type percentages			
Riparian low-gradient		Perennial depressional	
Riparian mid-gradient		Seasonal depressional	
Riparian high-gradient		Lacustrine fringe	
Slope discharge		Dry	
Slope peatland		Subsurface low-gradient	
Mound peatland		Subsurface mid-grad.	
Basin peatland		Subsurface high-grad.	
Notes:			

Structural patch categories (presence/absence)	
Hummocks/strings	
Pools/flarks/water tracks	
Floating mats	
Cobbles/boulders	
Unvegetated flats	
Animal mounds/burrows	
Standing snags	
Notes:	

Stressors (presence/absence)	
Point source discharge	
Non-point source discharge	
Ditches/diversions on site	
Upstream ditches/diversions	
Historic livestock grazing	
Current packstock grazing	
Groundwater extraction	
Fill placed in wetland	
Grading/compaction	
Heavy metal impaired	
Head cut/erosion	
Trash or refuse	
Mowing	
Excessive herbivory	
Social trails	
Developed trails	
Roads (gravel/dirt)	
Roads (paved)	
Tree cutting/sapling removal	
Evidence of fire	
Evidence of flood	
Check dams/riprap	
Notes:	

Land use information	
Natural	
Dispersed recreation	
Developed recreation	
Developed	
Notes:	

Figure SOP4.A3. Assessment Area and Plot Photo Sampling Form.

Wetland ID:	Visit ID:	Date:
Observers:		

Instructions: Record % cover as an integer for all vascular plant species (including trees), bryophytes, and ground cover categories within each of the 4 microplots. Tally any mature trees (>1.37 m) by species within the macroplot. Record cover classes for all vascular plant species and groundcover types encountered. Bryophyte species are recorded as present or absent in the macroplot. Collect a voucher for all species encountered and record voucher ID code. Complete a tally of saplings by height class in the subplot.

Cover Classes: record as the class average (in parentheses)

<1 (5), 1-5 (3), 6-25(15.5), 26-50(38), 51-75(63), 76-95(85.5), 95-100(98)

[illegible][illegible]

Sapling Tally (subplot)	Height Class (cm)					
Tree Species	<10	11-25	26-50	51-75	76-100	101-136

SIEN Wetlands Ecological Integrity Protocol
SOP 4. Electronic Data Entry

Macroinvertebrate Sampling

Wetland ID:	Date:
Observers:	

Terrestrial Macroinvertebrate Sampling (Sweep net)			
Sample ID		Shading by trees	
Start time		Dominant veg	
Soil moisture (dry, moist, saturated, inundated)		Nearest tall veg	
Wind speed (approx. mph)		Canopy height (cm)	Complexity Hits
Sky condition		N	N
Lost		S	S
Notes		E	E
		W	W

Aquatic Macroinvertebrate Sampling (D net)		Dominant veg.	
		Nearest tall veg.	
Sample ID		Canopy height (cm)	Water depth (cm)
Start time		1	1
Photo #		2	2
Entry point UTM E		3	3
Entry point UTM N		4	4
Sampling direction		Water flow	
Lost:			
Notes:			
Location notes:			

Terrestrial Invertebrate Sampling (Baiting)		
Sample ID:	Start time:	
Bait	Honey	Tuna
Vial ID		
Sample location		
Number inverts. observed		
Lost		
Notes:		

Figure SOP4.A5. Macroinvertebrate Data Collection Form

Well Data Logger Field Form

Date: _____ Personnel: _____

Time (24-hour time): _____ Pacific Standard Time*

Wetland Name: _____

Well ID: _____

Read Well depth from Top of Casing (TOC) before removing datalogger if possible:

Depth TOC: _____ Units: Meters Feet

Total Well Depth: _____ Units: Meters Feet

Stickup: _____ Units: Meters Feet

What data logger is being used?

Logger Brand: Solinst Hobo Other: _____

Logger Number: _____

Logger Serial Number: _____

Did you download the datalogger? Yes No

Battery Level: _____

Logger Date: _____ Logger Time: _____

Actual Time: _____

Log End Time (24-hour time): _____ Pacific Standard Time*

Did you (re)start the datalogger? Yes No

Did you reset the logger time to actual time (Pacific Standard Time)?

Yes No

Log Start Time (24-hour time): _____ Pacific Standard Time*

Logging Interval: 15 minutes

* Pacific Standard Time is one hour earlier than Pacific Daylight Time.

Figure SOP4.A6. Well Data Logger Download Field Form.

Flora of Sequoia and Kings Canyon National Parks
SIEN Wetland Ecological Integrity Monitoring

ERICACEAE dwarf billberry
Vaccinium cespitosum Michx.
 Synonyms (1993 Jepson):
 Large depressional system with lacustrine fringes apparently in process of transitioning to meadow. Dominated by Calamagrostis muiriana, Stipa kingii, and Gentiana newberryi, with wettest portions of system as Carex utriculata monocultures.

UTM: NAD83/11N/361257/4084674 Elevation (m): 3179
 Collectors: Cann, Corie Collection #: SEKI-18-WM-215-481
 Collection Date: 6/19/2015 Catalog #: SEKI-022963
 Determined By: Cann, Corie Accession #: SEKI-01174
 Sequoia and Kings Canyon National Parks Ash Mountain Herbarium

Flora of Sequoia and Kings Canyon National Parks
SIEN Wetland Ecological Integrity Monitoring

CYPERACEAE Yosemite bulrush
Trichophorum clementis (M.E. Jones) S.G. Sm.
 Synonyms (1993 Jepson): *Scirpus clementis* M.E. Jones
 Large depressional system with lacustrine fringes apparently in process of transitioning to meadow. Dominated by Calamagrostis muiriana, Stipa kingii, and Gentiana newberryi, with wettest portions of system as Carex utriculata monocultures.

UTM: NAD83/11N/361257/4084674 Elevation (m): 3179
 Collectors: Cann, Corie Collection #: SEKI-18-WM-215-485
 Collection Date: 6/19/2015 Catalog #: SEKI-022965
 Determined By: Cann, Corie Accession #: SEKI-01174
 Sequoia and Kings Canyon National Parks Ash Mountain Herbarium

Flora of Sequoia and Kings Canyon National Parks
SIEN Wetland Ecological Integrity Monitoring

ASTERACEAE alpine aster
Oreostemma alpinum var. *andersonii* (A. Gray) G.L. Nesom
 Synonyms (1993 Jepson): *Aster alpinus* (Torr. & A. Gray) A. Gray var. *andersonii* (A. Gray) M. Peck
 Large depressional system with lacustrine fringes apparently in process of transitioning to meadow. Dominated by Calamagrostis muiriana, Stipa kingii, and Gentiana newberryi, with wettest portions of system as Carex utriculata monocultures.

UTM: NAD83/11N/361257/4084674 Elevation (m): 3179
 Collectors: Cann, Corie Collection #: SEKI-18-WM-215-483
 Collection Date: 6/19/2015 Catalog #: SEKI-022964
 Determined By: Cann, Corie Accession #: SEKI-01174
 Sequoia and Kings Canyon National Parks Ash Mountain Herbarium

Flora of Sequoia and Kings Canyon National Parks
SIEN Wetland Ecological Integrity Monitoring

CYPERACEAE nearlyblack sedge
Carex subnigricans Stacey
 Synonyms (1993 Jepson):
 Large depressional system with lacustrine fringes apparently in process of transitioning to meadow. Dominated by Calamagrostis muiriana, Stipa kingii, and Gentiana newberryi, with wettest portions of system as Carex utriculata monocultures.

UTM: NAD83/11N/361257/4084674 Elevation (m): 3179
 Collectors: Cann, Corie Collection #: SEKI-18-WM-215-487
 Collection Date: 6/19/2015 Catalog #: SEKI-022966
 Determined By: Cann, Corie Accession #: SEKI-01174
 Sequoia and Kings Canyon National Parks Ash Mountain Herbarium

Figure SOP4.A7. Vascular plant herbarium labels.

**Sierra Nevada Inventory and Monitoring Network
Wetland Ecological Integrity Monitoring
Bryophyte Collection Envelope**

Admin. Unit: Devils Postpile Kings Canyon Sequoia Yosemite

Taxon: _____

State: California **County:** _____ **WEI Visit ID#:** _____

Location: _____

UTM e: _____ **UTM n:** _____ **Zone:** _____ **Datum:** _____

Substrate & Site Characteristics (circle all that apply):

Soil: mineral soil, gravel, sand, loam, silt, litter, duff, humus, peat, moss, or litter-fall

Rock type: granitic, metamorphic, calcareous _____

Rock feature: outcrop, boulder, cliff, crevice, ledge, talus, or under-hang

Light: full sun, partial shade, full shade **Elevation:** _____ ft. **Slope** _____ % **Aspect:** _____ °

Topography: meadow, ridge, slope, trail, or valley

Habitat: fen, dense/open forest, lake/pond, meadow, seep, spring, swamp, waterfall
stream/creek/river (intermittent), wetland, seasonally wet area, splash zone, or submerged

Site Moisture Regime: dry, mesic, moist, or wet

Collector: _____ **WEI Coll. #:** _____ **Date:** _____

Verified by: _____ **Date:** _____ **Notes:** _____

Accession # _____ **Catalog #** _____

Figure SOP4.A8. Bryophyte collection envelope labels.

SOP 4 Appendix B. Electronic Site Visit Sub-Forms

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit

Notes

Terres Sampling

- Aquatic Sampling
- Ant Sampling
- Assessment Area
- Buffer Info
- Hydrogeomorphic
- Special Status
- Photos
- Macro/Micro
- Seedling Tallies
- Ground Cover
- Plant Collections
- Water Depths
- Data Logger

Terrestrial Macroinvertebrate Sampling

Sample ID

Start Time (24hr)

Sampling Method

Nearest Tall Veg

Soil Moisture

Dominant Veg

Sky Condition

Shading by Trees %

Wind Speed

Canopy Height (cm) Complexity Hits

North	<input type="text"/>	<input type="text"/>
South	<input type="text"/>	<input type="text"/>
East	<input type="text"/>	<input type="text"/>
West	<input type="text"/>	<input type="text"/>

Notes

Lost

Figure SOP4.B1. Terres Sampling: Sub-Form for terrestrial macroinvertebrate data

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit

Notes

Terres Sampling
Aquatic Sampling
 Ant Sampling
 Assessment Area
 Buffer Info
 Hydrogeomorphic
 Special Status
 Photos
 Macro/Micro
 Seedling Tallies
 Ground Cover
 Plant Collections
 Water Depths
 Data Logger

Aquatic Macroinvertebrate Sampling

Start Time (24hr)

Sampling Method

Entry point UTM E N

Sampling Direction

Water Flow cm/sec

Dominant Veg

Nearest Tall Veg

Dist. on transect (m) 0 1.67 3.33 5

Canopy Height (cm)

Water depth (cm)

Notes

Species Found

Lost

Figure SOP4.B2. Aquatic Sampling: Sub-Form for aquatic macroinvertebrate data

SITE VISIT

Site Name Site Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit

Notes

Terres Sampling
 Aquatic Sampling
Ant Sampling
 Assessment Area
 Buffer Info
 Hydrogeomorphic
 Special Status
 Photos
 Macro/Micro
 Seedling Tallies
 Ground Cover
 Plant Collections
 Water Depths
 Data Logger

Ant Sampling

Sample Id

Start Time (24hr)

End Time (24hr)

Sampling Method

Bait Type

Vial Id

Sampling Location

Notes

Species Found

Lost

Record: 1 of 1 No Filter Search

Figure SOP4.B3. Ant Sampling: Sub-Form for ant macroinvertebrate data

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit

Notes

Terres Sampling
 Aquatic Sampling
 Ant Sampling
Assessment Area
 Buffer Info
 Hydrogeomorphic
 Special Status
 Photos
 Macro/Micro
 Seedling Tallies
 Ground Cover
 Plant Collections
 Water Depths
 Data Logger

Land Use Information

Natural ☐
 Dispersed Recreation ☐
 Developed recreation ☐
 Developed ☐
 Notes

Structural Patch Categories

HummocksStrings ☐
 PoolsFlarksWaterTracks ☐
 FloatingMats ☐
 CobblesBoulders ☐
 UnvegetatedFlats ☐
 AnimalMoundsBurrows ☐
 StandingSnags ☐
 Notes

Stressors

Point Source Discharge ☐
 Non-Point Source Discharge ☐
 Ditches/Diversions ☐
 Upstream Ditches/Diversions ☐
 Historic Livestock Grazing ☐
 Current Packstock Grazing ☐
 Groundwater Extraction ☐
 Fill Placed In Wetland ☐
 Grading/Compaction ☐
 Heavy Metal Impaired ☐
 Headcut/Erosion ☐
 Trash Or Refuse ☐
 Mowing ☐
 Social Trails ☐
 Developed Trails ☐
 Roads (gravel/dirt) ☐
 Roads (paved) ☐
 Tree Cutting/Sapling Removal ☐
 Evidence Of Fire ☐
 Evidence Of Flood ☐
 Check Dams/Riprap ☐
 Notes

Figure SOP4.B4. Assessment Area: Sub-Form for assessment area data including structural patches, stressors, and land use categories.

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit

Notes

Buffer Information

Buffer Direction	Distance	Change In Elevation
NE quadrant <input type="text"/>	<input type="text"/>	<input type="text"/>
NW quadrant <input type="text"/>	<input type="text"/>	<input type="text"/>
SE quadrant <input type="text"/>	<input type="text"/>	<input type="text"/>
SW quadrant <input type="text"/>	<input type="text"/>	<input type="text"/>

Notes

Left Sidebar Menu:

- Terres Sampling
- Aquatic Sampling
- Ant Sampling
- Assessment Area
- Buffer Info**
- Hydrogeomorphic
- Special Status
- Photos
- Macro/Micro
- Seedling Tallies
- Ground Cover
- Plant Collections
- Water Depths
- Data Logger

Figure SOP4.B5. Buffer Info: Sub-Form for buffer data.

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit Notes

	Hydrogeomorphic Type	Percent	Notes
Terres Sampling	<input type="text"/>	<input type="text"/>	<input type="text"/>
Aquatic Sampling			
Ant Sampling			
Assessment Area			
Buffer Info			
Hydrogeomorphic	<ul style="list-style-type: none"> Basin Peatland Mound Peatland Discharge Slope Peatland Depressional Seasonal Meadow Depressional Perennial Meadow Lacustrine Fringe Meadow Dry Meadow Discharge Slope Meadow Subsurface Low Gradient Meadow Subsurface Mid Gradient Meadow Subsurface Hi Gradient Meadow Low Gradient Riparian Mid Gradient Riparian Hi Gradient Riparian Other 		
Special Status			
Photos			
Macro/Micro			
Seedling Tallies			
Ground Cover			
Plant Collections			
Water Depths			
Data Logger			

Percent Total

Figure SOP4.B6. Hydrogeomorphic: Sub-Form for Hydrogeomorphic data. The pick-list of hydrogeomorphic types is shown in the figure.

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit Notes

Terres Sampling
 Aquatic Sampling
 Ant Sampling
 Assessment Area
 Buffer Info
 Hydrogeomorphic
Special Status
 Photos
 Macro/Micro
 Seedling Tallies
 Ground Cover
 Plant Collections
 Water Depths
 Data Logger

Largest Patch						
Plant	Type	Area (m2)	# of patches	UTM E	UTM N	Notes
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Figure SOP4.B7. Special Status: Sub-Form for special status plant data.

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit Notes

	Code	Photo #	Description	Photographer	Azimuth	Camera ID
Terres Sampling						
Aquatic Sampling						
Ant Sampling						
Assessment Area						
Buffer Info						
Hydrogeomorphic						
Special Status						
Photos						
Macro/Micro						
Seedling Tallies						
Ground Cover						
Plant Collections						
Water Depths						
Data Logger						
	Sign	Sign				
	C	Center				
	0	Photo from Well at an azimuth of 0 degrees				
	45	Photo from Well at an azimuth of 45 degrees				
	90	Photo from Well at an azimuth of 90 degrees				
	135	Photo from Well at an azimuth of 135 degrees				
	180	Photo from Well at an azimuth of 180 degrees				
	225	Photo from Well at an azimuth of 225 degrees				
	270	Photo from Well at an azimuth of 270 degrees				
	315	Photo from Well at an azimuth of 315 degrees				
	MN	Downward looking photo of N microplot				
	ME	Downward looking photo of E microplot				
	MS	Downward looking photo of S microplot				
	MW	Downward looking photo of W microplot				
	WF2	Witness Feature 2 photo				
	WF1	Witness Feature 1 photo				

Figure SOP4.B8. Photos: Sub-Form for plot and soil photo data. The pick-list of photo types is shown in the figure.

SITE VISIT

Site Name Site Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit Notes

Terres Sampling
Aquatic Sampling
Ant Sampling
Assessment Area
Buffer Info
Hydrogeomorphic
Special Status
Photos
Macro/Micro
Seedling Tallies
Ground Cover
Plant Collections
Water Depths
Data Logger

MICRO PLOT

Plant / Ground Cover **N E S W**

MACRO PLOT

Tally Cover Class Present Voucher Notes

Default sort = Scientific name with Ground Covers at top

Figure SOP4.B9. Macro/Micro: Sub-Form for macroplot and microplot vegetation and ground cover data. Count of mature trees by species (>1.37 m tall) is also tallied on this form.

SITE VISIT

Site Name **Site** Purpose Contact Role

Date Protocol Version Current Wetland Type

Site Visit

Notes

Terres Sampling
 Aquatic Sampling
 Ant Sampling
 Assessment Area
 Buffer Info
 Hydrogeomorphic
 Special Status
 Photos
 Macro/Micro
Seedling Tallies
 Ground Cover
 Plant Collections
 Water Depths
 Data Logger

Height Classes (cm)

Tree	< 10	11 - 25	26 - 50	51 - 75	76 - 100	101 - 137
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Tree **Common Name** **Height Class** **Tally** **Notes**

Figure SOP4.B10. Seedling Tallies: Sub-Form for tree seedling data. Count of tree seedlings by species and height class is tallied.

SITE VISIT

Site Name: **SEKI extent-004** Site: **Site** Purpose: **Install** Contact: Role:

Date: **3/7/2017** Protocol Version: Current Wetland Type: **Fen-Meadow**

Site Visit Notes:

	Point	Cover Type	Peat Depth (cm)	
Terres Sampling	1			
Aquatic Sampling	2	V Vegetation		
Ant Sampling	3	G Gravel		
Assessment Area	4	R Rock		
Buffer Info	5	W Wood		
Hydrogeomorphic	6	L Litter		
Special Status	7	B Bare Ground		
Photos	8	P Bare Peat		
Macro/Micro	9	D Standing Dead		
Seedling Tallies	10	S Standing Water		
Ground Cover	11			
Plant Collections	12			
Water Depths	13			
Data Logger	14			
	15			
	16			
	17			

Insert 100 points

Figure SOP4.B11. Ground Cover: Sub-Form for ground cover frequency data and peat depth. Five random points are selected for peat depth measurements in the form and highlighted in yellow. Look-up table of the different cover types is shown in the figure.

SITE VISIT

Site Name: SEKI extent-004 Site Purpose: Install Contact: Role:

Date: 3/7/2017 Protocol Version: Current Wetland Type: Fen-Meadow

Site Visit Notes:

Terres Sampling
Aquatic Sampling
Ant Sampling
Assessment Area
Buffer Info
Hydrogeomorphic
Special Status
Photos
Macro/Micro
Seedling Tallies
Ground Cover
Plant Collections
Water Depths
Data Logger

Voucher Num	Collected By	Plant	Unknown Species	Sent out for ID?	Mounted?	Acession #	Catalog #	Identified By Notes
-------------	--------------	-------	-----------------	------------------	----------	------------	-----------	---------------------

Figure SOP4.B12. Plant Collections: Sub-Form for plant collection data. This form is not used in the field, but is filled out once the field crew has returned to the office and has prepped the voucher specimens for archiving.

SITE VISIT				
Site Name	<input type="text" value="SEKI extent-004"/>	Site	Purpose	<input type="text" value="Install"/>
Date	<input type="text" value="3/7/2017"/>	Protocol Version	Current Wetland Type	<input type="text" value="Fen-Meadow"/>
Site Visit Notes	<input type="text"/>			
Contact	<input type="text"/>			
Role	<input type="text"/>			
Terres Sampling	Measure-	Distance	Distance	
Aquatic Sampling	ment	to	to Ground	
Ant Sampling	Time	Groundwater	Surface	Notes
Assessment Area	<input type="text"/>	<input type="text"/> cm	<input type="text"/> cm	<input type="text"/>
Buffer Info				
Hydrogeomorphic				
Special Status				
Photos				
Macro/Micro				
Seedling Tallies				
Ground Cover				
Plant Collections				
Water Depths				
Data Logger				

Figure SOP4.B13. Water Depths: Sub-Form for manual water table depth data.

SITE VISIT

Site Name: Purpose: Contact: Role:

Date: Protocol Version: Current Wetland Type:

Site Visit Notes:

	Logger Code	Time of download	Download Date	File Name	Download Device	Notes
<ul style="list-style-type: none"> Terres Sampling Aquatic Sampling Ant Sampling Assessment Area Buffer Info Hydrogeomorphic Special Status Photos Macro/Micro Seedling Tallies Ground Cover Plant Collections Water Depths Data Logger 	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Figure SOP4.B14. Data Logger: Sub-Form for data logger file data.

SOP 5. Equipment Decontamination Procedures

Version 2.0

Harold Werner, Jonathan Nesmith

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	20090709	Harold Werner	Expanded to include Wetland Ecological Integrity Protocol and to recognize recent taxonomic changes to sensitive amphibians.	Modified to include within Wetland Ecological Integrity Protocol	1.1
1.1	20131203	J. Nesmith	Edited text to clarify language and update decontamination procedures.	Revisions to clarify decontamination procedures.	2.0

Introduction

Field personnel have the potential to introduce and spread parasites and non-native organisms. These include the introduction and spread of the New Zealand mudsnail (*Potamopyrgus antipodarum*), quagga mussels (*Dreissena rostriformis bugensis*), zebra mussels (*Dreissena polymorpha*), and chytrid fungus (*Batrachochytrium dendrobatidis*), which are of particular regional concern. Sierra Nevada Network (SIEN) recognizes the need to minimize introduction and transport as part of the lake and wetland monitoring protocols.

Aquatic species can be transported on clothing and sampling equipment. To minimize this risk, SIEN requires the following general policies to be followed during aquatic microinvertebrate sampling:

- Start fieldwork with sterilized equipment.
- If the information is known, start field work from the cleanest site and work toward the dirtiest or contaminated site, when feasible.
- Start from the highest point in the drainage and work down, when feasible.

Disinfection Procedure

To avoid moving diseases from site to site, gear that has been in contact with water or animals during aquatic macroinvertebrate sampling must be disinfected before sampling the next water body. The only exception to this rule is when your next survey site is in the same area: directly connected or within 100 meters downstream of the site you just surveyed and connected to it by a stream. Between sites in the same area, all equipment should be rinsed of organic debris.

We elected to use a chlorine bleach disinfection procedure as part of the WEI sampling procedures. The alternative disinfectant is Quat-128®. Quat-128® is not used in this protocol because it is a source of nitrogen contamination. We recognize that chlorine bleach is a source of sodium and chloride ion contamination. However, disinfecting is a necessary step and, given our objectives, potential sodium and chloride contamination was determined to be the better of the two options.

Equipment should be disinfected at the ‘new’ site. Do not disinfect after sampling a lake and then store the equipment with bleach on it in the packs. Long exposure to the bleach is hard on the equipment, not to mention it will get bleach on everything in your pack. When you arrive at the new site take cautions to not allow the ‘contaminated’ equipment to contact water until it has been disinfected.

Use the following equipment to disinfect between sampling locations:

- Stiff scrub brush (if needed)
- Latex gloves
- Spray bottle
- 3 gallon collapsible bucket or dry bag
- Dry bleach (this should be in pre-measured, labeled packages for each sample site)

The following equipment should be cleaned and disinfected:

- Boots, shoes, waders, and sandals
- Dip nets
- Net poles
- Tarp
- Any other equipment that contacts water

Chlorine bleach is used to disinfect. Granulated chlorine bleach is preferred because it is lighter and easier to transport than liquid bleach and unlike liquid bleach it does not lose its effectiveness within 2 weeks. Granulated chlorine bleach can be purchased at swimming supply stores.

Prior to going into the field, package and label the disinfectant.

1. Get labels and containers to package the dry bleach. Containers can be plastic storage bags, plastic bottles, etc. If using plastic storage bags, put all bags for the trip into one dry bag, stuff sack, or hard sided container that can protect the plastic storage bags from being punctured.
2. Measure 1 cup of 56% available dry chlorine bleach (to get a 2% bleach solution when added to a 60% full 3 gallon bucket of water in the field).
3. Place dry bleach in plastic storage bag.
4. Label plastic storage bag.
5. Label the puncture resistant bag (stuff sack, dry bag, or hard sided container).
6. Repeat to have individual pre-measured containers for each lake.

The first step in the field is to thoroughly rinse equipment before leaving the area where it was used.

1. Remove all organic matter (mud, plants, algae, etc.). Particular attention should be given to the treads of boots, sandals, and waders. A stiff brush should be used if needed.
2. Ensure no water remains in any equipment by removing any residual water from all pumps, hoses, etc.
3. Dry as thoroughly as possible. When practical and appropriate, wipe dry.
4. Let all equipment air dry as long as possible.

After the equipment is thoroughly cleaned, use the following steps to disinfect once you have reached the next site.

1. For small equipment, such as dip nets and ropes:
 - a. Use a 2% solution of bleach.
 - b. Fill the 3 gallon collapsible bucket a little over half (60% full) with water at the new survey site.
 - c. Mix the pre-measured quantity of dry bleach into the water in the bucket.

- d. Soak all items (that have been cleaned of mud, etc.) for 1 minute.
 - e. If the solution becomes noticeably dirty, dispose of it and mix up a new batch.
 - f. After disinfecting your gear, rinse with water from the new survey site.
- 2. For large equipment that cannot be soaked:
 - a. Use the 2% solution of bleach.
 - b. Fill spray bottle with solution.
 - c. Spray cleaned surfaces. If needed, use a sponge to make sure all surfaces get covered with the spray solution.
 - d. Let air dry.
 - e. Rinse thoroughly with water from the new survey site to remove all disinfectant to avoid sample contamination, and getting bleach on clothing, etc.
- 3. Dispose of bleach solution at least 100 meters from water.

SOP 6. Determining Target Status of a Site in the Field Prior to Plot Establishment

Version 1.0

Peggy E. Moore, Jennifer Rains Jones, and Edward Gage

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

Page

Figure 6.1. Response design points in selected wetland complex in Sequoia National Park.....SOP 6.3

Introduction

For this monitoring protocol, the target population is defined as wet meadows and fens, larger than 0.5 hectare, that have been distinguished from surrounding uplands and any adjacent wetlands of another type and delineated using multiple data sources including color infra-red aerial photography (Pyrooz et al. 2015).

This SOP describes the procedure for evaluating the target wetland status of a point in the field. Target status refers to whether a point is of the same wetland type as the sampling frame from which it was originally selected (i.e., the same as what it was interpreted to be using aerial photography). If, for example, a site was selected as a fen_meadow, but upon field visitation was found to be only wet meadow, marsh or upland, the point would not be of the target type. This SOP is relevant to establishing new extensive sites, although the same process can be used to classify all sampling points, regardless of sampling design.

The first step in evaluating the target status of a point is determining whether the point falls within a wetland. The NPS standard for defining, classifying, and inventorying wetlands is “Classification of Wetlands and Deepwater Habitats of the US (USFWS 1979). Under the Cowardin definition, “wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season each year”. To determine if plants are hydrophytic species, refer to the wetland status assignments of plants specific to this region in the national wetland plant list (USFWS 1996) or the USDA plants database for wetland plant indicator status (USDA NRCS 2017). For hydric soil indicators, use Field Indicators of Hydric Soil in the U.S. (USDA NRCS 2006), and use a Munsell Soil Color Chart (Munsell Color Company 1954) to document the soil stratigraphy, looking for commonly used hydric soil indicators such as low chroma colors, mottling, or gleying.

Once it is determined that a site is a wetland, the wetland type is classified using a dichotomous key to wetland types (see Field Key to Wetland Types below).

Sample Placement

Sampling is driven by a series of GRTS (Generalized Random-Tessellation Stratified) survey points randomly placed in each wetland polygon selected during the sampling design. Points will direct where response measures (vegetation, invertebrates, and hydrology) are to be sampled and help to avoid subjectivity of plot placement (Figure SOP 6.1). The selected points are used to assess the ecological condition of fens and wet meadows at the park and network scale, and do not necessarily represent the condition of the individual wetland.

Points are visited in order (1-30) and the lowest possible numbered point that matches the target type is selected for sampling. Sites where 100 percent of the plot area match the target wetland type are the most suitable for sampling. However, sites are suitable for sampling if they are comprised of the target type over more than 80 percent of the plot. Many wetland complexes are formed by a mosaic of hydrologic regimes and soils reflected in vegetation stature and composition, microtopographic features, and hydric soil indicators. Ideally, sampling will be conducted in homogeneous hydrologic regimes and soils.

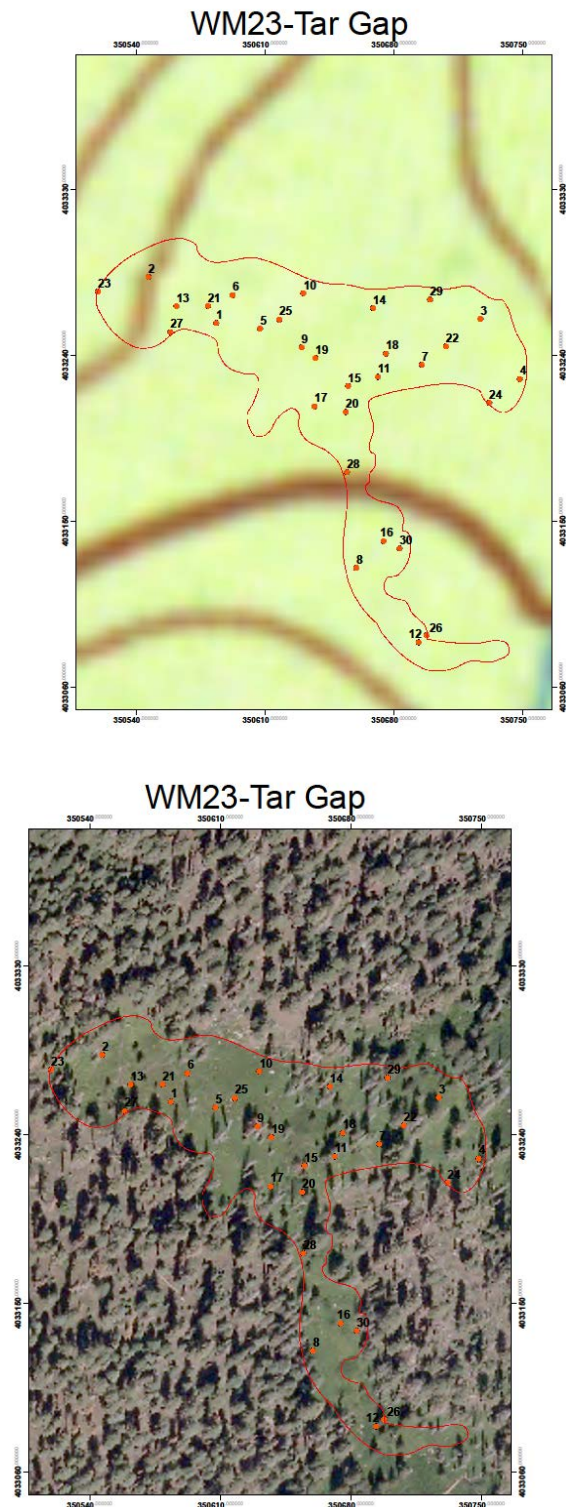


Figure SOP 6.1. Response design points in selected wetland complex in Sequoia National Park.

Due to frame and location inaccuracies, field crews are allowed to shift the plot center 20 meters to sample in an area of greater than 80% of the target type if no point among the first 30 points

SOP 6.3

SIEN Wetlands Ecological Integrity Protocol

SOP 6. Determining Target Status of a Site in the Field Prior to Plot Establishment

can be found. Plots will again be visited in ascending order and the lowest numbered point where a shift of <20 m results in the plot meeting the 80% target wetland type threshold will be selected. The criteria of 20 meters is based on estimated GPS error (average 4m) plus the average positional accuracy in base mapping methods (average of 9m) plus half the axis of size of the plot (7 m). Sites may be shifted up to 20 meters under the following conditions: 1) safety or compliance issues do not allow sampling at a site 2) no sites have been found in the first 30 points where the plot is at least 80% of the target type.

If the wetland was classified as having both fen and meadow target types, sampling points in each wetland type will need to be placed at the lowest numbered GRTS-ordered point of that target type, no matter where they fall in the wetland complex.

In the event that there are no target wetlands in the complex that can be sampled, i.e., the complex is predominantly upland, riparian, marsh, aquatic and none of the 30 points fall within or can be moved to contain at least 80 percent cover of a target wetland type, or there are access issues (safety or private property) with sampling the site, the site should be dropped and the lowest numbered site available from the GRTS oversample should be used as a replacement. If the classified type is not present in the wetland complex (i.e., site was classified as fen_meadow and there are no fen soils present) the lowest number in the GRTS-ordered list of sites that falls in the wet meadow type should be sampled and the field classification of the site should be recorded as wet meadow.

Final determination of whether a point is of the target type will be made based on soil and plant indicators and the professional judgment of the field crew. Documentation of general indicators and final wetland type determination are recorded on the site establishment data form (SOP 4, SOP 7). If selected for sampling, additional information is recorded in the site establishment form.

Equipment

- National wetland plant list (USFWS 1996)
- Field Indicators of Hydric Soils in the U.S. (USDA NRCS 2006)
- Munsell Soil Color Chart (Munsell Color Company 1954)
- Field key to wetland types
- Site establishment data form
- Site map with wetland complex boundary and GRTS points locations
- Shovel or auger to examine soils
- Soil probe to estimate peat depth
- GPS (Trimble Yuma with appropriate data dictionary or Garmin)
- Camera
- Clipboard, pencils, spare batteries

Procedure

- Step 1: Locate the first sample point from the 30 points and determine whether sample point falls within a wetland.

- Step 2: If first sample point falls within a wetland, identify wetland type using field key below and list the percentage of each wetland type that is within the plot area.
- Step 3: If plot around point is at least 80% of the target wetland type, soil depth is ≥ 100 cm, and also >50 m from any class 3-5 trails, and >25 m from any class 1-2 trails and campsites, skip to step 9.
- Step 4: If plot around point would not be at least 80 percent of the target type, and also within requisite distances from anthropogenic influences, estimate whether the point could be moved to meet this criterion and proceed to the next point within the wetland. Evaluate shifting the point as follows:
 - Determine the shortest distance and azimuth that will shift the point in the direction of greater inclusion of the target type that results in at least 80 percent cover of the target wetland type.
- Step 5: If point is of target type, but cannot be sampled because of safety or other issue, determine whether the plot could be moved within 20 m to resolve the issue and proceed to the next point within the wetland.
- Step 6: Place a temporary pin flag with the point number to be used for shifting of the point if none of the 30 points allow for the establishment of a plot within the targeted wetland type.
- Step 7: At subsequent point(s), repeat wetland determination and identify wetland type to determine if plot would be at least 80 percent of the target type until a valid plot location is found. If all 30 points are rejected and shifting any of the 30 points would not result in a valid plot, the site is dropped and a new site is selected from the GRTS oversample.
- Step 8: If none of the 30 points in the main panel matches the target wetland type and none can be shifted up to 20 m to match the target type, establish a site at the lowest numbered sample point that falls in the alternate wetland type (i.e., if seeking fen, and no fen at any of 30 points and cannot shift a point, establish site in wet meadow type).
- Step 9: Establish plot (SOP 7), install ground water monitoring well (SOP 8), and record wetland type indicators on site establishment data form (SOP 7). If the site had to be shifted to meet this criteria, record the distance and azimuth of the shift from the original point location on the site establishment data form.

Field Key to Wetland Types

Once wetland determinations are made (per USFWS 1979), the site is further classified to wetland type using the key below. This key applies to meadows classifiable as wetlands (e.g., wet meadows), but not to dry meadows lacking hydrophytic vegetation, hydric soils, or wetland hydrology.

1a The wetland is maintained by groundwater hydrology; soils contain at least 20 cm of peat within the top 40 cm; the water table appears to remain at or close to the ground surface for most of the year; vegetation is dominated by wetland obligate species..... **Fen**

1b Soil contains <20 cm of peat within the top 40 cm..... **(2)**

2a Site adjacent to and hydrologically connected to stream or river by surface water flows on timescales of years to decades. Site is dominated by active fluvial processes such as sediment depositions and erosion of cut banks driven by the presence of unidirectional moving water..... **Riparian**

SOP 6.5

2b Site lacks surface water connection to stream or river. Fluvial processes including sediment deposition may still occur sporadically, but active, continuous erosion from moving water is rare..... **(3)**

3a Sites formed in depressions or basins and subject to inundation on relatively frequent basis; vegetation dominated by annual or perennial grasses and sedges; water tables highly variable on both a seasonal and inter-annual basis; hydrologic regimes may be influenced by precipitation and snow-melt, surface water inputs, or groundwater..... **Marsh**

3b Sites found on both slopes and basins but rarely if ever inundated; vegetation dominated by perennial grasses, sedges, rushes, or shrubs such as willows (*Salix* spp.); water tables variable but rarely fall below 2 m of the surface; hydrologic regimes predominantly groundwater or, at high elevations, snow-melt driven; surface water inputs relatively unimportant..... **Wet meadow**

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SOP 7. Site Establishment and Assessment

Version 1.0

Edward Gage, Shawn T. McKinney, and Jonathan C. B. Nesmith

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

Page

Figure SOP 7.1. Site visit form..... SOP 7.2

Introduction

There are three general components to this SOP: site establishment, witness feature documentation, and site assessment. Application of the SOP assumes that the point's target type has been positively confirmed using SOP 6. If a point is rejected as not being of the target type (i.e., it is either upland or non-target wetland such as marsh) and the point cannot be shifted, then a new site must be selected from the over-sample list generated by the GRTS design. In this case, a new site establishment form is completed, and the form for the original point is archived.

This SOP first provides an overview of the initial steps taken when establishing a site; specific activities such as installing groundwater monitoring wells and laying out vegetation plots are described in detail in subsequent SOPs. Second, procedures are provided for documenting witness features that facilitate efficient relocation of the site in the future. Third, the SOP outlines procedures for conducting a basic site assessment – largely derived from the California Rapid Assessment Method (CRAM; information found at <http://www.cramwetlands.org>) – of the impact of anthropogenic stressors (e.g., hydrologic modifications due to ditches or diversions, historic livestock grazing and contemporary pack stock use). The assessment metrics include both site-level data and information gained through analyses of maps or GIS data.

Site Establishment

When a site is initially established, the site visit section of the field data form is completed (Figure SOP 7.1). General identification information, wetland description and classification, and contact information are recorded. This is also where the subplot tree sapling data are recorded.

The screenshot shows a software interface titled "SITE VISIT". The top section, outlined in green, contains the following fields:

- Site Name (dropdown menu)
- Date (text input)
- Protocol Version (text input)
- Purpose (dropdown menu)
- Wetland Type (dropdown menu)
- Contact (text input)
- Role (dropdown menu)

Below the green-outlined section is a section for "Height Classes (cm)". It includes a table with columns: Tree, Common Name, Height Class, Tally, and Notes. The table has rows for height classes: < 10, 11 - 25, 26 - 50, 51 - 75, 76 - 100, and 101 - 137. There is a "+" button to the right of the table.

At the bottom of the form is a list of witness features:

- Terres Sampling
- Aquatic Sampling
- Ant Sampling
- Assessment Area
- Buffer Info
- Hydrogeomorphic
- Special Status
- Photos
- Macro/Micro
- Seedling Tallies
- Ground Cover
- Plant Collections
- Water Depths
- Data Logger

Figure SOP 7.1. Site visit form. General information related to the specific site visit is recorded at the top of the form outlined in green in this figure.

Witness Feature Documentation

When sites are first established, crews should identify at least two large and permanent landmarks such as rock outcrops and large trees. This step is particularly important if a relatively low-grade GPS unit is used to navigate to the point (e.g., accuracy ≥ 10 m). Once a point has been

confirmed as the target type and a ground water monitoring well installed, the following steps are followed to document witness features to aid in relocation of the well during subsequent visits.

- Identify at least two prominent and long-lasting features such as rock outcrops and large trees. If a feature has substantially changed in character in a subsequent revisit to a site (e.g., a tree falls), the change should be documented by description and photo if it remains a viable landmark. If it is no longer a viable landmark (e.g., the tree burned to ashes), then a new landmark is chosen and the same initial procedures for documenting the witness feature are followed.
- Use a compass to read the azimuth from a feature to the well and record the value (degrees) on the field form. The compass should be adjusted for current magnetic north declination prior to entering the field (SOP 2).
- Measure the distance from the feature to the well (along the same azimuth) and record this distance (m) on the field form. The distance should be estimated if over 100 m.
- If local features are absent, triangulation techniques are used to identify the relative position of the plot well to distant landmarks such as mountain peaks. Azimuths from the well to two distant landmarks are taken and recorded. Effort is given to choose two landmarks that are far apart from each other such that their distance subtends an angle between the well and the landmarks that can be read with reasonable precision (e.g., angle ≥ 30 degrees). Written descriptions and sketches of the landmarks are made and included with the data forms. Crews returning to a site in subsequent years will locate the landmarks and orient themselves along the two azimuths to home in on the well location.

Assessment Area

Following witness feature documentation, a 1-ha circle (56.4 m radius) centered on the groundwater monitoring well is assessed to determine land use, land cover, anthropogenic stressors, buffer width, and location and abundance of invasive and rare species in the surrounding area. This must be done in the field but may be informed through the use of maps or aerial photographs to help estimate buffer distance, for example.

One purpose of the assessment is to provide data that are complementary to other CRAM-derived data from the region, and that can then be evaluated by scientists to generate information useful to managers (CWMW 2013). For example, the presence and integrity of natural buffers (i.e., areas free of roads, trails, or other human installations or disturbances) around the margins of wetlands is commonly used as an indicator of wetland condition (Fennessey et al. 2007). Disturbances in surrounding watersheds may affect wetlands through altered water quality or increased sediment yield. Buffers may mitigate anthropogenic effects to wetlands by helping attenuate overland flow, filter sediments and pollutants, and by providing important habitat features for wildlife species (Lee et al. 2004, Miller et al. 2006).

There are two different approaches for evaluating buffer width. Buffers are evaluated in the office using GIS coverage of the wetland sampling frame along with layers such as roads, developed trails, campgrounds, or other infrastructure. Buffers are also evaluated in the field. Crews will record the presence and condition of buffers while conducting site assessments. The shortest straight-line distance between a sampling point (well) and human disturbance (e.g. road, trail, ditch, etc.) is measured and recorded for each of the four plot quadrants and then averaged

to arrive at a single buffer width value for the wetland. The direction of change in elevation change (uphill or downhill) will also be recorded for each quadrant.

Another purpose of the assessment is to combine the CRAM data with the project's plot-level data (e.g. vegetation, hydrology) and meso-scale landscape context metrics calculated in the office using a GIS and other information sources. One potential use of these three data sources is to generate multimetric index scores to assess the ecological integrity of a site (Faber-Langendoen et al. 2006, Rocchio 2006).

In addition to inventorying stressors and evaluating condition metrics, crews will photographically document any significant anthropogenic stressors present in or adjacent to sample sites. Specific procedures for taking digital photographs and for collecting appropriate metadata are provided in SOP 11.

The crew will also document the location and abundance of any invasive or rare species found within the assessment area. These lists will be updated annually in cooperation with park natural resource staff.

Field Assessment

Walk the approximate perimeter of the assessment area, defined as a 1-ha circle centered on the groundwater monitoring well (radius = 56.4 m).

- Identify and estimate the percentage of each land use type and the presence/absence of different land cover types within the 1-ha assessment area and record them on the assessment form.
- Complete the stressor checklist on the assessment form. The presence and relative importance of different stressors is evaluated for the entire 1-ha assessment area.
- Estimate buffer width from the well by distance class (<10m, 11-25m, 26-50m, 51-100m, >100m) and elevation change from the well to the nearest human disturbance in each of four quadrants.
- Complete the "Structural Patch Categories" section of the assessment form to assess the structural characteristics of the wetland. This information is evaluated for the entire 1-ha assessment area.
- Record the presence/absence, location, and patch size (m²) of any rare or exotic species found within the 1-ha assessment area.

Equipment

- Witness feature documentation and initial field assessment form
- Field computer with field forms loaded
- Writing utensils
- Digital camera
- GPS
- Compass
- 50 m field tape

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SOP 8. Groundwater Monitoring Well Installation

Version 1.0

Edward Gage and Jim Roche

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures and Tables

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Figure SOP 8.1. Schematic illustration of groundwater well. SOP 8.3

Figure SOP 8.2. Site form where information on the groundwater monitoring well and soils are recorded.....SOP 8.4

Figure SOP 8.3. Examples of soil hydric indicators.....SOP 8.5

Figure SOP 8.4. Close-up photograph of well casing cut down near to the ground and painted gray to camouflage.....SOP 8.6

Table SOP 8.1. Humification (decomposition) rate using the von Post method.....SOP 8.5

Introduction

This SOP gives step-by-step instructions for the installation of shallow polyvinylchloride (PVC) groundwater monitoring wells. Monitoring wells allow for direct measurement of water table levels. Direct measurements of water table depth are far more precise and accurate for characterizing hydrologic regime than indirect hydrologic indicators like the presence of hydric soils. Hydrologic data collected in conjunction with vegetation sampling improve understanding of natural variability in ecosystem properties due to natural or anthropogenic factors and such data are essential for effective ecological restoration (Winter and Woo 1990, Winter 2000).

Most published methods for monitoring well installation are for monitoring water table depths greater than needed for most wetlands, where water tables typically remain at or near the ground surface (Sprecher 2000). Standard methods also typically involve the use of imported materials such as bentonite clay or pre-sorted sand, which are impractical and inappropriate for use in backcountry and wilderness areas. For ecological studies, wells installed directly into sites can provide accurate measurements and remain functional for long time periods, allowing for long-term data collection (Cooper 1990).

Monitoring wells consist of a perforated section of pipe installed vertically in the ground. Perforations extend from just below the ground surface to the bottom of the pipe, which is capped with a hole drilled for drainage. Water levels inside the pipe result from the integrated water pressures along the entire length of perforations (Figure SOP 8.1). In contrast, piezometers are perforated only at the bottom of the pipe with water levels inside the pipe resulting from the water pressure over the narrow zone of perforation at the bottom of the pipe (Sprecher 2000). Caps are installed at the top of well casings to protect them from rain or contamination. It is important that caps be loosely fixed so that they may be removed for measurement without excessive force. Wells will be vented to allow equilibration of air pressure inside and outside of well casing. This can be done via either a small hole drilled in the cap or a slot along the side of the casing made with a hacksaw.

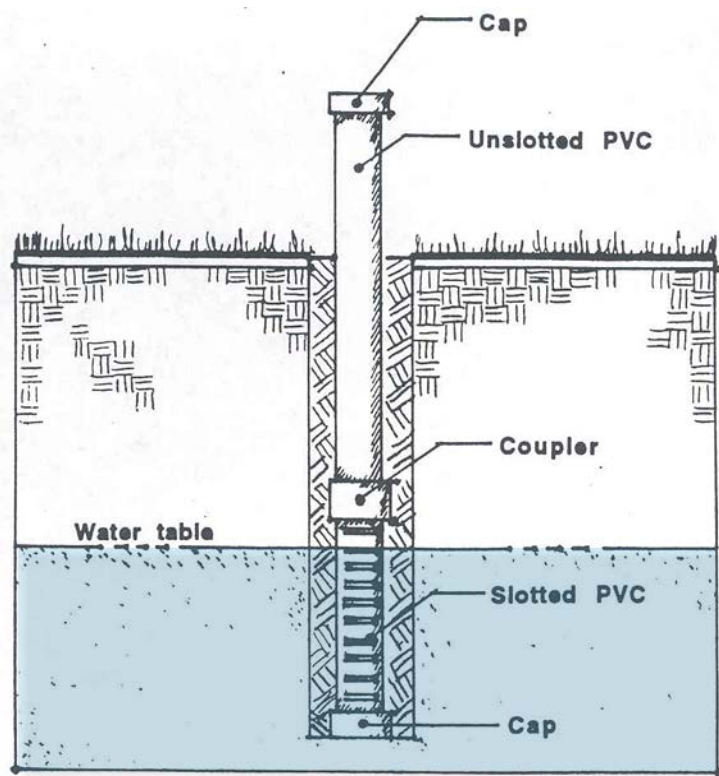


Figure SOP 8.1. Schematic illustration of groundwater well. Note that the height of the slotted section must be significantly greater than the likely amplitude of water table fluctuations, extending to the surface, if necessary.

When new wells are installed as part of new site establishment, soils from the hole augured for the well casing must be described on the site establishment form (Figure SOP 8.2). Variables of particular interest include gross stratigraphy and make-up of the soil profile (e.g. texture, organic matter content) and the presence of hydric soil indicators (Figure SOP 8.3). Hydric soil indicators such as the presence of gleyed soil horizons or redoximorphic features such as mottles provide useful indirect indicators of wetland hydrologic regime. Detailed descriptions of specific hydric soil indicators are provided by the USDA NRCS (NRCS 2006). Where organic (peat) soils are present, a peat humification rating is applied using the von Post scale (von Post and Granlund 1926). The degree of peat decomposition strongly influences general soil physical characteristics such as hydraulic conductivity and can be an important variable for peatland classification. The degree of decomposition can be assessed by evaluating the fiber content peak, using either laboratory methods or a field-based approach such as the von Post procedure (Table SOP 8.1). The von Post procedure (von Post and Granlund 1926) involves compressing a sample of saturated peat by hand and evaluating the color or turbidity of the extruded liquid and the proportion of extruded matter. Observations are made on a 10 point scale (H1-H10). H values can be classified into one of three categories: fibric (H1-H3), mesic (H5-H6), or humic (H7-H10). These data are used to help classify site wetland type. A background in soils is useful but not necessary for this SOP; crews will be trained to accurately describe soils and recognize hydric soil indicators.

SITE

Wetland Name Panel Type

Site GRTS Order Site Name

Hydrogeomorphic Type Site Notes

Dsgn UTM E

Dsgn UTM N

WELL DETAILS

Well Number

Installation Date

Field UTM East

Field UTM North

UTM Zone

Coord Datum

GPS Unit

Casing Length (cm)

Field Elevation (m)

Witness feature

	1	2
Distance (m)	<input type="text" value=""/>	<input type="text" value=""/>
Azimuth	<input type="text" value=""/>	<input type="text" value=""/>
GPS Error (m)	<input type="text" value=""/>	<input type="text" value=""/>
Well Installation Notes	<input type="text" value=""/>	
Well Location Notes	<input type="text" value=""/>	

SOILS

Organic Horizon Depth	Peat Humification rate	Gleyed	Sulphuric Odor	Mottled	Organic Horizon	Other	Depth Range	Start	End	Soil Color	Soil Texture
<input type="text" value=""/>	<input type="text" value=""/>	☐	☐	☐	☐	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>

Record: 1 of 1

Figure SOP 8.2. Site form where information on the groundwater monitoring well and soils are recorded.

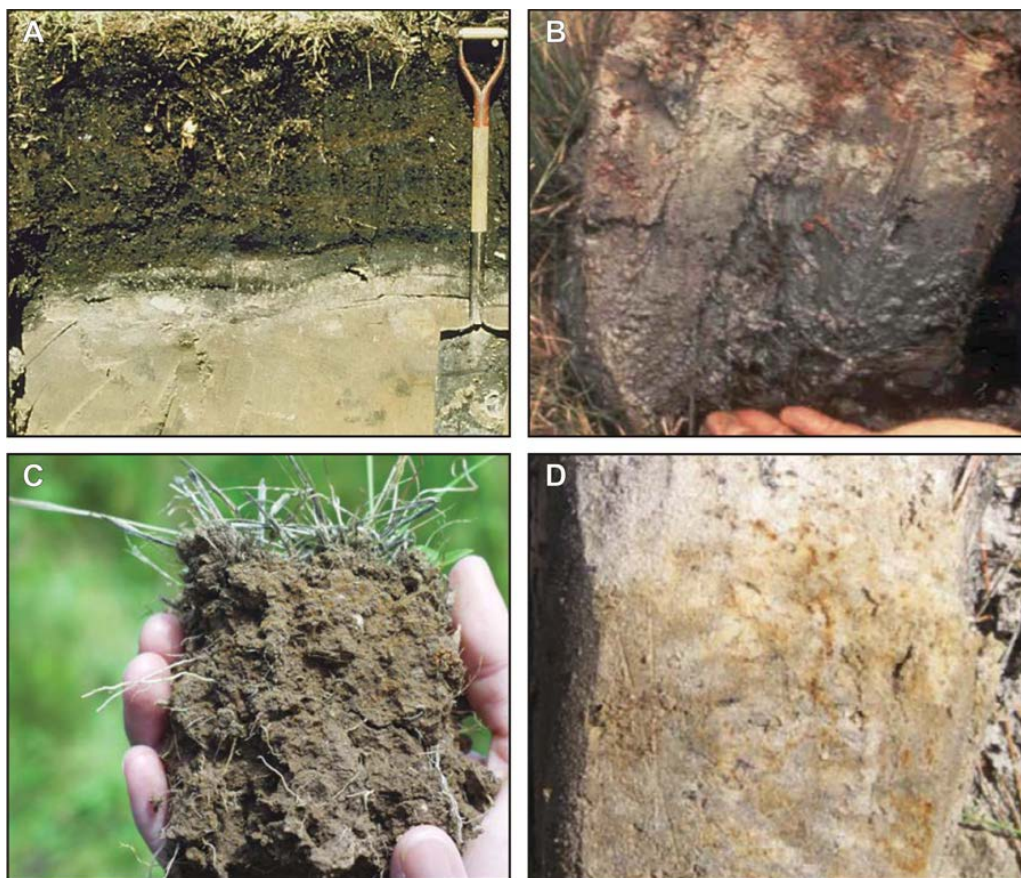


Figure SOP 8.3. Examples of hydric soil indicators. Panel (A): Indicator A1 (Histosols); (B) Indicator F2 (Loamy Gleyed Matrix). The gleyed matrix begins at a depth of about 18 cm, while indicator F3 (Depleted Matrix) is between the gleyed matrix and the surface layer; (C) Indicator F8 (Redox Depressions); (D) Indicator S5 (Sandy Redox). The redox masses occur almost to the surface (NRCS 2006).

Table SOP 8.1. Humification (decomposition) rate using the von Post method. Peat soils are assigned a rating, recorded on the well installation and soils section of the site establishment form.

H	Plant residues	Extruded matter	Residues after pressing
1	Unaltered	Clear water	Nonpasty
2	Distinct	Brown--yellow, clear water	Nonpasty
3	Distinct	Brown turbid water	Nonpasty
4	Distinct	Brown very turbid water	Nonpasty
5	Distinct	Brown, very turbid water with plant residues	Somewhat pasty
6	Somewhat indistinct	One third of the peat material extruded	Very pasty
7	Indistinct but recognizable	One half of the peat material extruded	Very pasty
8	Very indistinct	Two thirds of the peat material extruded	Few fibers
9	Almost nonrecognizable	Almost all peat material extruded	Few fibers
10	Nonrecognizable	All peat material extruded	No residues

Following well installation, casings are cut to within 6 inches of the ground surface using a hack saw (Figure SOP 8.4).

SOP 8.5



Figure SOP 8.4. Close-up photograph of well casing cut down near to the ground and painted gray to camouflage.

Equipment

- Work gloves
- 3 in. diameter bucket auger
- Plastic tarp to temporarily hold excavated soils
- Munsell color chart
- Tape measure (metric, 2m minimum length)
- Clip board
- Pencils
- Data form
- Bailer or small pump to clear wells
- Hack saw, extra hack saw blades
- 1.25 in. diameter schedule 40 PVC pipe, machine slotted or slotted by hand using hack saw. The specific length needed will vary depending on wetland type; shallow wells, only a couple feet long, will be sufficient for most fens, while wet meadows will generally require installation of longer wells.
- 1.25in. diameter PVC cap with hole predrilled though center (bottom cap)
- 1.25 in. diameter PVC cap (top cap), notches cut into side to facilitate cap removal and hole predrilled to accommodate attachment of aluminum tag.
- Indelible marker (e.g. Sharpie)

Well installation

- Lay plastic tarp down next to plot center point where well will be installed. Care must be taken not to trample microplots during well installation.
- Using a bucket auger, begin to auger hole at well location. Auger down approximately 8 in. at a time, laying out soil cores from the auger bucket end to end on tarp for stratigraphic description, use a tape measure each bucket load to maintain correlation between core length and well depth.

- Auger to ≥ 1.5 m below the soil surface if possible. A minimum of 1 m below the soil surface must be reached or the point should be rejected as the well will be too shallow and will be more likely to become unstable. The soil probe should be used to test the soil depth prior to beginning to auger to ensure that the well hole will be >1 m deep.
- Record observations of soil texture, soil matrix color using a Munsell color chart, and the presence of hydric soil indicators such as mottling, oxidized root channels, or gleyed colors on site establishment form. Record von Post humification scale values for peat soils (Table SOP 8.1). If the well depth reaches 1.5m and no wetland characteristic soil properties have been observed in the soil core such as redox soils or organic soils, the site's classification as a fen or wet meadow should be re-evaluated in the context of this information.
- Once a hole is at sufficient depth, test fit the well with bottom cap secured.
- Using hack saw, cut top of casing to a height of <6 inches above the ground surface.
- Make sure the well casing is vertical and centered in the hole then begin to backfill with excavated soil. Care must be taken during backfilling to ensure no large voids are present.
- Bail well using bailer or small pump. Remove a sufficient amount of water so that groundwater refilling the well is largely clear and non-turbid.
- Attach pre-labeled aluminum tag to casing using wire.
- Because of displacement by the well casing some left over soil will be present. Excess soil must be scattered outside of the plot.

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SOP 9. Measuring Groundwater Monitoring Wells (Manual Measurements)

Version 1.0

Edward Gage and Jim Roche

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

To measure water levels within wells, two separate measurements are recorded on the Groundwater Depth Form: (1) a stick up height, referring to the distance from the top of the well casing to the ground surface, and (2) the distance from the water table to the top of the well casing. The groundwater depth is then calculated as the difference between the two readings.

Electronic water level readers can be obtained from commercial vendors, but are expensive and not really needed for shallow wells. A simpler approach that is better suited for use at remote sites is to use a water soluble marker or construction chalk to mark a steel measuring tape; when dipped into the well, the water level is indicated by where the ink or chalk has been washed away.

Equipment

- Clip board
- Pencils
- Data form (or personal computer for electronic entry) – see SOP 4 for form
- Engineers rule
- Construction chalk or soluble marker

Well Measurement

- Remove well cap and measure stickup height (ground surface to top of well casing); record value in the appropriate data field on field computer or paper forms. Where casing is uneven, mark location on inside edge well where measurement will be taken.
- Measure water table level in well and record value.
- Replace cap.

For well measurements taken during the same visit as well installation, measurements should be made as long after well installation as possible to allow time for groundwater equilibration. Because hydraulic conductivity can be low, the time between the initial augering and water table measurement should be recorded in the notes.

If a data logger is used, follow manufacturer instructions and procedures for installation and data downloading (See SOP 15 for data logger instructions).

SOP 10. Laying Out a Site

Version 1.0

Edward Gage, Peggy Moore, Jennifer Rains Jones, and Sylvia Haultain

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

Page

Figure SOP 10.1. Overview of steps in laying out a plot.. SOP 10.2

Figure SOP 10.2. Overview of plot design..... SOP 10.3

Figure SOP 10.3. Subplot corner rebar markers..... SOP 10.3

Figure SOP 10.4. Use of 50m tapes to establish macroplot corners. SOP 10.5

Figure SOP 10.5. Macroplot and microplot locations marked with pin flags, tapes, and microplot frame..... SOP 10.5

Overview

This SOP describes the procedure for setting up a plot for sampling vegetation at wetland ecological integrity (WEI) monitoring sites. These instructions apply to both newly established sites and revisits. For new site establishment, additional steps covered in other SOPs will need to be completed prior to or in conjunction with implementing the steps detailed here. Whether a revisit or a new site establishment, this SOP also assumes that the site has already been sampled for invertebrates prior to plot set up.

The overall approach involves delineating three nested plot sizes laid out using a compass and three field tapes or ropes measured and marked to the plot dimensions. The macroplot measures 10 m x 10 m (100 m²) and contains a 4 m x 4 m subplot (16 m²) and four microplots (1 m²; Figure SOP10.1). The layout involves setting up two field tapes perpendicular to one another and oriented along the cardinal (N, S, E, W) directions (Figure SOP 10.1).

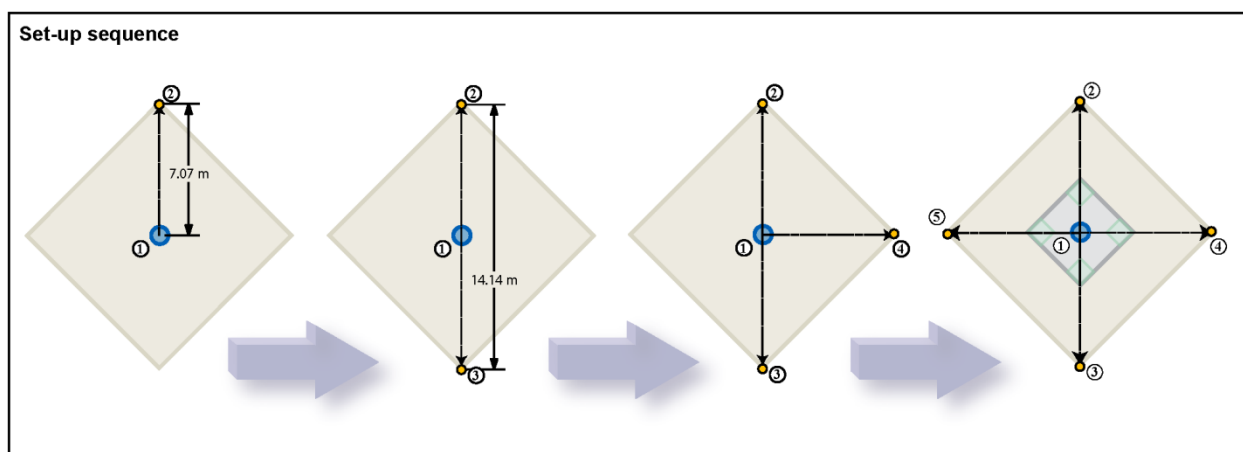


Figure SOP 10.1. Overview of steps in laying out a plot. Tapes are laid orthogonal to one another along cardinal directions. Once corners are established, tapes can be used to define the edges of the macroplot. Distances to subplot corners/microplot corners are measured from the well using tapes.

The groundwater monitoring well in the center of the nested plot design serves as the main monument for plot re-establishment (Figure SOP10.2). Marked corners of the subplot are monumented with an approximately 12 in. long piece of 3/8 in. diameter reinforcing bar (rebar) capped with an aluminum survey marker stamped with the initial of the cardinal direction. Broad flat washers, secured by two internal tooth lock washers are added to the rebar below the cap to help prevent markers from sinking below ground level (Figure SOP 10.3). The rebar is inserted into the ground so that the washers are flush with the ground. It is recommended that the lock washers, broad washers, and monument marker caps be assembled on the re-bar during pre-field preparations.

Generally, sampling procedures are the same in index sites and extensive sites. Because index sites are subjectively chosen, there is considerable flexibility in where index sites are established. Extensive sites must be established at the x, y coordinate in the GRTS sample list or within 20 m

of that coordinate to ensure the plot is at least 80 percent within the target wetland type. The groundwater monitoring well is in the center of the nested plot design.

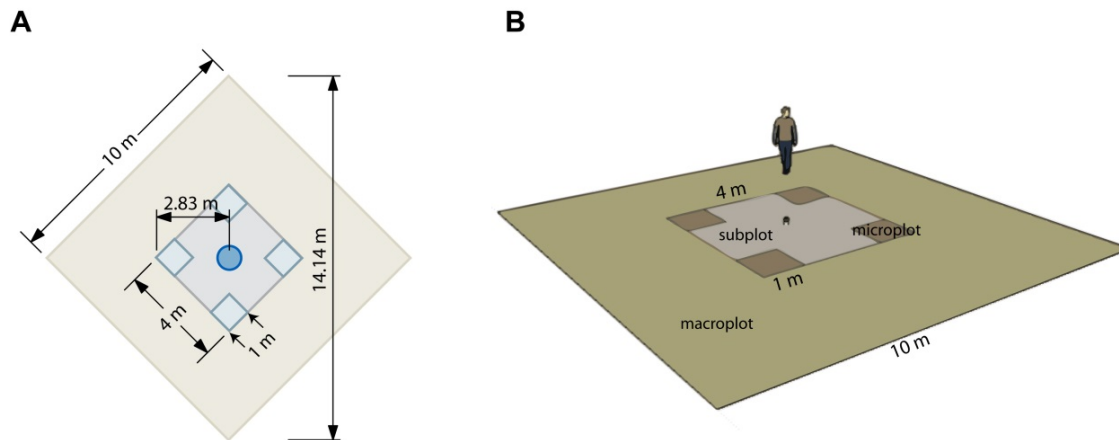


Figure SOP 10.2. (A) Overview of plot design. Landscape staples or pin flags are used to temporarily mark the corners of the macroplot; pin flags are used to temporarily mark the corners of subplots and microplots. (B) Oblique view of nested plot design.



Figure SOP 10.3. Left: Close-up image of subplot corner marker made from 12 in. long piece of 3/8 in. diameter rebar, aluminum survey marker cap, and flat washers secured by two internal tooth lock washers. Right: Image of entire rebar assembly showing location of washers relative to rebar length.

Equipment

- Compass with declination properly set (see SOP 2)
- Field tapes or lengths of parachute cord or mason's line knotted for plot corners (3 total)

- two tapes/cord 50 m in length
 - one tape/cord 20 m in length
- Reinforcing bar: 30 cm (12 inch) lengths of 0.95 cm (3/8 inch) diameter (4 pieces)
- Caps for the top of rebar, pre-stamped with each cardinal direction (N, S, E, W) (1 each = 4 total)
- Metal washers greater than 6 cm outside diameter with opening greater than 1 cm diameter (4 pieces)
- Internal tooth lock washers (8 pieces)
- 1 m² plot frame
- Landscape staples or large diameter nails to temporarily fix tapes.
- Pin flags to temporarily mark macroplot, subplot and microplot corners (12x)

Procedure

The steps described in this SOP assume that the field crew has confirmed that the point in question is of the target wetland type or that sampling is a revisit of an established site and that a well has been installed. Also, sampling for invertebrates should have already been completed.

- Using a compass, run the end of one 50 m tape or line due north (0°) for exactly 7.07 m from the center of the groundwater well housing. If this is the initial plot establishment, double check that tape is set along the correct azimuth. If this is a revisit, crew members will locate and flag a subplot marker at a distance of 2.83 m from the well to ensure that the same azimuth is being followed as during plot establishment. Avoid trampling the microplot vegetation while placing tapes.
- Temporarily anchor end of tape using nail, landscape staple or pin flag; walk tape spool due south (180°) 7.07 m from the well. Total length of the tape will be 14.14 m (Figure SOP 10.4).
- Using a compass, run the end of a 50 m tape due east (90°) for exactly 7.07 m from the well housing.
- Temporarily anchor end of tape using nail or pin flag; walk tape spool due west (270°) a distance of 7.07 m from the well housing. If this is the initial plot establishment, double check that tape is set along the correct azimuth. If this is a revisit, locate and flag the east and west subplot markers at 2.83 m in either direction from the well and temporarily mark with pin flags. These points correspond to the subplot and microplot corners. Avoid trampling the microplot vegetation while placing tapes.
- Delineate the sides of the macroplot using the 50 m tape or line.
- Attach the end of the 20 m tape to one corner of the subplot and extend to each corner to define the subplot perimeter.
- If establishing a new plot, monument the subplot corners by inserting pre-assembled rebar with surveyor's caps so that the washer is flush with the ground surface.
- Mark microplot locations by either using pin flags or by placing the microplot frame centered diagonally on the tape with the corner most distant from the well located on the subplot corner (Figure SOP 10.5).



Figure SOP 10.4. Use of 50m tapes to establish macroplot corners. Tape stretched due south (180°) 7.07 m from the groundwater monitoring well using a compass for the azimuth and using pin flags to anchor the tape. Surveyor's cap and washer attached to rebar (lower left) prior to setting washer flush with the ground surface. (USGS-Peggy Moore)



Figure SOP 10.5. Macroplot and microplot locations marked with pin flags, tapes, and microplot frame. (USGS-Peggy Moore)

SOP 11. Photo Point Documentation

Version 1.0

August 2009

Peggy E. Moore and Edward Gage

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures and Tables

Page

Figure SOP 11.1. Orientation of photo points taken at sampling locations. SOP 11.2

Table SOP 11.1. List of required photographs. SOP 11.1

Introduction

This SOP describes the procedure for taking and documenting digital photographs on sampling sites. Because camera technology changes rapidly, model-specific procedures and settings should be reviewed whenever new equipment is purchased and the user guide should be readily available to the crew for reference.

Photographs have two primary purposes. They are to be used to assist field crews in relocating plots by documenting plot appearance and positioning and notable landmarks or landmark features such as rock outcrops or large trees. Photographs also provide useful information regarding ecological processes such as the effects of changes in water table height and tree or shrub encroachment (Jakubos and Romme 1993, Zier and Baker 2006).

The protocol involves collecting photographs at fixed azimuths from the well at the center of the plot module as well as photographs of the macroplot and the microplots (Figure SOP 11.1). Additional photographs are taken to assist with relocation and to document site conditions. Photographs are also taken of obvious anthropogenic impacts such as ditches, diversions and exotic species within the assessment area.

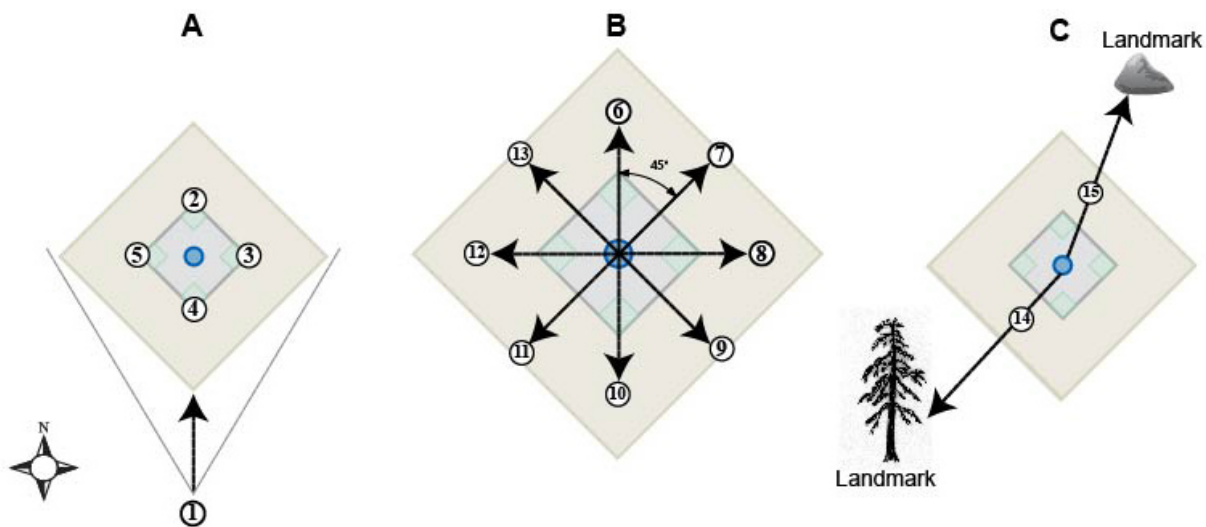


Figure SOP 11.1. Orientation of photo points taken at sampling locations.

Required photographs are taken during each visit; however, photos of diseased vegetation, landscape disturbances, or wildlife evidence or activity can clarify a description and should be taken whenever these and other observations are made. Photo-documentation provides the following benefits to the program (Acker et al. 2010):

1. A graphical depiction of aspects of the vegetation and the landscape context of each plot (i.e., a snapshot in time).
2. A graphical depiction of any nearby features that might prove significant in understanding changes that could occur within a plot, such as ecotones, potential sources of disturbance, and conspicuous landmarks.

3. Once out of the field, plot photographs provide a way to ‘revisit’ a plot if questions arise during data entry or analysis.
4. A method to graphically display apparent changes in the vegetative cover of a plot. Sometimes a picture will capture changes that have occurred when other sampling measurements do not capture the change.

One field biologist will be assigned the lead role for photo-documentation. Often other field biologists will shoot some of the required photos, but the lead biologist for this role is responsible for ensuring that all required photos are taken, and any good photo opportunities to illustrate the plot condition or landscape are utilized. The lead biologist for photo documentation should become familiar with the camera manual and guidelines for downloading and processing images (SOP 30).

Responsibilities of the Lead Photographer

The lead technician for the photo-documentation protocol will need to:

- a. Become proficient in the operation and features of the digital camera prior to going into the field, and must be skilled at the following functions of the camera: image resolution, image file size, exposure settings, white balance settings, focus control, zoom or wide-angle capabilities, and the ‘macro’ feature.
- b. Make sure that the data sheet is completely and correctly filled out, which is crucial to the photo-documentation process, and that any notes are entered into the project database at the end of each tour.
- c. Check that the correct date and time are entered in the camera.
- d. Ensure that a sufficient number of charged batteries and storage cards are brought into the field each field tour and each day.
- e. Ensure that the equipment is well maintained, and that the camera is stored in dry conditions during inclement weather.
- f. Be familiar with the methods and protocol, hardware and software required to download the images following a tour.
- g. Ensure that the images get correctly downloaded, copied, renamed, sorted, and entered into the database at the end of each tour, as described below.
- h. Be responsible for recharging the batteries such that they will be ready for use during subsequent field excursions.
- i. Make recommendations at the end of the field season about lessons learned and improvements to this procedure.

Guidelines for Shooting and Recording Photos

- a. Plot photos are taken before sampling the plot. It is essential that you take the plot photos before the measurements are made, so that images of the plot represent its state prior to any sampling-related trampling.
- b. Make every effort to minimize trampling within the plot while taking the photographs. Use single stances for multiple photographs when possible; take the photographs in an order that helps minimize trampling. Never trample the microplots.
- c. Consider Time of Day and on sunny days, earlier or later in the day is best. Photos should not be taken with the sun producing glare on the lens.
- d. If it is raining, ensure the camera does not get wet. Take advantage of any break in the rain to get images of the site.
- e. Before taking the photo, check that the zoom is set to 35 mm view angle. See camera manual for details concerning equivalency to 35mm for the standard shooting mode.
- f. Take photo from a standing position.
- g. Use a high resolution format for photos with a minimum resolution of 2048 x 1024. The typical file size of photos will range between 2 MB and 8 MB. Store images in TIFF format, if available, or a high resolution jpeg format. Field excursions can last for 8 days, and you must not exceed the storage capacity of available memory for images. There should be storage capacity for the required photos for all plots planned for the excursion, at a minimum of 16 photos per plot, plus room for additional photos.

Equipment

- Digital camera
- Camera batteries sufficient for field tour
- Digital photograph storage media with sufficient memory for field tour
- Compass, with declination properly set (SOP 2)

Camera Setup

Prior to visiting field sites, crews should synchronize the time between the camera and GPS unit so that dates and times match in subsequent data sets (i.e., in stored GPS data and digital images). Use either a 35 mm static lens or set the zoom lens to 35 mm (wide angle). Use auto-focus setting.

Procedure

In the case of new sites, the plot location has been confirmed as the target wetland type (i.e., wet meadow or fen) and the center point of the module (i.e., well location) has been marked temporarily with a stake. For site revisits, this SOP assumes that the crew has successfully located the well. In both cases, **plots are laid out** (i.e. meter tapes and flags placed at corners) **prior to the collection of photographs.**

- a. Identify the plot. The first photo for each plot should be a zoomed in image of a datasheet containing the site and well numbers, type of plot, park, date, and initials of the crew surveying. (i.e. SEKI-07-WM-243 06/20/2015 CC, CS, RK). Be sure this image is well-focused and legible; shade the datasheet to avoid overexposure.

- b. Photograph the plot. Take the photographs specified in table SOP 11.1 described below.
- c. Image number. Every photo that is taken must be recorded. The camera automatically assigns a number to each image. Record this number beside the photo code on the data sheet. If the photo is not represented by a code, for example landmark feature photos, write an abbreviated description of the subject being photographed.
- d. Image File Name. This is the file name that will be given to the image back in the office. Fill in the park and plot code on the data sheet, at least for the first photo. This will help facilitate image naming back in the office.
- e. Images. Total number of required photos is 16. Views are described below.

Required Photo Views

For list of required photographs, see Table SOP 11.1.

- a. First, take a full-frame photo of the sign with plot information
- b. Take a photo of the macroplot from south of the south corner with the well at the center of the photo and the flags at the east and west corners of the macroplot just inside the photo frame.
- c. Take 8 plot photos with the camera over the well and angled slightly down to include subplot corners and as much of the rest of the plot, horizon, and landscape setting as the 35 mm camera allows. Take one photo each at 0, 45, 90, 135, 180, 225, 270, and 315 degrees azimuth.
- d. With the camera over the well and angled down at approximately 45 degrees below horizontal, take one photo each of the north, east, south, and west microplots, centered on the microplots with the meter board placed at the subplot marker of each.
- e. With the camera above the well, take an image of the chosen landmark with either flagging or field crew member standing on or near the landmark as a reference. Choose permanent landmarks (e.g., bedrock or boulders) when possible or somewhat stable landmarks (e.g., prominent trees).
- f. From the chosen landmark, take an image of the plot, with the well at the center of the image. Record azimuth and approximate distance from landmark to the well.

Table SOP 11.1. List of required photographs.

Photo	Code	Description	Perspective
1	Sign	Plot code, date information	Full-frame plot sign
2	C	Macroplot centered on well	Horizontal-low*
3	0	From well at 0 degree azimuth	Horizontal-low**
4	45	From well at 45 degree azimuth	Horizontal-low
5	90	From well at 90 degree azimuth	Horizontal-low
6	135	From well at 135 degree azimuth	Horizontal-low
7	180	From well at 180 degree azimuth	Horizontal-low
8	225	From well at 225 degree azimuth	Horizontal-low
9	270	From well at 270 degree azimuth	Horizontal-low
10	315	From well at 315 degree azimuth	Horizontal-low
11	MN	From well centered on north microplot	45 degrees below horizontal***
12	ME	From well centered on east microplot	45 degrees below horizontal
13	MS	From well centered on south microplot	45 degrees below horizontal
14	MW	From well centered on west microplot	45 degrees below horizontal
15	Plot2LM	Landmark from plot; required at establishment only	Horizontal
16	LM2Plot	Plot from landmark; required at establishment only	Horizontal

* Photo of the macroplot from south of the south corner with the well at the center of the photo and the flags at the east and west corners of the macroplot just inside the photo frame

** Perspective from center of plot should include subplot corners and as much of the rest of the plot and horizon as the 35 mm angle allows

***Perspective from center of plot should include all of each microplot and enough of the meter board, placed at the subplot marker, to display the vegetation height

Additional Photographs

Record camera location, image number, and description of each additional photo subject on the photograph data sheet. Although additional photographs are not required, take photos if they help describe or clarify plot characteristics, or work being conducted.

- If there are landmark features, take photographs from the well towards any landmark features and from landmark features towards the well/plot center and record the distance, azimuth and subject of each photograph. Take photographs for at least one landmark.
- Photograph any ecotones with non-meadow types that occur within the 1 ha assessment area and photo-document any noteworthy physiographic features in relation to the plot such as oxbows, channels, or hummocks. Take photographs of any specific stressors encountered during the initial reconnaissance of the wetland. This includes features seen within the wetland and within 100 m of the wetland margin.

- c. Take two to four photos at some distance from the plot showing the landscape context and vegetation mosaic in the vicinity of the plot. The distance and direction of these photographs will obviously depend upon what aspect gives the best overall picture of the area. Record distance from the well and azimuth relative to the well.
- d. Take photos to illustrate interesting, rare, or diagnostic plant species, disturbance, etc.
- e. Occasionally photograph crew members implementing protocol.
- f. Record a GPS point for photos taken far from the plot. Record in the additional photograph form: the camera location, image number, azimuth of the image (direction photograph was taken), a brief description of the subject, the GPS file number, and the unique label for that photograph within the GPS file for units where that is an option).

Literature Cited

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- Jakubos, B., and W. H. Romme. 1993. Invasion of subalpine meadows by lodgepole pine in Yellowstone National Park, Wyoming, USA. *Arctic and Alpine Research* 25(4): 382-390.
- Acker, S. A., A. Woodward, J. R. Boetsch, K. Hutten, M. Bivin, R. Rochefort, C. C. Thompson, and L. Whiteaker. 2010. Forest vegetation monitoring protocol for the North Coast and Cascades Network. Natural Resource Report NPS/NCCN/NRR—2010/242. National Park Service, Fort Collins, Colorado.
- Zier, J. L., and W. L. Baker. 2006. A century of vegetation change in the San Juan Mountains, Colorado: an analysis using repeat photography. *Forest Ecology and Management* 228(1-3): 251-262.

SOP 12. Vegetation Sampling

Version 1.0

Edward Gage, Jennifer Rains Jones, and Jonathan Nesmith

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

Page

Figure SOP 12.1. Overview of plot layout indicating key vegetation attributes measured in each plot type.....SOP 12.4

Figure SOP 12.2. Estimating plot cover.....SOP 12.5

Introduction

This SOP provides step-by-step instructions for sampling the composition and abundance of vascular plant species groundcover variables found in permanent plots. Separate SOPs have been developed for sampling bryophyte species richness (SOP 13) and voucher specimen collection (SOP 14).

This SOP is focused on several specific attributes: plant species composition and absolute abundance, which is collected using ocular estimates of canopy cover, absolute cover of different groundcover types, and counts of tree seedlings (<1.37 m) and mature trees (≥ 1.37 m). Some of these variables are measured at different scales (i.e., microplot, subplot, macroplot) using multiple metrics (percent cover, cover class, counts).

General Guidelines

- Refer to SOP 10 (Laying Out a Site) for step-by-step instructions for laying out the vegetation sampling plots.
- Different species reach maturity or flower at different times during the growing season, complicating data collection. Some species may be present but not identifiable because of the lack of distinguishing parts such as flowers or fruits, which are critical for identification of some species. It is important to set a sampling period that corresponds to peak maturity of as many taxa as possible. This varies with elevation and is a key variable in planning the field schedule.
- A multi-scale, nested plot design is used to capture species composition and cover at various scales (Figure SOP 12.1). Canopy cover to the nearest percentage point of all plant species (vascular plants and bryophytes) is collected in four 1 m² microplots. Canopy cover by cover class (<1, 1-5, 6-25, 26-50, 51-75, 76-95, 95-100) of vascular plants and presence absence of bryophytes is recorded in the 100 m² macroplot.
- The boundaries of the microplots are delineated prior to sampling by a 1 m² plot frame marked at 10 cm increments to aid in ocular cover estimates. The subplot and macroplot corner marking and perimeter delineation are described in SOP 10.
- Cover is defined as the vertically-projected outline of the foliage onto the ground for individual species, expressed as a proportion of the plot area (Peet 1998). Cover is estimated to the nearest percent for each vascular plant species separately as an integer between 1% and 100% within the four microplots (Figure SOP 12.2). Cover is recorded as the average percentage (0.5, 3, 15.5, 38, 63, 85.5, 98) of each cover class for each vascular plant species separately within the macroplot. Due to dense vegetation cover found in many wetlands in the region and multiple herbaceous strata, the sum of all species cover may exceed 100%. Cover for individual vascular plant species may not exceed 100%.
- Plant nomenclature and species coding follows that used by the USDA in the Natural Resource Conservation Service (NRCS) PLANTS database (USDA NRCS 2017).
- A current, complete list of vascular plants observed in Yosemite, Sequoia, and Kings Canyon national parks, and Devils Postpile National Monument and their associated NRCS PLANTS codes is 1) uploaded annually in field computers for reference and data entry during vegetation sampling and 2) carried in hard copy with paper field forms in the

event field computers are not available during sampling. These lists are obtained each year from the appropriate subject matter expert in each park. These lists will indicate which species are considered invasive for reporting following procedures described in SOP 7.

- Each species encountered for which the identity is uncertain (and for which there are sufficient individuals present to tolerate collecting pressure - at least 25) must be assigned a collection number and be collected for positive identification. Follow the procedures for collecting vouchers as outlined in SOP 14. Record all collection numbers in the Voucher field in the computerized form or column on the datasheet, leaving room for annotation post identification. Also record as much species information as you have in the Species column. Do not collect plants within the permanent plot; make all collections from outside of the plot boundaries. If that is not possible, photograph any unknown plants. Some taxa may only be identifiable to the family or genus level due to phenology (e.g., lack of development of key characteristics). If taxa cannot be identified, they are described as unknowns and assigned cover values in each plot in which they are encountered. If phenologically undeveloped taxa have enough defining characteristics that they may be compared later to more developed samples, they should be collected as defined in the voucher specimen collection SOP 14 and retained for comparison with more mature specimens.
- Plants with foliar cover in the plot rooted in or outside of the plot are included in cover estimates. For mature tree and seedling tallies, individuals are counted only when a majority of the tree/seedling's stem is rooted within the plot.

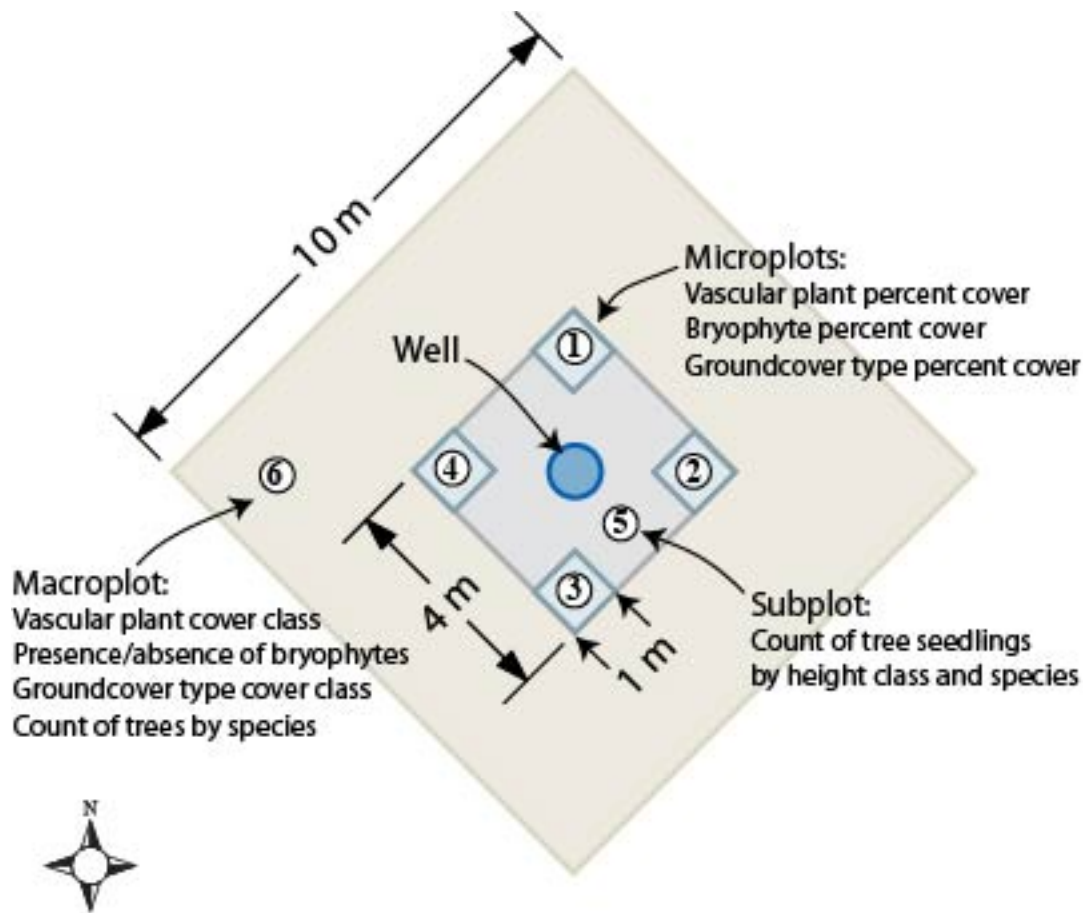


Figure SOP 12.1. Overview of plot layout indicating key vegetation attributes measured in each plot type (e.g. macroplot, subplot, microplot).



Figure SOP 12.2. Estimating plot cover. Estimation should be performed by looking at the entire plot from above and assigning cover to each species individually and then inspecting the plot closer for smaller, less evident species. Note that the observer is standing outside of the subplot while reading the microplot.

Equipment

- Plot data forms
- Pencils
- Permanent marker for labeling plant collections
- Clipboard
- Field computer with vegetation data entry software installed
- Plant identification guide(s)
- Plant press with newsprint and blotters
- Percent cover (salt-and-pepper) diagrams for estimating cover

Steps

Lay out site. Refer to SOP 10.

- Begin by recording percent cover for each vascular plant species encountered in each microplot, starting with plot #1 (due north), and working clockwise through plots #2 (east), #3 (south), and #4 (west).
- Record percent cover for each bryophyte species encountered in each microplot (SOP 13).
- Record total absolute cover to the nearest percentage point for the following groundcover parameters in each microplot:

- Percent rock: Estimate the percent cover of all rock fragments larger than 6.4 cm (~2.5 inches) diameter.
 - Percent gravel: Estimate the percent cover of all rock fragments between 2 mm - 64 mm diameter.
 - Percent bare: Estimate the percent cover of bare mineral soil less than 2 mm diameter.
 - Percent bare peat: Estimate the percent cover of bare peat. In practice, this is usually peat that has been exposed by disturbance, such as being dug up by animal activity.
 - Percent litter: Estimate the percent cover of litter. In the context of this protocol, litter includes all downed dead plant herbaceous material laying on the soil surface plus all woody material less than 1 cm diameter.
 - Percent standing dead: Estimate the percent cover of standing dead plant material.
 - Percent wood: Estimate the percent cover of dead, down wood that is greater than 1 cm diameter.
- Tally the number of tree seedlings (<1.37 m) by height class (<10, 11 – 25, 26 – 50, 51 – 75, 76 – 100, 101 – 136 cm) and species in the subplot.
 - Record the absolute cover by cover class of all vascular plant species that occur within the macroplot.
 - Record the presence/absence of all bryophyte species that occur in the macroplot.
 - Record the absolute cover by cover class for the groundcover parameters in the macroplot.
 - Tally the number of mature trees (≥ 1.37 m) by species in the macroplot.

Literature Cited

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USDA NRCS. 2017. The PLANTS Database (<http://plants.usda.gov>, 05 January 2017). National Plant Data Team, Greensboro, NC 27401-4901 USA.

SOP 13. Bryophyte Sampling

Version 1.0

Edward Gage and Jennifer Rains Jones

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

Page

Figure SOP 13.1. Schematic diagram of a fen with well-developed microtopography.....
.....SOP 13.3

Figure SOP 13.2. Bryophyte collection label for voucher samples collected in the field.....
.....SOP 13.4

Introduction

This SOP describes the procedure for documenting bryophyte diversity and abundance in the 1 m² vegetation microplots and the 100 m² macroplot. Because moss identification is challenging, requiring examination under magnification and training not possessed by all botanists, the procedure relies heavily on collecting samples for outside expert analysis. The methods are appropriate for any wetland type with measurable bryophyte cover.

General Guidelines

- Cover is defined as the vertically-projected outline of the foliage onto the ground for individual species, expressed as a proportion of the plot area (Peet 1998). Within the microplots, cover is estimated to the nearest percent for each bryophyte species separately as a number between 1% and 100%. Although the sum of all species cover may exceed 100%, cover for individual bryophyte species may not exceed 100%. Presence/absence is recorded for all bryophyte species within the macroplot.
- Different bryophytes often occupy distinct niches on hummocks or peat mounds (Vitt et al. 1975, Andrus et al. 1983) and often segregate along gradients of water table depth and water chemistry. Targeting these microhabitats may help in detecting different taxa within a plot (Figure SOP 13.1).
- All species encountered that are unknown, or their identity is uncertain, must be assigned a collection number and vouchered for later positive identification. Refer to SOP 14 for specific details involving making voucher collections of non-vascular species.
- Bryophyte collection envelopes made of water resistant (e.g. *Rite in the Rain* paper) with pre-printed labels are made up in the office prior to field sampling (Figure SOP 13.2). This allows samples to be efficiently stored as well as sent out to subject matter experts for determination.
- Plant nomenclature and species coding follows that used by the USDA in the Natural Resource Conservation Service (NRCS) PLANTS database (USDA NRCS 2017).
- A current, complete list of bryophytes observed or expected to occur in Yosemite, Sequoia, Kings Canyon national parks and Devils Postpile National Monument and their associated NRCS PLANTS codes is 1) uploaded annually in field computers for reference and data entry during vegetation sampling and 2) carried in hard copy with paper field forms in the event field computers are not available during sampling. These lists are obtained from the appropriate subject matter experts within each network park.

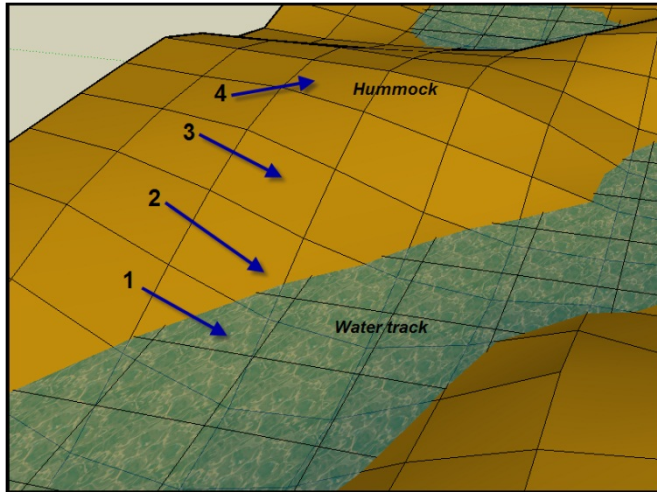


Figure SOP 13. 1. Schematic diagram of a fen with well-developed microtopography. Searches for different species are focused along topographic and hydrologic gradients, such as the water track to hummock top gradient (points 1-4) illustrated in the figure.

Equipment

- Water resistant (e.g. *Rite in the Rain* paper) bryophyte collection envelopes with pre-printed labels
- Pencils
- Knife or similar collecting tool
- Black indelible marking pens

Steps

- Begin by recording absolute cover to the nearest percentage point for each bryophyte species encountered in each microplot, starting with plot one (due north), and working clockwise through plots #2 (east), #3 (south), and #4 (west). This should be done concurrently with the vascular plant sampling.
- Survey the entire 100 m² macroplot area while walking slowly through the plot, paying special attention to areas that appear to have different hydrology or microtopography than the microplots (Figure SOP 13.1). Record presence/absence for each bryophyte species encountered in the macroplot.
- Collect voucher specimens for each taxon encountered on the plot.
- Complete a field label for each specimen (Figure SOP 13.2) on pre-printed collecting envelope.
- Set specimens out in an aerated setting to dry. Before leaving the plot, package specimens in a nylon stuff sack or rigid plastic container for transport back to the lab. Make sure samples are carefully transported to prevent breakage.

**Sierra Nevada Inventory and Monitoring Network
Wetland Ecological Integrity Monitoring
Bryophyte Collection Envelope**

Admin. Unit: Devils Postpile Kings Canyon Sequoia Yosemite

Taxon: _____

State: California **County:** _____ **WEI Visit ID#:** _____

Location: _____

UTM e: _____ **UTM n:** _____ **Zone:** _____ **Datum:** _____

Substrate & Site Characteristics (circle all that apply):

Soil: mineral soil, gravel, sand, loam, silt, litter, duff, humus, peat, moss, or litter-fall

Rock type: granitic, metamorphic, calcareous _____

Rock feature: outcrop, boulder, cliff, crevice, ledge, talus, or under-hang

Light: full sun, partial shade, full shade **Elevation:** _____ ft. **Slope** _____ % **Aspect:** _____ °

Topography: meadow, ridge, slope, trail, or valley

Habitat: fen, dense/open forest, lake/pond, meadow, seep, spring, swamp, waterfall stream/creek/river (intermittent), wetland, seasonally wet area, splash zone, or submerged

Site Moisture Regime: dry, mesic, moist, or wet

Collector: _____ **WEI Coll. #:** _____ **Date:** _____

Verified by: _____ **Date:** _____ **Notes:** _____

Accession # _____ **Catalog #** _____

Figure SOP 13.2. Bryophyte collection label for voucher samples collected in the field.

Literature Cited

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SOP 14. Collecting Voucher Specimens

Version 1.0

Edward Gage and Jennifer Rains Jones

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This Standard Operating Procedure describes the procedures for vouchering vascular and non-vascular plant species in permanent vegetation monitoring plots in the Sierra Nevada Network (SIEN). Voucher specimens serve two essential roles that are especially pertinent to long-term monitoring programs:

1. Specimens allow the positive identification of taxa using tools and references that are not available in the field, including comparison with reference collections. Correct identifications are essential to preventing the reporting of false occurrences that may then be misinterpreted as changes in composition over time.
2. Specimens serve as a tangible, geo-referenced record of species occurrences. The voucher is more reliable than a field observation of an occurrence because it is verifiable and can be re-determined should changes in taxonomy or nomenclature occur.

General Guidelines

1. The field crew maintains two series of collection numbers – one series for vascular plant collections, and one series for non-vascular plant collections. The lead technician is responsible for assigning and tracking the collection numbers and associated collections.
2. The lead technician maintains a collection notebook listing each collection, its identity, collection site, date, and description throughout the field season. These records are also maintained on the voucher labels and within the electronic data forms. This notebook is maintained in a series of sequentially numbered Rite-in-the-Rain Field notebooks. The following format is used for assigning collection numbers: initials-year-series. For example, “JB-09-001” reflects the 1st collection of the worker Jennifer Brown in the year 2009. In the field notebook, each collection is assigned a number and a preliminary field identification. The date and plot number where the collection was made are also recorded for each collection, along with any characteristics needed for identification. On the datasheets, it is critical to enter the unique collection number in all of the appropriate fields so that if changes are made to a species determination, they can be made across all data streams that are affected by the change.
3. Unless the identity of a taxon is known with absolute certainty, and the characteristics that distinguish the species from other morphologically similar taxa are known to the observer, the species is assumed to be unknown and a voucher specimen is collected. Similarly, if it is not certain that two plants are of the same species, a voucher collection is required. There is no substitute for proper vouchering of plant species observed in the field, because the permanent record of the specimen can always be referenced and different names can be applied if taxonomic changes occur. If there is any doubt of a species’ identification, a voucher specimen is collected.
4. Except for the most common and the most easily identifiable taxa, all species encountered within a site should have at least one voucher specimen. For annual panel sites that are visited every year. Vouchers of all species should be collected once every four years. Whenever a new species is detected, it should also be vouchered.
5. Certain taxa cannot reliably be identified in the field and must be collected in order to make a definitive determination of species identity. This is especially true for non-vascular plants, whose identification often requires the use of chemical tests and

compound microscopes, and many of the wetland sedges, which have cryptic and often highly variable characteristics.

Vascular Plant Specimens

1. When it is necessary to collect a particular taxon, search for it outside the boundaries of the permanent plot. Avoid collecting in the plot unless there is absolutely no other choice.
2. There must be more than 25 individuals present in an area in order to take a whole plant as a specimen. When it is not appropriate to collect a specimen because of the small population size and presumed vulnerability, photograph the plant, taking care to capture key diagnostic characteristics.
3. Specimens should provide as complete a representation of the full plant as possible, including all reproductive and vegetative structures required to make a positive determination. If possible, find individuals that have both flowering and fruiting structures present, and include the roots of the plant in the specimen. Assume that the specimen will become a permanent collection that will be accessioned into the parks herbarium. Take the time to carefully collect and handle the specimen so that a voucher of high quality can be produced. Keep notes concerning morphology or characteristics not observable on the collected materials. For example, if a branch from a tree or shrub is collected, note the stature and growth form of the complete individual in the collection notebook. Color of structures that may change with drying should also be noted.
4. Where possible, multiple plants should be included in the voucher collection. This will allow for destructive examination of a subset of the individuals, with at least two individuals remaining for the permanent voucher specimen.
5. Carefully excavate and collect each specimen, gently removing soil and debris from the roots. If necessary, specimens may be placed in a 2-gal Ziplock[®] style re-sealable plastic bag for temporary storage, as long as the bag is carefully labeled and collections are not mixed together.
6. All specimens must be pressed upon return from fieldwork (on the same day). Do not let the specimens sit overnight in the plastic bags. Place each collection in a separate sheet of newsprint, arranging each plant on the sheet so that it will dry in a shape that reflects its natural state and displays the reproductive structures. Slice thick parts, such as tap roots and thick stems, lengthwise and spread them out so they will dry easily. Label the outside of each sheet with permanent pen, recording the collection number, date, site number, and field determination. Take care to write legibly.
7. When assigning a field determination to an unknown taxon, provide the most detailed level of taxonomy that is known for the plant plus a useful descriptor. This facilitates sorting of the specimen during pressing, and can aid in later identification.
8. Using the above method for assigning field identifications allows for the referencing of the code and collection number repeatedly, if the same taxon is encountered in a subsequent subplot or microplot in the same site. It is critical that any subsequent references to the taxon are for exactly the same species, otherwise additional vouchers must be made. It is acceptable to voucher an unknown taxon multiple times, if field workers are not confident of the identity of the taxon. This is preferable to having one name applied to several taxa due to under-vouchering.

9. Once all specimens are pressed, firmly tighten the straps on the field press so that pressure is placed evenly across the cardboards. Avoid over-tightening the press because it prevents airflow and any subsequent drying of the specimens. During the day, place the press so that air can move through it, but so it won't get wet if the weather turns.

Non-Vascular Specimens

1. Once you have determined you are going to collect a particular taxon, search for it as follows: first, search outside the macroplot area. If the species is not positively found within several minutes, begin searching within the macroplot area. If any uncertainty exists in positively collecting an unknown species outside of the microplot or macroplot in which it was originally observed, make a judgment call as to whether there are enough individual specimens of that species that could be collected from within the micro- or macroplot to make a positive identification, while not significantly altering the overall abundance of the specimen within that plot. If it is reasoned that there are enough individual specimens of the species to obtain a positive identification, then carefully proceed with the collection. Always err on the conservative side when deciding whether or not to collect voucher specimens within the plot area.
2. Collect enough well developed, representative specimens to adequately fill a 10 cm by 15 cm bryophyte voucher envelope. Whenever possible collect material which also has reproductive structures, which are often important for later determination (sporangium, gemmae, apothecia, sordia, etc.). There should be enough material in the voucher to allow for adequate destructive sampling for determination requirements, but still allow for an unaltered permanent collection record to be retained.
3. Carefully remove the specimen from the substratum, using a pocket knife if needed, to pry the specimen loose. After the specimen has been cleaned of extraneous matter (soil, detritus, etc.), place it into a bryophyte voucher envelope. Fill out all applicable sections on the voucher, most importantly Site ID, collection number, and subplot or microplot location. Confirm that the voucher envelope is labeled with a unique collection number, and then reference it accordingly in the datasheet column "Species".
4. Once a plot survey is finished, look through all vouchers one last time to make sure that all applicable sections of the collection envelope are filled out, and that all collection numbers have been referenced accordingly on the datasheet.
5. All bryophyte vouchers collected during a day should be stored in a secure container, such as a stuff sack, extra-large Ziplock[®] style re-sealable bags, or rigid plastic storage container.
6. At the end of each field day, voucher collections should be stored in a covered, dry area (e.g., tent) and allowed to have access to fresh air for the duration of the field trip. Vouchers stored in Ziplock[®] style re-sealable bags during the day should be carefully removed and stored. Fresh air will facilitate drying of specimens and reduce the chances of them developing mold.

Field Equipment

1. Plant Press
2. Newspapers
3. Cardboard ventilators
4. Felt spacers
5. Hand lens
6. Trowel or digging knife
7. Stuff sacks and extra-large Ziplock[®] style re-sealable plastic bags
8. Non-vascular voucher envelopes with pre-printed labels
9. Sharpie[®] style permanent marker pen

SOP 15. Data Logger Installation, Calibration, and Download

Version 1.0

Jim Roche, Jeff Holmquist, and Edward Gage

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

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Figure SOP 15.1. Illustration of a typical deployment of the Solinst Levellogger gold unit used in SIEN pilot studies.....SOP 15.3

Introduction

This SOP provides information related to monitoring of groundwater or surface water using continuous data loggers. A continuous record of water level in groundwater monitoring wells or stream stage is obtained through the use of instruments capable of recording water-surface elevation. Several commonly used instruments sense water depth through pressure transducers including models produced by Global Water, HOBO, and Solinst. This technology requires barometric pressure compensation, necessitating the use of vent tubes or an additional unit placed at atmospheric pressure for calibration, adding significant costs. Alternative technologies are available, but are relatively untested for use in wetlands in the region. All of these units can be used successfully, and issues of cost or other circumstances may dictate choice of instruments. Since the technology will inevitably change over time and manufacturers will introduce new products, users must refer to product documentation from the unit manufacturer for specific information on calibration and operation. Currently, the Sierra Nevada Network (SIEN) has chosen to use Solinst leveloggers (see Figure SOP 15.1) because these are already in use in Yosemite National Park in monitoring wetland wells associated with research and restoration projects, and they have been found to be more reliable and longer lasting than the HOBO loggers. Solinst also has the capability for a direct read cable feature that is not available with HOBO.

Fluctuations in water tables and the levels of streams, lakes, and ponds are important drivers of ecological processes in wetlands. A hydrograph, the graphical representation of water levels in a stream or a wetland over time, provides important information. Continuous data is far more useful than isolated measurements, as seasonal fluctuations in water tables are often more important than mean, min, or max levels. Currently, data loggers will be installed in all annually visited sites (Annual Panel, DEPO Index site). The use of data loggers is recommended in the alternating panel sites when resources allow, as they allow for more efficient and higher resolution data collection.



Figure SOP 15.1. Illustration of a typical deployment of the Solinst Levellogger gold unit used in SIEN pilot studies. Two loggers are required: one to measure atmospheric pressure changes (1 in figure), and a second submerged in the well (2). Data are downloaded to small personal computer or laptop (3). More information is available at: <http://www.solinst.com/Prod/3001/3001-data-loggers.html>

Equipment

- Data logger
- Laptop or field computer with appropriate software loaded
- Appropriate cable for data download and calibration
- Extra batteries
- Tape measure (with gradations in cm)
- Water level indicator for manual well measurement.
- Teflon coated stainless steel cable or similar non-reactive, non-stretching cable
- Bolt that is ½ inch longer than the outside diameter of the well casing; wingnut to fit bolt
- Drill and drill bit sufficient for above bolt
- Sharpie
- Leatherman-type tool w/ wire cutters
- cable ties
- field instructions
- well data logger field sheet (Figure SOP 4 A.6)
- clipboard

Installation Steps

- Make sure that equipment is calibrated, either at the factory or by the user following guidance from the manufacturer.
- Many data loggers require atmospheric pressure compensation in order to produce accurate data. Some models have integrated vent tubes to allow the logger to automatically adjust for atmospheric pressure changes. Other models require that a separate unit be placed above ground to record atmospheric pressure changes. These data are subsequently integrated with loggers placed inside well casings to calibrate well measurements.
- Follow manufacturer specific guidance regarding installation.
- Establish a specific download schedule for all loggers placed into the field. At present, loggers are planned at all annually visited sites and data download, software upgrades, and equipment inspection will occur during the annual visits.
- Before installing the logger, set the logger time to Pacific Standard Time (PST), set the logging interval to 1 hour, set the elevation of the logger (model dependent), and set the logger to start on the next hour (future start logging).
- Measure the depth to water from the top of casing to the nearest millimeter. Record the time (PST).
- Drill a hole through the top of the casing just below the level of the cap. Fit the hole with a bolt and wing-nut. This is best done during pre-field preparations.
- Suspend the data logger from the bolt using a cable sized so that the logger is several centimeters from the bottom of the well (the logger sensor must be suspended not resting on the bottom of the well).
- Note the time of installation of logger in PST.

Data Download Steps

General Instructions: Applicable to Any Type of Logger

- Refer to the well-logger maintenance instructions and field sheet for the particular model in use.
- Record water level from the top of the casing to the nearest millimeter and the time in PST.
- Remove the logger and follow downloading instructions for the particular in use.
- Record the logger time and date and the current time and date.
- Record the logger model, name, and serial number.
- Restart the logger following the above instructions. The logger should start on the hour, the recording interval should be an hour, and the logger time and date must match the current time and date. Logger time must be in PST.
- Reinstall the logger in the well. Note the time in PST.

Specific Instructions: Solinst Levelloggers:

1. Upon arrival at a well with a data logger, record the date, time (Pacific Standard Time), the wetland name, and well ID, if available. (Note: Pacific Standard Time is one hour earlier than Pacific Daylight Time. **Record all times as Pacific Standard Time in 24-hour format.**)
2. Without removing the data logger, measure the depth to water below the top of the well casing on the north side of the well. If the logger must be removed to read the water level, wait at least 15 minutes before reading. Also measure the stickup, the distance from the ground surface to the top of the well casing, again on the north side. Record both values and the units.
3. Connect the data logger to the Leveloader using the appropriate cable. Turn on Leveloader and select “Leveloader Setup” in the Leveloader Gold Menu to verify date and time of the leveloader. Edit as needed. Return to the main menu.
4. Next, select “Connect to Logger”, then “Edit Levellogger”. Record the logger brand (Solinst in most cases), the data logger name (e.g. SIEN LL5), the serial number (e.g. #1026227), and the Levellogger Date and Time. Record the actual time in Pacific Standard Time. Return to the Levellogger Menu. Select “Info from Levellogger” to record the battery level.
5. To download data from the data logger, select “Data from Levellogger”, then “Save Log.” Record the download time in “Log End Time” space on the form. Verify that the file has been saved by returning to the Leveloader Gold Menu and selecting “View Stored Data”. Select the Log ID associated with the data logger serial number.
6. Before leaving the site, start a new log. First verify logger settings: a) select “Edit Levellogger” in the Levellogger Menu, b) edit time and date if necessary by ‘sync’-ing the logger to the loader, c) verify/edit logging interval (should be 15 minutes), d) logger location (if changed), e) logger altitude (if changed). Return to Levellogger Menu. Select “Restart Levellogger”, then “Future Start Logging”. Set the start date and time to the next 15 minute interval (e.g. if the time is 12:37 PST, set the start time to be 12:45). Verify the date.

SOP 16. Aquatic Invertebrate Sampling: D-Frame Dipnet

Version 1.4

Jeff Holmquist and Jutta Schmidt-Gengenbach
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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	3 June 2007	Holmquist	Modified field procedures and data sheet	New information gained from initial implementation and vegetation and hydrology SOPs	1.1
1.1	5 Oct 2007	Holmquist	Modified field procedures	New information gained from first full summer of implementation	1.2
1.2	6 March 2008	Holmquist	Modified references and other minor changes	New literature available	1.3
1.3	4 July 2008	Holmquist	Modified field procedures and data sheet	To improve documentation of aquatic sites and speed data entry	1.4

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Introduction

This SOP gives step-by-step instructions for sampling the aquatic arthropods associated with flooded portions of meadows. Invertebrate assemblage data are collected in conjunction with the vegetation sampling schedule, because both sampling components utilize the same design and because co-locating plots within wetlands is both more efficient and allows relationships among fauna, flora, and physical characteristics to be explored. This SOP describes the procedure for collecting data and filling in Data form “Aquatic Invertebrate Data Collection Form.”

The D-frame dipnet (EPA 2002, Hoffman et al. 2005, Merritt et al. 2008) will be the primary tool used for aquatic invertebrate sampling. These samples can be collected quickly by experienced crews (EPA 2002, Hoffman et al. 2005) and the apparatus is transportable, and like sweep nets, integrates samples over a relatively large area, creates no wilderness issues, is easily mastered by field crews, and provides reproducible data with variances that are no higher than those produced by intensive sampling methods such as throw trapping (Holmquist and Schmidt-Gengenbach 2006). This technique is the most common method used in sampling shallow, vegetated freshwater wetlands (EPA 2002) and was chosen for the WEI Protocol after comparing several sampling methods in the field.

Equipment List

Field

- Random number table or electronic equivalent
- Waders (front country) and Neoprene booties or equivalent (backcountry)
- D-frame aquatic net with a 30.5cm diameter aperture (Figure SOP 16.1) and 178cm two-piece handle (BioQuip #7512D). The net/handles separate into 81 and 97cm sections. Mesh size is 0.5x0.5mm.
- Collapsible 11.4 liter bucket with handle (e.g., Seattle Sports Pocket Bucket; REI #685002) to hold sample prior to sorting and for disinfecting gear for both the invertebrate and the vegetation/hydrology team
- Small tape measure (e.g., 3’ Stanley Powerlock #33-115)
- Small aquarium dipnet (approx. 10x8cm) with an approximately 30cm handle and mesh size of 0.5x0.5mm
- Shallow plastic storage container (e.g., Rubbermaid 4022; 30x20x7cm, 2.7 liter) for sample sorting. Lid not necessary. The exterior bottom should be painted white to enhance visibility of fauna.
- Two featherweight sorting forceps (e.g., Fine Science Tools #26029-10) that bend away from, rather than damaging, specimens. Flagging attached to prevent loss.

- Pieces of 100% rag content card stock (3.5x5.0cm) for scooping specimens from sample
- Thirty ml (1 oz.) glass jars with polypropylene lid with Teflon liner (e.g., Qorpak #2S01QEDC)
- Non-denatured, 95% alcohol for partially pre-filling jars
- Lexan or Nalgene container (~200ml) containing supplemental alcohol
- Eye dropper
- Labels, 100% rag content. At a minimum, each label should include sample number, date, and sampling device.
- Electrical tape
- Clipboard
- Data sheets (Appendix SOP 16.A). Include a few Rite-in-the-Rain or Nalgene Sheets (e.g., BioQuip #1165E). To prevent confusion between “Rite-in-the-Rain” paper and regular paper, pencil in an “R” for “Rain” in one corner of the Rite-in-the- Rain paper.
- Mechanical pencils with replacement lead and erasers
- GPS receiver
- Compass

Lab

- Tissue culture dishes with lids: 35x10 mm (e.g., Falcon #3001) and 60x15 mm (e.g., Falcon #3002)
- Watch glasses with lids: 60x28mm and 33x10
- Wash bottle (250ml; e.g., Fisher Scientific #03-409-22B)
- Illuminated magnifying glass (e.g., BioQuip #1129L)
- Non-denatured, 70% ethanol
- Research grade dissecting microscope with flexible fiber optic lighting, ring light, and ocular micrometer. Magnification to at least 80x. The importance of a high quality microscope cannot be overemphasized; data will be lost without access to research grade optics.
- Research grade compound microscope with oil immersion - magnification to at least 1250x
- Fine-point dissecting forceps: Dumont #5 Biologie tip, Inox (e.g., Fine Science Tools #11252-20) is highly recommended
- Teasing needles (e.g., BioQuip #4751)
- Insect pin holder (e.g., Thomas) for use with 0.15mm diameter insect pins (“minutens” e.g., BioQuip #1207SA) as delicate teasing needle
- Slides: general purpose (76x25mm) slides; e.g., BioQuip #6351A); depression slides (76x25mm; e.g., BioQuip #6330A); thin (No. 1) cover slips (22x22mm; e.g., BioQuip #6341B)
- Glycerin for wet mounts
- Eye droppers (e.g., BioQuip #4775)

- Tally counters; at least three six-unit banks (e.g., McMaster-Carr #1714T15)
- Vials with polyethylene-lined caps: 1 dram (4.5ml; 15x45mm; e.g., BioQuip #8801P); 2 dram (9ml; 17x60mm; e.g., BioQuip #8802P)
- Parafilm “M,” 5cm width (Fisher Scientific #13-374-16)
- Unit vial trays with partitions for 1 or 2 dram vials (e.g., BioQuip #1025AV)
- Taxonomic references (Appendix B)
- Mailing supplies including electrical tape, bubble wrap, mailing tubes, and labels

Procedures

Field

Aquatic sampling can be performed as long as ponded areas persist in the targeted wetlands. In general, these flooded areas will be present until four to eight weeks after snowmelt, and sampling later than the second week after snowmelt will yield the greatest species richness and abundance of fauna (Holmquist 2005, Holmquist and Schmidt-Gengenbach 2006).

The goal is to perform ten “pushes” (or “bounces” or “sweeps”) within a given ponded area. Sampling is performed by briskly pushing the net through the submerged vegetation canopy, and bouncing the net frame off the substrate before each push, or about every 50cm, while moving forward in a linear fashion at a walking pace of about 2km/h (Figure SOP 16.2). The purpose of the bouncing is to disturb fauna living near the substrate and force these animals into the water column where capture can occur. Bouncing accumulates much less sediment and fine organics than scraping the bottom with the net and thus makes sorting more efficient. These ten pushes equate to eight seconds of sampling and cover 5 m, if sufficient contiguous habitat is present.

The closest *ephemeral* water to the macroplot should be identified. These water bodies will typically be ephemeral ponds with varying expected persistence. Some of these ponds may be expected to persist through the summer following wet winters. Sheet flow in ponded areas is acceptable, and small, ephemeral trickles may be sampled as well. **Streams of any size with an established bed and/or gravel or larger substrata should be avoided as should permanent ponds or marshes.** If suitable habitat is present in the macroplot, this habitat should be sampled. If suitable aquatic habitat is not present in the macroplot, the nearest suitable habitat within the meadow should be located and sampled. If no suitable aquatic habitat exists at the time of sampling, this is noted on the datasheet and aquatic sampling is skipped.

Once the sampling site has been selected, the random number table should be used to determine the point at which to enter the ponded area and the direction in which sampling will occur. The numbers that are used in making this determination should be crossed out to prevent future use. If the ponded area is very small, the random number table should be used to identify an additional location for sampling such that the goal of ten pushes, or 5 m of total sampling, can be achieved. If multiple sampling locations are necessary, the samples should be kept separate rather than combining them so as to maximize information retention. The selected site(s), entry point(s), and sampling direction(s) will be used for all subsequent visits. If water is not present at a given location on a future site visit, then the absence of habitat at the location will be noted, and a new site will be chosen, if possible, using the above procedures.

At each site, the sampler should assemble the net and put on waders (front country) or neoprene booties, water shoes, or equivalents (backcountry). About eight liters of sorting water should be collected in the collapsible bucket from a portion of the pond distant from the area to be sampled. Disturbance must be minimized both to prevent changes in behavior of the fauna to be sampled and to minimize turbidity in the sorting water. Care must be taken not to collect any fauna in the process of water collection; allowing only the lip of the bucket to dip below the surface works well in this regard. After the water is collected in the bucket, the water should be scrutinized for any inadvertently collected fauna, and these animals should be removed. The bucket should be brought to a nearby area that is relatively dry and level.

The sampler should enter the sample location at the randomly chosen point and begin netting in the randomly chosen direction. After sampling, the accumulated material should be shaken into the cod end (bottom) of the net (Figures SOP 16.3, SOP 16.4), washed by dipping the cod end into clean water, and the net should be carried to shore quickly and inverted into the bucket. After the sample has been removed from the net, the net should be examined carefully for any fauna that might remain. These animals should be placed in the bucket. If any highly mobile fauna, such as backswimmers or water striders, are noted, the bucket should be covered immediately, for instance with a piece of clothing, to prevent escape of fauna. After netting is complete, water depth and canopy height should be measured at four equal intervals along the route swept by the net, and the four measures for each metric should then be recorded on the data sheet (Appendix SOP 16.A).

The sample should be sorted in the field, because living animals are easier to detect, and because field sorting will greatly reduce the weight and volume of material that must be carried back to the trailhead. Samples should be sorted completely, rather than subsampling, because complete sorting reduces the variance of metrics and increases taxon richness (Courtenmanch 1996, Doberstein et al. 2000).

Sorting should take place immediately after collection. If flying or jumping fauna are observed at the surface, these animals should be collected from the bucket before sorting and placed in the pre-labeled alcohol jar. The plastic storage container is used as a sorting tray, and the container is dipped into the bucket and half-filled with water. If more than two sorters are available, the other plastic storage container (used for transport of collected sweep net samples; SOP 17) can also be temporarily used for sorting. The small dipnet is used to collect a small (approx. 5cm diameter) mass of litter, which is then transferred to the tray for sorting (Figures SOP 16.3–5). It is ideal to have two sorters for efficiency and also so that the two persons can check each other's work. Some animals, such as mayflies (Figure SOP 16.5) and damselflies, are best collected with flexible forceps. Other fauna, such as mosquito larvae (Figure SOP 16.5) and adult diving beetles, are more easily captured by using the small paper cards to confine these animals against the side of the tray before lifting them into the jar. Both methods minimize damage to fauna. The sorter(s) should work methodically by accumulating litter on one side of the tray and inspecting each blade of vegetation for adhering animals. It is often useful to run pieces of litter between the fingers in order to detect small animals. When in doubt, the item should be retained. It is often helpful to keep the alcohol jar on the sorting tray for stability; further, if the jar tips over, the sample is still contained in the tray and not lost. If any fauna escape, the number and type of animals should be immediately recorded on the data sheet under "Lost" and in the appropriate family row (Appendix SOP 16.A).

SOP 16.5

When the sorters are confident that no animals remain in the tray, the remaining material can be emptied and the process repeated. After most of the litter in the bucket has been sorted, the remaining fine material and animals in the bucket can be poured through the dipnet and placed in the tray for the last sorting. A sample will typically require one to two person-hours to sort. When the sample is complete, additional alcohol or water may need to be added with the eye dropper. It will typically not be necessary to add much water, because of water collected incidentally with the specimens. Jar lids should be sealed with a wrap of electrical tape, and the jars should be cushioned with a piece of clothing. An effort should be made to 1) keep the jars in the center of the pack, and 2) keep the pack in the shade whenever possible. Once the sample has been secured, sample number, location description, point entered, direction sampled (using compass), UTM (NAD83), date, time, dominant vegetation type, nearest vegetation greater than 2m in height (forest, willows, etc.), flow, notes, collectors, and sorters can be recorded on the data sheet (Appendix SOP 16.A). Flow should be noted as "0" (no flow), "1" (<1cm/sec), or "2" (>1cm/sec).

Because of the unique nature of many ephemeral aquatic habitats, the area should be photographed and a detailed description and labeled drawing should be recorded on the back of the data sheet. The drawing will help relocate the plot and will characterize the area.

Other notes can also be recorded on the back of the data sheet. If two or more ponded areas were required for the sample, data sheet entries should be made for each sample where appropriate.

Before travel to the next site, all equipment should be decontaminated following the procedures described in SOP 5. Equipment Decontamination Procedures. The collapsible bucket can be used as the container for the washing process. Rinsing should be done at least 30m from aquatic habitat and over generally organic substrates.

Lab

Each sample should be emptied into a watch glass or tissue culture dish, using a wash bottle if need be. Tally counters should be pre-labeled with common families and placed near the dissecting microscope. Material to be examined should be moved to one side of the dish if possible, and the observer should work through the sample under the microscope identifying each organism to family, clicking the appropriate counter, and using flexible forceps to place the identified organism in 70% ethanol in a vial of appropriate size. Alternatively, identified fauna can be sequestered in one portion of the dish for transfer en masse when this stage of sorting is complete. If the sample is large, the material may need to be divided into several dishes for examination. Plant material should be discarded when encountered. Exuviae (molts) should also be discarded without counting. If damaged animals are encountered, only body portions containing the head should be retained. For example, a head and thorax would be identified and retained, whereas an isolated femur or abdomen would be discarded. This process ensures that a given animal will not be counted twice. Within a given family, multiple morphospecies (groupings of morphologically distinct specimens, nominally different species [Lattke 2000]) may be encountered, and a separate tally should be established for each (Appendix 16.A). When family-level identifications cannot be made for some individuals at this microscope sorting stage, unidentified animals should be transferred to another dish for further examination.

Most family-level identifications can be accomplished under the dissecting microscope with use of general or order-level taxonomic references with keys to families (Appendix SOP 16.B). It may at times be necessary to use family-level references and primary literature, particularly for illustrations. Identification may require mounting of isolated appendages and examination under the compound microscope. In most cases a wet mount using water or glycerin will suffice. In general, the material is placed on the slide, a drop of medium is added, and a cover slip is drawn at an angle across the slide until contact is made with the liquid, at which time the cover slip can be lowered onto the slide. This procedure reduces bubble formation. Appendages can sometimes be manipulated under the compound microscope by gently sliding the cover slip against the slide.

Once identifications and counts are complete, represented families not listed on the data sheet should be added, and all individuals should be tallied by family and, if applicable, morphospecies (Appendix SOP 16.A). Any organisms not previously transferred to the sample vial should be transferred at this time along with the sample label, and the taxonomist should add his/her initials to the data sheet. The vial should be completely filled with 70% ethanol and sealed with Parafilm. The vial should be added to the appropriate unit vial tray. Any taxa not previously encountered should be placed in a separate, labeled vial and stored in the voucher collection.

Occasionally material will need to be sent to specialists for confirmation. If material is to be sent to a specialist, it is important to contact the worker in advance (see also Arnett and Samuelson 1986, Latke 2000). Requests are most likely to meet with favorable results if abundant site information is included in the request email. If the specialist is willing to examine specimens, information about the specimens must be carefully recorded so that the material can be tracked through this additional identification process. Each vial should be completely filled with alcohol to avoid sloshing, sealed with electrical tape, and wrapped with bubble wrap before padding the entire package. A paper copy of detailed site information should be included with the material for examination. Mailing tubes work well. Follow-up emails to the specialist will often be necessary as reminders, but a firm date of when identification is expected to be completed should be established when the contract is first agreed upon. This process can often take several months.

Data should be entered in Microsoft Access or Excel. Fields to be entered or calculated include indexing information such as sample number (separated 11 into component fields), date, time, year, park, abundance and frequency for each order and family, total individuals, family richness, morphospecies richness, morphospecies richness following Margalef's correction for abundance ($(S - 1)/\ln N$, where S = number of species and N = number of individuals; (Clifford and Stephenson 1975, Magurran 1988), family richness, Margalef's corrected family richness, % dominance, and proportion of individuals representing common functional feeding groups (e.g., predators). The person entering the data for each data sheet should add her/his initials and date entered in the appropriate place on the data sheet (Appendix SOP 16.A). After data is entered, the data should be printed, compared with the data sheet, and generally examined for inconsistencies, other problems, and initial trends. The person doing this verification should similarly add his/her initials to the data sheet along with the date of verification.

Richness measures generally decline in conjunction with various forms of disturbance (Kerans and Karr 1994, Barbour et al. 1996, Fore et al. 1996, Holmquist et al. 1998) and often have

relatively high power for detecting intersite differences (Sandin and Johnson 2000). Similarly, proportions of predators and grazers are likely to decline with increasing disturbance or other factors that degrade water quality, whereas the proportion of filterers tends to increase (Kerans and Karr 1994).

Although community structure is likely to demonstrate coarse similarities across sites, differences in abundance are probable. For instance, abundances may be lower at sites with even minimal sheet flow (e.g., many sites in the Giant Forest in Sequoia National Park) versus quiescent waters (e.g., most areas of Tuolumne Meadows in Yosemite National Park; Figure SOP 16.6; [Holmquist and Schmidt-Gengenbach 2006]). Family richness may also be different among sites (Figure SOP 16.6). Field and lab processing times will vary accordingly.



Figure SOP 16.1. D-frame net (J Schmidt-Gengenbach photo).



Figure SOP 16.2. Net in use (J Schmidt-Gengenbach photo).



Figure SOP 16.3. Sample shaken into cod end of net (J Schmidt-Gengenbach photo).



Figure SOP 16.4. Dragonfly nymph amid litter. The nearby shiny object is a head and thorax of a dead damselfly adult (J Holmquist photo).



Figure SOP 16.5. Mayfly nymph (bottom) and mosquito larva in tray after removal of most of the litter (J Holmquist photo).

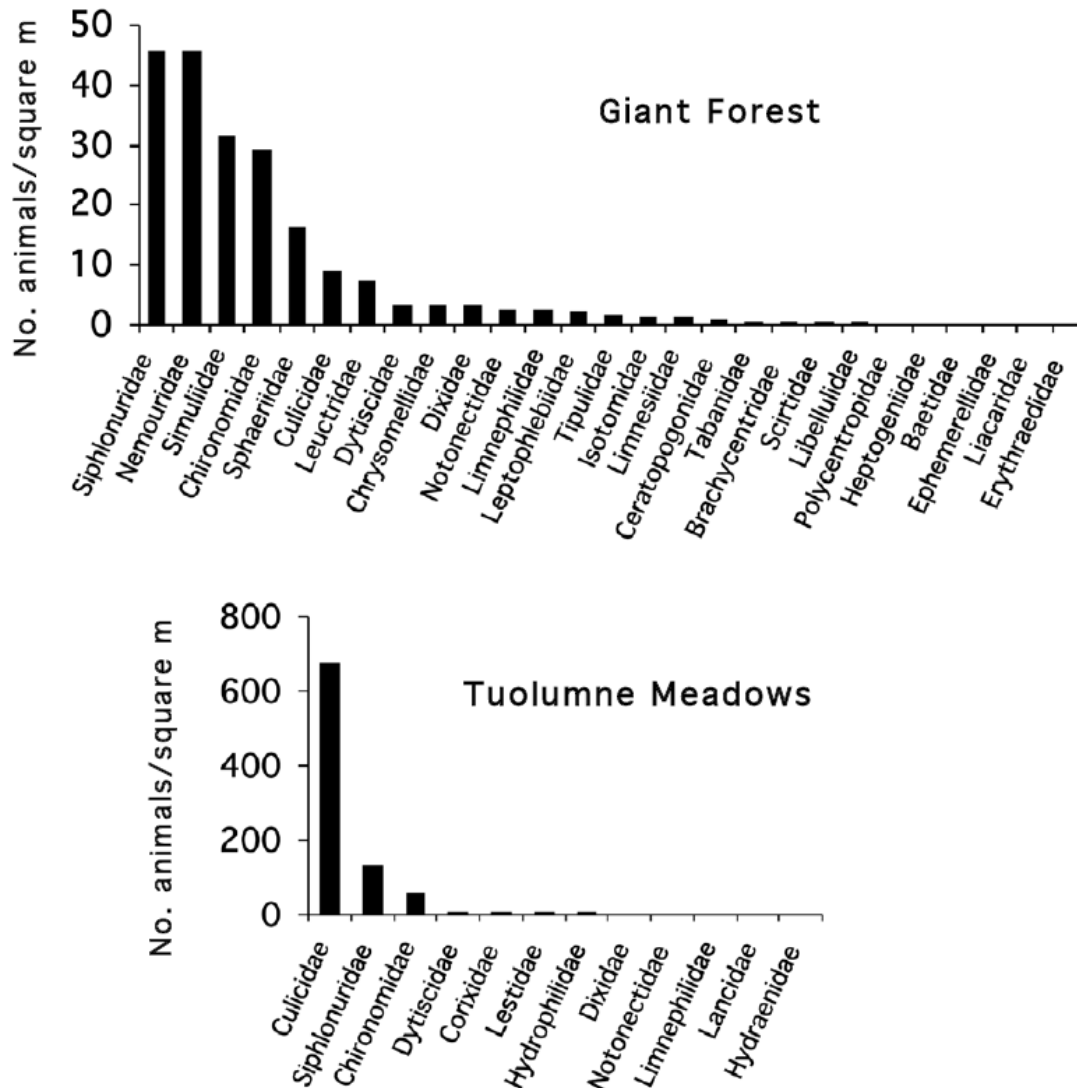


Figure SOP 16.6. Aquatic rank-abundance by family in the Giant Forest (top) and Tuolumne Meadows (bottom) during summer of 2005. n= 12 in both locations (Holmquist and Schmidt-Gengenbach 2006).

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Appendix SOP 16. A. Example Data Sheet

Common taxa listed with space for additional taxa. Bold indicates pencil entries. Commas separate abundances for each morphospecies. l= larva; p= pupa.

Aquatic Data Collection Form: D-frame sampling

Location:	Tuolumne Meadows, 20m 30° from macroplot	Sample #:	06-1-1-3
UTM(s):	292551 4194453 NAD 83	Entry point(s):	from 120°
Date:	2 July 06	Sampling direction(s):	330°
Time(s):	0815	Collectors:	JGH/JSG
Sorted by:	JSG/JGH	Canopy Height("):	12, 10, 15, 12
Depth ("):	4, 5, 4, 4	Flow(s)?	0
Dominant plant taxon(a):	<u>Carex vesicaria</u>	No. jars:	1
Notes:	lost 1 gerrid (recorded below)	Nearest tall vegetation:	100m, forest
Taxonomy:	JSG/JGH	Data entered/initials:	2 Oct 06/JSG
		Data verified/initials:	9 Oct 06/JGH

Common Taxa	Abundance/morphospecies
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Odonata

Lestidae	39
Libellulidae	

Ephemeroptera

Siphonuridae	36
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Plecoptera

Nemouridae	
Leuctridae	

Trichoptera

Limnephilidae	
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Hemiptera

Notonectidae	
Corixidae	
Gerridae	1

Coleoptera

Dytiscidae	1
Hydrophilidae	1

Diptera

Culicidae	27 (26 l, 1 p), 3 (3 l)
Chironomidae	2 (2 l)
Bibionidae	
Simuliidae	
Dixidae	

Acari	3
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SOP 17. Terrestrial Invertebrate Sampling: Sweep Net

Version 1.4

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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	31 May 2007	Holmquist	Modified field procedures and data sheet	New information gained from initial implementation and vegetation and hydrology SOPs	1.1
1.1	13 Aug 2007	Holmquist	Modified field procedures	New information gained from first full summer of implementation	1.2
1.2	5 March 2008	Holmquist	Modified references and other minor changes	New literature available	1.3
1.3	4 July 2008	Holmquist	Modified data sheet	Improvements from second summer of implementation	1.4

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Introduction

This SOP gives step-by-step instructions for sampling the terrestrial arthropods associated with the vegetation plots and groundwater monitoring wells. Invertebrate assemblage data are collected in conjunction with the vegetation sampling schedule, because both sampling components utilize the same design and because co-locating plots is both more efficient and allows relationships among fauna, flora, and physical characteristics to be explored. This SOP describes the procedure for collecting data and filling in “Terrestrial Arthropod (Sweep Net) Data Collection Form.”

Sweep nets are conical framed nets with a handle (New 1998) and have a number of advantages for sampling remote areas. The apparatus is light in weight, easily transportable, easily demonstrated to field crews, does not impact wilderness character, integrates collection over a wide area, produces samples that require little sorting, and provides reproducible data with variances that are no higher than those produced by intensive sampling methods such as vacuum netting (Holmquist and Schmidt-Gengenbach 2006). Sweep nets can also be used in areas that are heavily saturated but not flooded. These habitats, which are common in montane wetlands in the Sierra Nevada, are not sampled well by vacuum netting and yet cannot be sampled with aquatic techniques (Holmquist and Schmidt-Gengenbach 2006). Although ground dwellers in Sierra Nevada Network meadows are not sampled as well as with vacuum netting, these animals are represented in sweep net samples (Holmquist and Schmidt-Gengenbach 2006). Sweep nets have been shown to yield higher numbers of individuals, species, families, and orders, and capture higher levels of diversity than pitfall traps, light traps, or scented traps (Gadagkar et al. 1990). Sweep nets have been used in other National Park Service monitoring programs (e.g., in Channel Islands National Park; Fellers and Drost 1991).

Equipment List

Field

- Random number table or electronic equivalent.
- Collapsible sweep net (Figure SOP 17.1) with a 30.5cm diameter aperture and 70cm handle (BioQuip #7112CP). Collapsed diameter is 11cm, and the handle separates into 13 and 61cm sections. Mesh size is 0.5x0.75mm.
- Self-sealing (“Zip-Lock” style), freezer-grade, one-gallon (3.79 liter) plastic bags. One bag per sample.
- Labels, 100% rag content. Labels should be pre-labeled with, at a minimum, sample number, date, and sampling device.
- Cotton balls, approximately 3cm, one ball per sample.
- Ethyl acetate, 99%, (e.g., BioQuip #1185A) in a 30 ml (1 oz.) glass jar with polypropylene lid with Teflon liner (e.g., Qorpak #2S01QEDC). Ethyl acetate is a component of nail polish and a killing agent for insects, yet relatively nontoxic to humans (Triplehorn and Johnson 2005). Ethyl acetate is therefore an excellent alternative to traditional killing agents such as chloroform or carbon tetrachloride.
- One-dram vials with polyethylene-lined caps (4.5ml; 15x45mm; e.g., BioQuip #8801P) pre-filled with non-denatured, 70% ethanol.

- One or more plastic containers, depending on the number of sites to be visited. A Rubbermaid 4022 (2.7 liter; 30x20x7cm) container will hold six typical sweep samples. Housing samples in these containers prevents damage to specimens and reduces loss of ethyl acetate from sample bags.
- Plastic, box-style clipboard, (e.g., Dexas SlimCase).
- Data sheets (Appendix A). Include a few Rite-in-the-Rain or Nalgene Sheets (e.g., BioQuip #1165E). To prevent confusion between “Rite-in-the-Rain” paper and regular paper, pencil in an “R” for “Rain” in one corner of the Rite-in-the- Rain paper.
- Mechanical pencils with replacement lead and erasers.
- Small tape measure (e.g., 3’ Stanley Powerlock #33-115)

Lab

- Freezer for sample storage.
- Enamel trays for sample sorting (Figs. 3, 4); shallow 30x46x1.5cm size works best as the very shallow depth allows a comfortable sorting posture.
- Two-inch (5.1 cm) natural bristle paint brushes. Large brushes work better than small brushes for coarse sorting.
- Fluorescent bench lights (Figure SOP 17.3).
- Featherweight sorting forceps (e.g., Fine Science Tools #26029-10) that bend away from, rather than damaging, specimens.
- Tissue culture dishes with lids: 35x10 mm (e.g., Falcon #3001) and 60x15 mm (e.g., Falcon #3002).
- Watch glasses with lids: 60x28mm and 33x10
- Illuminated magnifying glass (e.g., BioQuip #1129L).
- Non-denatured, 70% ethanol.
- Research grade dissecting microscope with flexible fiber optic lighting, ring light, and ocular micrometer. Magnification to at least 80x. The importance of a high quality microscope cannot be overemphasized; data will be lost without access to research grade optics.
- Research grade compound microscope with oil immersion. Magnification to at least 1250x.
- Fine-point dissecting forceps: Dumont #5 Biologie tip, Inox (e.g., Fine Science Tools #11252-20) is highly recommended.
- Teasing needles (e.g., BioQuip #4751).
- Insect pin holder (e.g., Thomas) for use with 0.15mm diameter insect pins (“minutens” e.g., BioQuip #1207SA) as delicate teasing needle.
- Slides: general purpose (76x25mm) slides; e.g., BioQuip #6351A); depression slides (76x25mm; e.g., BioQuip #6330A); thin (No. 1) cover slips (22x22mm; e.g., BioQuip #6341B).

- Glycerin for wet mounts.
- Eye droppers (e.g., BioQuip #4775).
- Tally counters; at least three six-unit banks (e.g., McMaster-Carr #1714T15).
- Vials with polyethylene-lined caps: 1 dram (4.5ml; 15x45mm; e.g., BioQuip #8801P); 2 dram (9ml; 17x60mm; e.g., BioQuip #8802P).
- Parafilm “M,” 5cm width (Fisher Scientific #13-374-16).
- Unit vial trays with partitions for 1 or 2 dram vials (e.g., BioQuip #1025AV).
- Taxonomic references (Appendix SOP 17.B).
- Mailing supplies including electrical tape, bubble wrap, mailing tubes, and labels.

Procedures

Field

Sweep netting can be performed from melt-off until snowfall. However, the period from two to twelve weeks after melt-off will yield the greatest species richness and abundance of fauna (Holmquist and Schmidt-Gengenbach 2006). Sweeping should be done in dry vegetation (New 2005), and *sampling should be postponed if at all possible if the field team encounters heavy dew or rain*. Sweep netting should be performed immediately after the plot location is established and prior to plot set up to minimize disturbance of the site as much as possible (See Figure 11 in the Narrative for an illustration of sampling activity order).

One sweep net sample should be collected on each vegetation monitoring site immediately after the well site is located and before other work is performed on the macroplot (animals run away faster than plants). The goal is to perform 50 sweeps across the area to be used for vegetation assessment.

Sampling is performed by briskly sweeping the net through the upper portions of the vegetation canopy in a figure-eight pattern (as viewed from in front of the sampler) while moving forward at a walking pace of about 3km/h (Figure SOP 17.1). Each figure-eight motion sweeps across the vegetation twice and therefore represents two sweeps. Thus 25 complete figure-eight patterns are required per sampling site.

Prior to sampling the sweep net should of course be assembled, and a self-sealing bag with the proper label for the site should be selected. The random number table should be used to determine which of the four sides will be the entry point to the macroplot (Figure SOP 17.2), and the used number should be crossed out to prevent future use. To avoid damage to vegetation prior to plant cover estimates, the sweeper should walk an M-shaped path that avoids the four microplots (Figure SOP 17.2) while making 50 sweeps. After completing the 50 sweeps, the sampler should vigorously sweep the net through the air twice to be certain to drive all collected fauna into the cod end (bottom) of the net. The sampler then grasps the net near the cod end to keep any fauna from escaping. At this point, the sampler and assistant should approach each other, and the assistant should open the self-sealing bag. The sampler inverts the net into the bag while the assistant keeps the bag open just enough to accommodate the net. Both team members

should use care at this stage not to be stung or bitten by any collected bees, wasps, hemipterans, or spiders. In practice, there is very little risk, and we have used these techniques for several years without mishap. With the net inverted into the bag, the sampler should progressively invert the net while shaking and while the assistant in turn both shakes the bag and maintains a good seal around the net. Shaking is necessary in order to minimize the possibility of having animals escape through the aperture of the bag. After the net has been completely inverted, and all animals have been removed, the net is quickly withdrawn, and the bag is rapidly sealed. The entire sweeping and bagging procedure should take less than three minutes, and at this time the rest of the work planned for the site can proceed.

If any fauna escaped, the number and type of animals should be immediately recorded on the data sheet under “Lost” (Appendix SOP 17.A). Five drops of ethyl acetate should be applied to a cotton ball. The ball is then quickly dropped into the sampling bag, and the bag is resealed, making an effort to remove excess air. The ethyl acetate container should be immediately recapped to prevent evaporation. The sample is then transferred to the plastic container to prevent damage to fragile fauna. An effort should be made to 1) keep the sample container in the center of the pack, and 2) keep the pack in the shade whenever possible in order to prevent deterioration of the samples. If more than six sites will be visited, the field crew must take a second plastic container into the field to prevent damage to specimens. Although samples will survive field conditions for a week or more, it is advisable to transfer sample bags to a freezer as soon as possible, bundling groups of samples to simplify later access.

Although sampling dry vegetation is extremely important, if extreme logistical concerns dictate that a site must be sampled while the vegetation is wet, it may be best to transfer insects adhering to the net to an ethanol vial with forceps, rather than placing them in the bag. Animals that are still motile under these conditions can be transferred to the bag as per the usual procedures; then animals adhering to the net can be transferred to the vial. The vial is then placed in the bag.

Once the sample has been secured, maximum canopy height should be measured at the outside corner of each microplot (Figure SOP 17.2) with the tape measure and recorded on the data sheet (Appendix SOP 17.A). Maximum canopy height is defined as the tallest vegetation within 2.5cm of the tape measure at each measuring point. In addition, sample number, location description, UTM (NAD 83), dominant vegetation species, date, time, notes, sky condition, shading by trees, nearest vegetation greater than 2m in height (forest, willows, etc.), estimated wind speed, soil moisture (dry, damp, or saturated), presence and nature of moisture on vegetation, and initials of collectors can be recorded on the data sheet (Appendix SOP 17.A). Other notes should be recorded on the back of the data sheet.



Figure SOP 17.1. Sweep net in use (J. Holmquist photo).

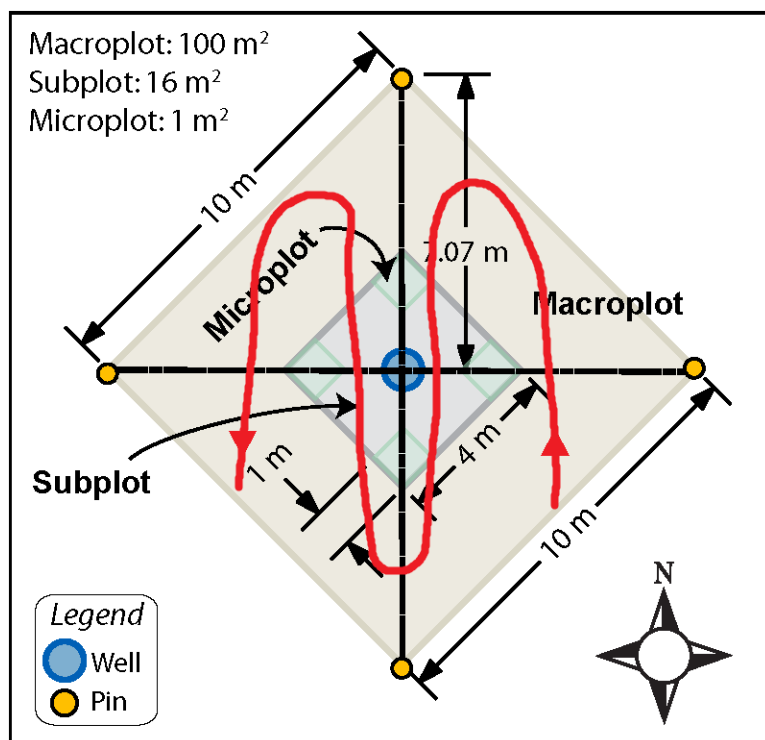


Figure SOP 17.2. Red line indicates sweep netting path through macroplot.

Lab

Sweep netting produces relatively little extraneous plant material, and sorting is generally straightforward. Moisture in the sample bags rarely presents a problem, and sorting can generally begin as soon as samples are removed from the freezer. If moisture is observed in a given bag, lab workers should shake the sample to the bottom of the bag, fold the lip of the bag out to provide more air access, and allow the sample to air dry for one to two hours.

Each sample is to be emptied into an enamel tray by gently shaking out the contents. Ensure good lighting (Figure SOP 17.3). Because of static electricity, some material may adhere to the inside of the bag, but such material can be removed by gentle brushing of remnant flora and fauna into the tray with the paintbrush. Carefully check the bag for flattened fauna. The label should be transferred to a watch glass or tissue culture dish filled with 70% ethanol. Accumulate sample material on one side of the enamel tray and use the paintbrush and/or forceps to incrementally move plant material to the other side of the tray (Figures SOP 17.3, SOP 17.4), removing any fauna, pieces of fauna, or unidentifiable material, and placing these items in the watch glass or equivalent for further examination under the dissecting microscope. Use of an illuminated magnifying glass can help resolve ambiguities. Items should be transferred with flexible forceps to prevent damage to delicate fauna. Once initial sorting is complete, the sample dish should be moved to the stage of the dissecting microscope and the sorter should add her/his initials to the data sheet.

Tally counters (Figure SOP 17.4) should be pre-labeled with common families and placed near the dissecting microscope. Material to be examined should be moved to one side of the dish if possible, and the observer should work through the sample under the microscope identifying each organism to family (plus ants to genus or species), clicking the appropriate counter, and using flexible forceps to place the identified organism in a vial of appropriate size. Alternatively, identified fauna can be sequestered in one portion of the dish for transfer en masse when this stage of sorting is complete. If the sample is large, the material may need to be divided into several dishes for examination. Plant material should be discarded when encountered. Exuviae (molts) should also be discarded without counting. If damaged animals are encountered, only parts containing the head should be retained. For example, a head and thorax would be identified and retained, whereas an isolated femur or abdomen would be discarded. This process ensures that a given animal will not be counted twice. Within a given family, multiple morphospecies (groupings of morphologically distinct specimens, nominally different species [Lattke 2000]) may be encountered, and a separate tally should be established for each (Appendix SOP 17.A). When family-level identifications cannot be made for some individuals at this sorting stage, unidentified animals should be transferred to another dish for further examination.

Most family-level identifications can be made under the dissecting microscope with use of general or order-level taxonomic references with keys to families (Appendix SOP 17.B). It may at times be necessary to use family-level references and primary literature, particularly for illustrations. Identification may require mounting of isolated appendages and examination under the compound microscope. In most cases a wet mount using water or glycerin will suffice. In general, the material is placed on the slide, a drop of medium is added, and a cover slip is drawn at an angle across the slide until contact is made with the liquid, at which time the cover slip can be lowered onto the slide. This procedure reduces bubble formation. Appendages can sometimes be manipulated under the compound microscope by gently sliding the cover slip against the slide.

Once identifications and counts are complete, represented families not listed on the data sheet should be added, and all individuals should be tallied by family and, if applicable, morphospecies and ant species (Appendix SOP 17.A). Any organisms not previously transferred to the sample vial should be transferred at this time along with the sample label, and the taxonomist should add his/her initials to the data sheet. The vial should be completely filled with 70% ethanol and sealed with Parafilm. The vial should be added to the appropriate unit vial tray. Any taxa not previously encountered should be placed in a separate, labeled vial and stored in the voucher collection.

Occasionally material will need to be sent to specialists for confirmation. If material is to be sent to a specialist, it is important to contact the worker in advance (see also Arnett and Samuelson 1986, Lattke 2000). Requests are most likely to meet with favorable results if abundant site information is included in the request email. If the specialist is willing to examine specimens, information about the specimens must be carefully recorded so that the material can be tracked through this additional identification process. Each vial should be completely filled with alcohol to avoid sloshing, sealed with electrical tape, and wrapped with bubble wrap before padding the entire package. A paper copy of detailed site information should be included with the material for examination. Mailing tubes work well. Follow-up emails to the specialist will often be

necessary as reminders, but a firm date of when identification is expected to be completed should be established when the contract is first agreed upon. This process can often take several months.

Data should be entered in Microsoft Access or Excel. Fields to be entered or calculated include indexing information such as sample number (separated into component fields), date, time, year, park, abundance and frequency for each order, family, and ant genus/species, total individuals, morphospecies richness, morphospecies richness following Margalef's correction for abundance ($((S - 1)/\ln N)$, where S= number of species and N= number of individuals; Clifford and Stephensen 1975, Magurran 1988), family richness, Margalef's corrected family richness, % dominance, and proportion of individuals representing common functional feeding groups (e.g., predators). The person entering the data for each data sheet should add her/his initials and date entered in the appropriate place on the data sheet (Appendix SOP 17.A). After data is entered, the data should be printed, compared with the data sheet, and generally examined for inconsistencies, other problems, and initial trends. The person doing this verification should similarly add his/her initials to the data sheet along with the date of verification.

Although community structure is likely to demonstrate coarse similarities across sites, differences in abundance are probable. For instance, abundances can be anticipated to be higher in lower, wetter, montane sites with longer growing seasons (e.g., the Giant Forest in Sequoia National Park) versus higher, dryer, subalpine sites with shorter growing seasons (e.g., Tuolumne Meadows in Yosemite National Park; Figure SOP 17.6; Holmquist and Schmidt Gengenbach 2006).

Processing times will vary accordingly.



Figure SOP 17.3. Volunteers assisting with sorting in lab. Note enamel trays and good lighting (J Holmquist photo).



Figure SOP 17.4. Partially sorted sample in enamel tray with counters. Brush is used for coarse sorting (J Holmquist photo).



Figure SOP 17.5. Sorted sample showing extraneous plant material and, from left to right, wasps, ants, flies, leafhoppers, spiders, and a hemipteran. Several of these groups are represented by multiple families, which in turn are represented by multiple morphospecies.

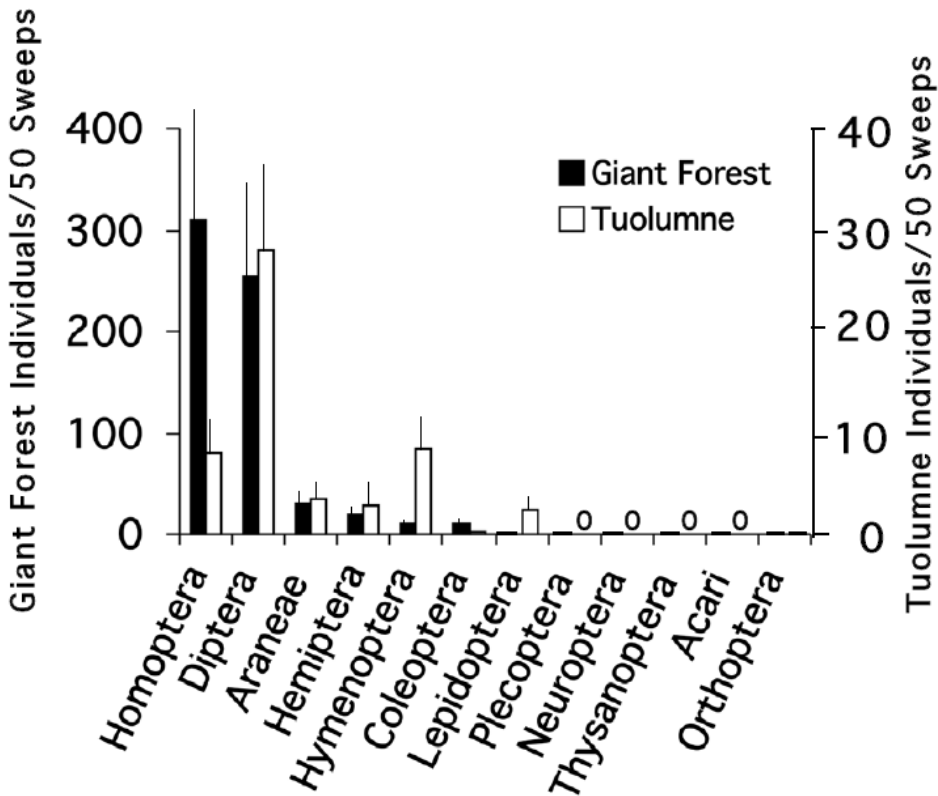


Figure SOP 17.6. Mean catch by order (SE) per 50 sweeps for the Giant Forest in Sequoia National Park (left y-axis) versus Tuolumne Meadows in Yosemite National Park (right y-axis). Note different scales. $n = 12$ in both locations (from data in Holmquist and Schmidt-Gengenbach 2006). Zeros indicate absence of a given order in Tuolumne versus very low numbers in the Giant Forest.

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Appendix SOP 17.A. Example of Data Sheet

Common taxa listed with space for additional taxa. Bold indicates pencil entries. Commas separate abundances for each morphospecies.

Terrestrial Arthropod (Sweep Net) Data Collection Form

Location:	Log Meadow	Canopy height (""):	25, 31, 35, 22
Sample #:	05-2-2-38	Nearest tall vegetation:	20m, forest
UTM:	344044	Soil moisture:	Heavily saturated
	4047366 NAD 83	Sky condition:	Clear
Date:	3 Sept 05	Wind speed:	~10km/h
Time:	0845	Shading by trees:	20%
Collectors:	JGH/JSG	Sorted by:	JSG/ASA
Lost:	One fly	Taxonomy:	JSG/JGH
Cotton ball:	✓	Data entered/initials:	12 Dec 05/JSG
Dominant vegetation:	<u>Elymus glaucus</u>	Data verified/initials:	18 Dec 05/JGH

Common Taxa	Abundance/morphospecies
Hemiptera	
Nabidae	4
Lygaeidae	8, 3
Homoptera	
Delphacidae	65, 17
Psyllidae	
Aphididae	6
Cicadellidae	2, 1, 1
Coleoptera	
Carabidae	4
Coccinellidae	5
Latridiidae	16
Anthicidae	15
Hymenoptera	
Braconidae	20, 4
Pteromalidae	
Formicidae	4 <u>Camponotus modoc</u>
Ichneumonidae	1
Diptera	
Sciaridae	4
Empididae	12
Lonchopteridae	10
Muscidae	3, 1
Sepsidae	13
Chloropidae	15, 6
Sphaeroceridae	140, 7, 1
Drosophilidae	15
Ephydriidae	5

Appendix SOP 17.B. Some Taxonomic References for Family-Level Identifications, Plus Keys for Identifying Ants to Genus or Species

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SOP 18. Terrestrial Vertebrate Sampling: Ant Baits

Version 1.2

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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	1 June 2007	Holmquist	Modified field procedures	New information gained from initial implementation and vegetation and hydrology SOPs	1.1
1.1	5 March 2008	Holmquist	Modified references and other minor changes	New literature available	1.2

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Overview

This SOP gives step-by-step instructions for sampling the ants associated with the vegetation plots. Ant data are collected in conjunction with the vegetation sampling schedule, because both sampling components utilize the same design and because co-locating plots is both more efficient and allows relationships among fauna, flora, and physical characteristics to be explored. This SOP describes the procedure for collecting data and filling in Data Form “Terrestrial Arthropod (Bait) Data Collection Form”.

Ants are often used as bioindicators of ecosystem health and environmental change (Gerlach et al. 2013, Cuautle et al 2016). They also tend to be under-represented in sweep net samples and the alternate sampling method is preferable to try and more fully capture accurate records of ant species composition and abundance. Baiting (Bestelmeyer et al. 2000, Delabie et al. 2000) targets ants and may also collect other taxa (Alonso 2000, Andersen and Majer 2004). Baiting is the most common method for monitoring ant assemblages (Bestelmeyer et al. 2000) and has a number of advantages for sampling in remote areas. The materials are light in weight and easily transportable. Baiting is easily demonstrated to field crews, creates no wilderness issues, integrates collection over a wide area, and produces samples that require no sorting. Baiting can also be used in areas that are heavily saturated but not flooded. These habitats, which are common in montane wetlands in the Sierra Nevada, are not sampled well by vacuum netting and yet cannot be sampled with aquatic techniques (Holmquist and Schmidt-Gengenbach 2006a). Various baits have been tested in the Sierra, and honey and tuna offer the best combination of field practicality and attractiveness to multiple ant taxa (Holmquist and Schmidt-Gengenbach 2006b).

Equipment List

Field

- Polypropylene line (28.3m in length) from macroplot with tape markings 1 m from each end
- Honey, transferred to an approximately 25ml plastic container
- Tuna packed in oil, transferred to an approximately 25ml plastic container
- Heavy weight, green construction paper (e.g., Art Street, Riverside Paper Company). Two 8x16cm sheets per site (Figure SOP 18.1). Paper allows liquids to soak through to the other side, potentially allowing more taxa to be present at the bait: more dominant taxa may appear on the bait lying on the paper, while less aggressive species may be able to access the bait that has soaked into the bottom of the paper (Bestelmeyer et al. 2000).
- Rocks for weighting bait cards (can often be located near plot). Rock weights work better than nails or other devices.
- Watch with alarm
- Featherweight forceps (e.g., Fine Science Tools #26029-10) that bend away from, rather than damaging, specimens. Flagging attached to prevent loss.
- Labels, 100% rag content. At a minimum, each label should include sample number, location, date, and bait type.

- One-dram vials with polyethylene-lined caps (4.5ml; 15x45mm; e.g., BioQuip #8801P) pre-filled with non-denatured, 70% ethanol. Two vials per site.
- Electrical tape
- Clipboard
- Data sheets (Appendix SOP 18.A). Include a few Rite-in-the-Rain or Nalgene Sheets (e.g., BioQuip #1165E). To prevent confusion between “Rite-in-the-Rain” paper and regular paper, pencil in an “R” for “Rain” in one corner of the Rite-in-the-Rain paper.
- Mechanical pencils with replacement lead and erasers
- Rubberbands to secure data sheets to clipboard and to bundle vials together

Lab

- Fluorescent bench lights
- Featherweight sorting forceps (e.g., Fine Science Tools #26029-10) that bend away from, rather than damaging, specimens
- Tissue culture dishes with lids: 35x10 mm (e.g., Falcon #3001) and 60x15 mm (e.g., Falcon #3002)
- Watch glasses with lids: 60x28mm and 33x10
- Non-denatured, 70% ethanol
- Research grade dissecting microscope with flexible fiber optic lighting, ring light, and ocular micrometer -- magnification to at least 80x
- Research grade compound microscope with oil immersion -- magnification to at least 1250x
- Fine-point dissecting forceps: Dumont #5 Biologie tip, Inox (e.g., Fine Science Tools #11252-20) is highly recommended
- Teasing needles (e.g., BioQuip #4751)
- Insect pin holder (e.g., Thomas) for use with 0.15mm diameter insect pins (“minutens” e.g., BioQuip #1207SA) as delicate teasing needle
- Slides: general purpose (76x25mm) slides; e.g., BioQuip #6351A); depression slides (76x25mm; e.g., BioQuip #6330A); thin (No. 1) cover slips (22x22mm; e.g., BioQuip #6341B)
- Glycerin for wet mounts
- Eye droppers (e.g., BioQuip #4775)
- Tally counter (e.g., McMaster-Carr #1714T15)
- One-dram vials with polyethylene-lined caps (4.5ml; 15x45mm; e.g., BioQuip #8801P)
- Parafilm “M,” 5cm width (Fisher Scientific #13-374-16)
- Unit vial trays with partitions for 1 dram vials (e.g., BioQuip #1025AV)
- Taxonomic references (e.g., Wheeler and Wheeler 1986, Hölldobler and Wilson 1990, Bolton 1994, Hansen and Klotz 2005, Ward 2005, California Academy of Sciences 2002-2006, Fisher and Cover 2007)
- Mailing supplies including electrical tape, bubble wrap, mailing tubes, and labels

Procedures

Field

Baiting can be performed from melt-off until snowfall. However, the period from two to twelve weeks after melt-off will yield the greatest species richness and abundance of fauna (Holmquist and Schmidt-Gengenbach 2006a).

Baits should be placed after sweep netting and macroplot establishment but prior to any other work on the plot. An ideal time for baiting is while microplots are being read, as this work is relatively sedentary and occurs away from the baits. The goal is to have one honey and one tuna bait in place on the plot for exactly 30 minutes. One person can complete all field procedures without assistance.

Prior to sampling, a pair of rocks (~5cm diameter and ~100g) should be located for use in weighting the bait cards, to prevent loss due to wind. The honey bait card should be placed close to the mark 1 m from the north end of the macroplot (Figure SOP 18.2), but movement away from the chosen point in an effort to avoid obstructions is acceptable. The card should be weighted with a rock on one end and a 15 mm diameter puddle of honey should be created in the center of the card at the opposite of the card from the rock (Figure SOP 18.1). This puddle will expand in the heat (Figure SOP 18.3). The tuna card should be placed at the 1 m mark on the south end of the macroplot (Figure SOP 18.2). Forceps are used to apply about one cubic centimeter of tuna (Figure SOP 18.3). The time should be noted on the data sheet and the watch alarm set for 30 minutes. Bait setting should only require 3-5 minutes. Other work can proceed on the site at this time, but minimizing disturbance while working on the macroplot, particularly near the baits, will allow ant foraging trails to remain relatively intact.

When the alarm sounds, the worker should slowly approach the honey bait holding forceps and the appropriate pre-labeled vial. Approach should be made with a minimum of disturbance and while avoiding casting a shadow on the bait. A count should be made of the number of ants present at the bait; all individuals will typically be of the same species (Figure SOP 18.3). There may be a great deal of activity with ants arriving at, and departing from, the bait, so it may be necessary to estimate numbers. The vial should be uncapped, and the ants can be removed from the bait singly with the forceps and placed in the vial. Collection of individual ants with forceps works better than collection of the entire bait card or aspiration, even with large numbers of ants (Holmquist and Schmidt-Gengenbach 2006b). It is important to create minimal disturbance during removal, or the ants may flee the bait. If animals do escape, the number can be noted or estimated by subtracting the number of ants in the vial from the initial count. Any losses should be immediately recorded on the data sheet under “Lost” (Appendix SOP 18.A). Lastly, check the bottom of the paper for ants. The same procedure should be used next for the tuna bait. Remaining bait material can be wiped from the cards on vegetation, and the cards are then added to the technicians’ other waste material for disposal at the trailhead. The collection phase of the baiting process should require about five minutes.

Vial caps should be sealed with a wrap of electrical tape, and the pair of vials should be bundled together with a small rubber band and then included with the rest of the vials bound with a large

rubber band. The bundle of vials should be cushioned with a piece of clothing. An effort should be made to 1) keep the vials in the center of the pack, and 2) keep the pack in the shade whenever possible. Once the vials have been secured, sample number, location description, date, time, notes, and names of collectors can be recorded on the data sheet (Appendix SOP 18.A). Further entries are not necessary, because of the more extensive site descriptions included on the sweep netting data sheet.



Figure SOP 18.1. Construction paper with honey bait weighted with rock.

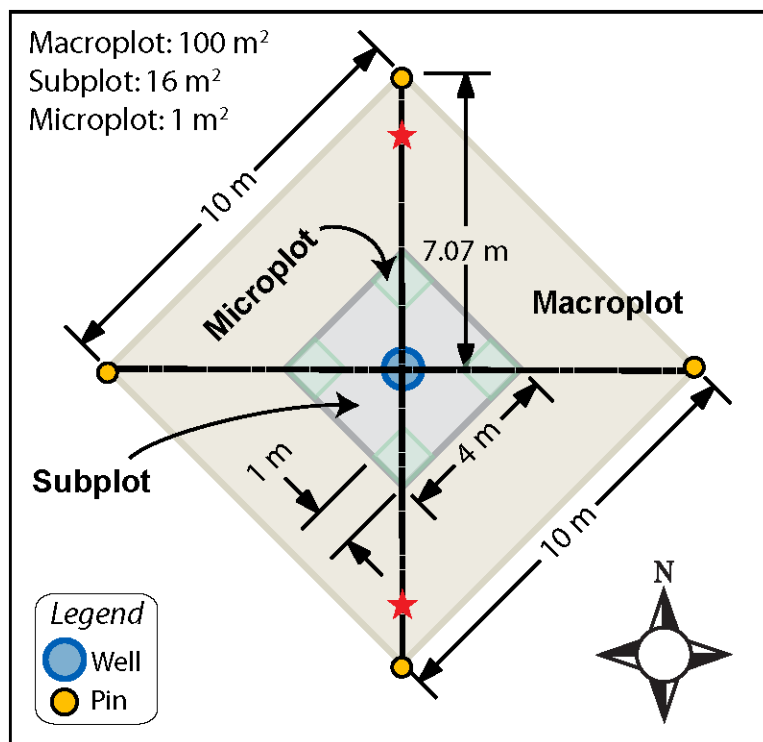


Figure SOP 18.2. Ant bait locations within the Macroplot. Red stars on N-S line indicate bait locations one meter in from the plot boundary. The honey bait is placed near the N marker and the tuna bait is placed near the S marker.

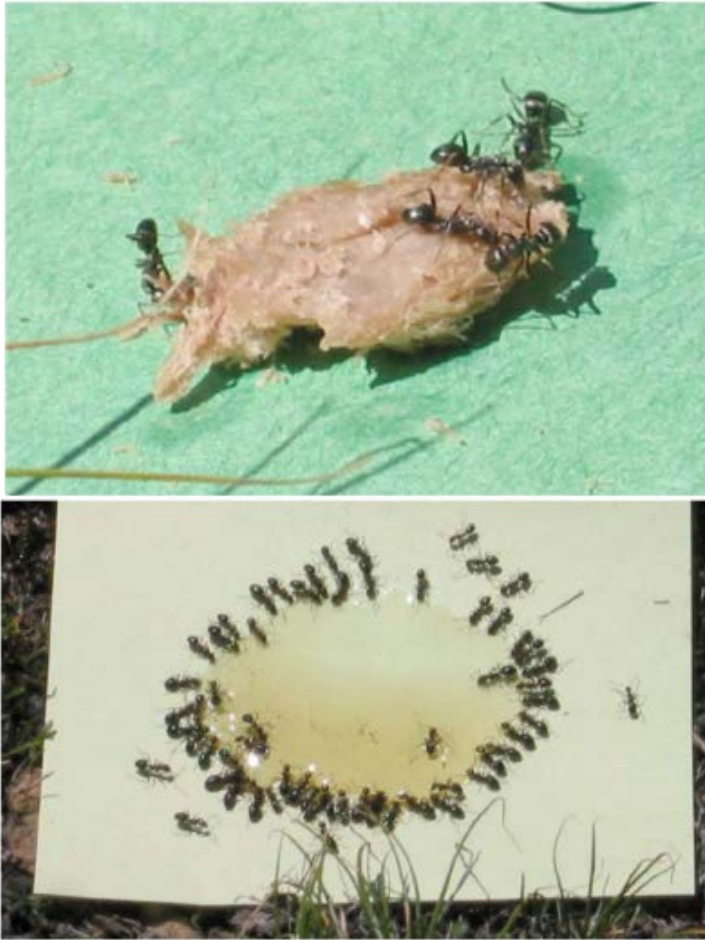


Figure SOP 18.3. Tuna (upper) and honey baits (lower) on cards with attracted ants.

Lab

Because ants are collected individually with forceps, no sorting is required. Each vial should be emptied into a watch glass or tissue culture dish. The most effective way to empty a vial of fauna is to unscrew the cap, place a thumb over the aperture, invert the vial, wait for the specimens to settle, hold the vial over the dish, and rapidly remove one's thumb, allowing the fauna and alcohol to flow into the dish. The label should then be removed and placed in the dish with the specimens. The sample dish should be moved to the stage of the dissecting microscope.

Tally counters should be pre-labeled with common taxa and placed near the dissecting microscope. Material to be examined should be moved to one side of the dish if possible, and the observer should work through the sample under the microscope identifying each organism to species whenever possible, clicking the appropriate counter, and using flexible forceps to place the identified organism in a vial of appropriate size. Alternatively, identified fauna can be sequestered in one portion of the dish for transfer en masse when this stage of sorting is complete. If damaged animals are encountered, which is unlikely with this collection technique, only parts containing the head should be retained. For example, a head and thorax would be identified and retained, whereas an isolated femur or abdomen would be discarded. This process ensures that a given animal will not be counted twice.

Many identifications can be made under the dissecting microscope using the references cited in the Equipment List. It may at times be necessary to use genus-level references and primary literature. Identification may require mounting of isolated appendages and examination under the compound microscope. In most cases a wet mount using water or glycerin will suffice. In general, the material is placed on the slide, a drop of medium is added, and a cover slip is drawn at an angle across the slide until contact is made with the liquid, at which time the cover slip can be lowered onto the slide. This procedure reduces bubble formation. Appendages can sometimes be manipulated under the compound microscope by gently sliding the cover slip against the slide.

Once identifications are complete, all taxa and counts should be recorded on the data sheet (Appendix SOP 18.A). Any organisms not previously transferred to the sample vial should be transferred at this time along with the sample label, and the taxonomist should add his/her initials to the data sheet. The vial should be completely filled with 70% ethanol and sealed with Parafilm. The vial should be added to the appropriate unit vial tray. Any taxa not previously encountered should be placed in a separate, labeled vial and stored in the voucher collection.

Occasionally material will need to be sent to specialists for confirmation. If material is to be sent to a specialist, it is important to contact the worker in advance (see also Arnett and Samuelson 1986, Latke 2000). Requests are most likely to meet with favorable results if abundant site information is included in the request email. If the specialist is willing to examine specimens, information about the specimens must be carefully recorded so that the material can be tracked through this additional identification process. Each vial should be completely filled with alcohol to avoid sloshing, sealed with electrical tape, and wrapped with bubble wrap before padding the entire package. A paper copy of detailed site information should be included with the material for examination. Mailing tubes work well. Follow-up emails to the specialist will often be necessary as reminders, but a firm date of when identification is expected to be completed should be established when the contract is first agreed upon. This process can often take several months.

Data should be entered in Microsoft Access or Excel. Fields to be entered or calculated include indexing information such as sample number (broken into components), date, time, year, park, abundance and frequency for each ant species, total individuals, species richness, species richness following Margalef's correction for abundance $((S - 1)/\ln N)$, where S = number of species and N = number of individuals; Clifford and Stephenson, 1975, Magurran 1988), percent dominant, and proportion of individuals representing common functional feeding groups (e.g., predators). Sorenson's similarity coefficient (Krebs 1989) will also be calculated in accord with contrasts of interest. This index is calculated as $2a/(2a + b + c)$, where a = number of species in Group A and Group B, i.e., joint occurrences; b = number of species in Group B but not in Group A; c = number of species in Group A but not in Group B. The person entering the data for each data sheet should add her/his initials and date entered in the appropriate place on the data sheet (Appendix SOP 18.A). After data is entered, the data should be printed, compared with the data sheet, and generally examined for inconsistencies, other problems, and initial trends. The person doing this verification should similarly add his/her initials to the data sheet along with the date of verification.

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Appendix SOP 18.A. Example of Data Sheet

Terrestrial Invertebrate Sampling- Baiting

Location: **Log Meadow** Sample #: **05-2-2-38**
Date: **3 Sept 05** Time started: **0845**
Collector: **JGH** Vials: **Honey only**
Taxonomy: **JSG/JGH**
Notes: **lost 1 ant from honey bait, probably Myrmica**
Data entered/initials: **12 Dec 05/JSG**
Data verified/initials: **18 Dec 05/JGH**

Taxa	Honey	Tuna
<u>Myrmica discontinua</u>	6	

SOP 19. Groundcover and Peat Depth Sampling

Version 1.0

Jonathan Nesmith, Edward Gage, and Jennifer Rains Jones

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Figures

Page

Figure SOP 19.1. Overview of plot layout and illustration of grid points used to sample groundcover type frequency and peat depth within the macroplot.....SOP 19.3

Figure SOP 19.2. Use of a pin flag to assess groundcover type within a macroplot.....SOP 19.4

Introduction

This SOP provides step-by-step instructions for sampling the frequency of groundcover variables and peat depth found in the Wetlands Ecological Integrity monitoring protocol permanent plots. This SOP is focused on two specific attributes: groundcover composition and frequency and average peat depth, measured within the 100 m² macroplot.

The quantity of bare ground has often been used as a metric of meadow condition, primarily when assessing the effects of livestock grazing (Weixelman et al. 1997, Weixelman and Zamudio 2001, Cole et al. 2004). Intensive grazing has been shown to increase the frequency of bare soil, decrease plant cover primary productivity, and shift species composition (Olson-Rutz et al. 1996, Fahnestock and Detling 2000, Cole et al. 2004).

The frequency of occurrence of all types of ground cover within the macroplot is recorded using a point intercept sampling method. Within each macroplot a 10 x 10 m grid of 100 points is established using measuring tapes, string, and pin flags (Figure SOP 19.1). The number of pin hits of each groundcover type is recorded. Only one cover type can be recorded at each location. Types of groundcover include:

- Live vegetation
- Rock: rock fragments larger than 6.4 cm (~2.5 inches) diameter
- Gravel: rock fragments from 2 mm – 6.4 cm diameter
- Bare Ground: bare mineral soil less than 2 mm diameter (not rock or gravel).
- Bare peat: in practice, this is usually peat that has been exposed by disturbance, such as being dug up by animal activity
- Litter: in the context of this protocol, litter includes all downed dead plant herbaceous material laying on the soil surface plus all woody material less than 1 cm diameter
- Standing dead: standing dead plant material
- Wood: dead, down wood that is greater than 1 cm diameter

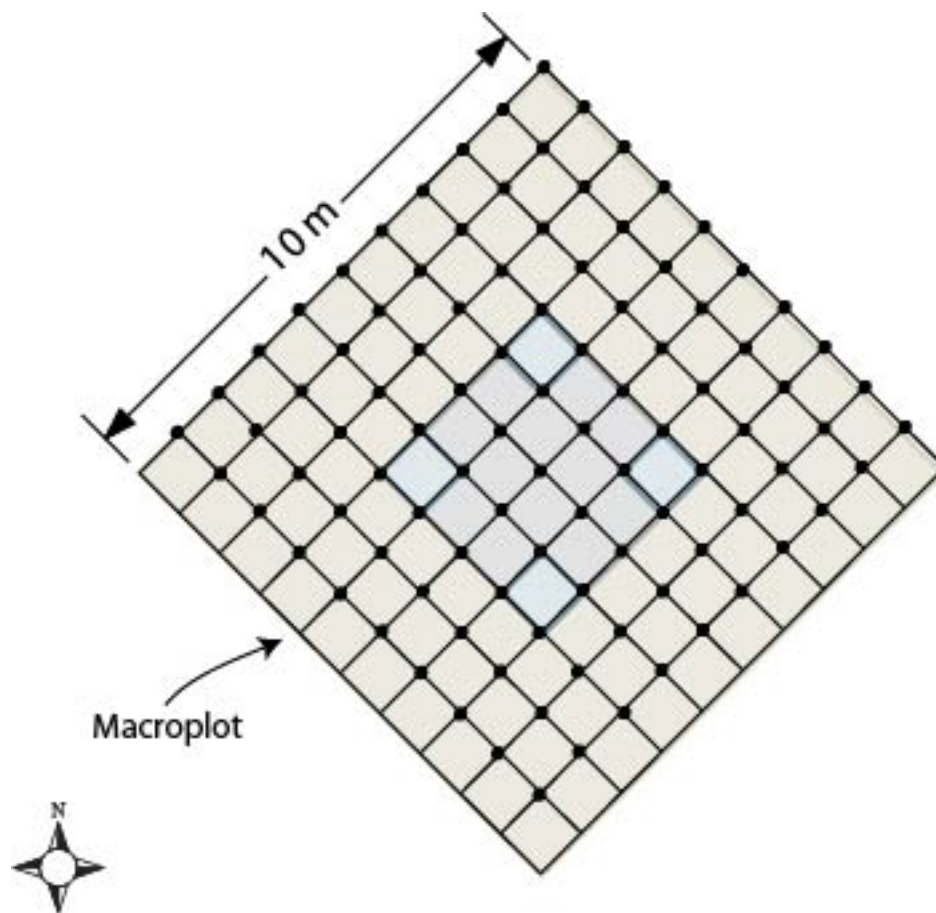


Figure SOP 19.1. Overview of plot layout and illustration of grid points used to sample groundcover type frequency and peat depth within the macroplot.

The cover type is determined by evaluating the spot where a pin flag contacts the ground when placed perpendicular to the soil surface at each grid point (Figure SOP 19.2).

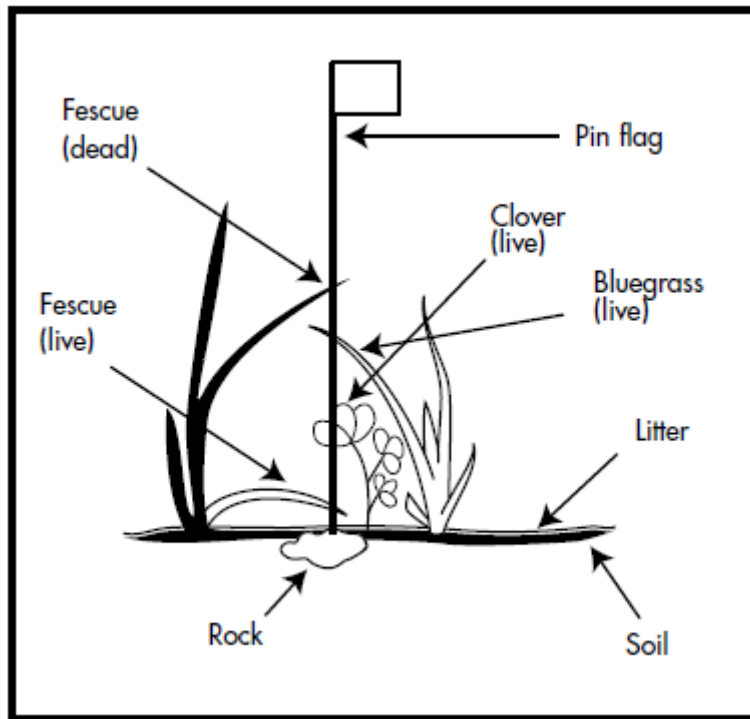


Figure SOP 19.2. Use of a pin flag to assess groundcover type within a macroplot. Figure modified from Herrick et al. 2005.

Peat depth is measured at five randomly selected points from the 100 point grid used to estimate ground cover within the macroplot. A random number table is used to select the five points and peat depth up to 1.5 m is estimated using a soil probe (Lindsay 2010). Peat points should be measured at the same time as the 100 ground cover points. Another commonly used approach to measure peat depth is through the use of ground penetrating radar (Rosa et al. 2009). However, given the remoteness of our sites and the cost of this type of equipment, this option was not feasible for this protocol.

The soil probe is used to assess the depth of peat within the soil profile. Relatively thin mineral strata may be present, but organic horizons dominate. Organic soils resemble decomposing roots and leaves (fibric) or may feel slippery (hemic and sapric). Peat accumulation can cause the wetland to appear to have a domed surface. The ground surface in areas that contain peat may feel spongy under foot. The mean peat depth for the macroplot is determined by averaging the five readings. The soil probe is inserted vertically into the soil to measure depth. The sound of the probe as it passes through the soil is also evaluated. Mineral soils will produce a grating, gravelly sound, compared to a smooth, silky sound of organic soils. When removing the soil probe, the types of deposits left along its shaft can also be evaluated to help in the determination of peat depth.

Equipment

- Plot data forms
- Pencils

- Permanent marker for labeling plant collections
- Clipboard
- Field computer with vegetation data entry software installed
- 18 pieces of 10 m long twine with loops tied at the ends to aid in staking
- 40 pin flags to reading ground cover type and staking down the twine
- Random number table (1 – 100)
- Soil probe

Steps

- Lay out site (SOP 10).
- Use pin flags and 10 m lengths of twine to establish a 1 x 1 m grid across the entire macroplot (Figure SOP 19.1)
- Record the type of groundcover encountered at each of the 100 points using the following groundcover parameters:
 - o Rock: rock fragments larger than 6.4 cm (~2.5 inches) diameter.
 - o Gravel: rock fragments between 2 mm - 64 mm diameter.
 - o Bare ground: bare mineral soil less than 2 mm diameter.
 - o Bare peat: peat that has been exposed by disturbance, such as being dug up by animal activity.
 - o Litter: litter includes all downed dead plant herbaceous material laying on the soil surface plus all woody material less than 1 cm diameter.
 - o Standing dead: standing dead plant material.
 - o Down wood: dead, down wood that is greater than 1 cm diameter.
- Record the peat depth at five randomly selected grid points using a soil probe.

Literature

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SOP 20. Procedures for Processing Plant Specimens and Making Final Determinations of Species Identities

Version 1.0

Sylvia Haultain

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP describes step-by-step instructions for processing and identification of plant specimens (both vascular and nonvascular) collected as part of the Sierra Nevada Network Wetland Ecological Integrity monitoring protocol. These procedures are intended to ensure accurate and repeatable results from the monitoring protocols for species composition (SOPs 12, 13, and 14). The importance of vouchering species identities with well-documented, properly curated specimens cannot be overstated, particularly within the context of long-term monitoring.

Steps

1. Immediately upon return from a field sampling tour plant specimens are transferred from the lightweight field press into a full sized wooden press, and stored in a warm, dry, well-ventilated and secure area so that they quickly dry and are not compromised due to mold.
2. After they are thoroughly dried, plant specimens are removed from the plant press and organized by genus into folders. Inspect field collection sheets to make sure attributes including collector, collection date, collection number, and site are clearly noted. Loose materials such as seeds or inflorescences are placed into fragment envelopes that are also labeled clearly and stored along with the plant specimen in the newsprint folder. These folders are stored in the lab, preferably in sealed herbarium cabinets.
3. Preliminary determinations are made in the laboratory by the lead botanist, using accepted taxonomic references and comparing against collections in the local herbarium. If a second botanist is available (e.g. the lead from another park in the network, the field assistant, or local park staff), it is optimal to solicit verification of determinations. Determinations are documented directly on the newsprint or collection packet along with the initials of the determiner and the date of identification. Notes may also be made documenting diagnostic characters, references used, and if the specimen was compared to an existing voucher in a local or university herbarium.
4. Incomplete or immature collections insufficient for identification must be documented as such at this point, by noting “no determination” on the folder along with initials and date.
5. If there is any uncertainty regarding a determination or if specific taxonomic groups require the input of a specialist, collections are sent out for identification. Specialists for California groups can be located by contacting the Jepson Herbarium at the University of California at Berkeley, especially those serving as treatment authors for the Jepson Manual, the accepted flora for California.
6. Identification and/or verification of members of the Cyperaceae, Juncaceae and Salicaceae can be contracted through the *Carex Working Group* at Oregon State University. They work on a per plant basis and can be contacted through: Dick Brainard, *Carex Working Group*, Oregon State University, OR 97331.
7. Identification and/or verification of nonvascular plants can be contracted through the laboratories of Dr. Paul Wilson, Department of Biology, California State University, 18111 Nordhoff St., Northridge, CA 91330-8303 or Dr. Brent Mischler 4156 Valley Life Sciences Building, Department of Integrative Biology, University of California, Berkeley CA 94720.
8. After the final determinations of specimens are made or received from outside specialists, the original field data sheets are annotated with the identities of the specimens. It is

crucial that each reference to a particular specimen on these data sheets is annotated so that the correct species names are entered into the database. The principal investigator will maintain and update a master database with the accepted taxonomy for the project. This database will be archived each year in order to facilitate any changes in species nomenclature that may need to occur in the future. In general, this project follows the accepted nomenclature of the USDA Plants database (USDA NRCS 2017).

9. Once all final determinations have been received, specimen data are entered into the final collection database. NPS accession and catalog numbers are then obtained from the appropriate park curator and assigned to each specimen. Once data entry is completed a label for each specimen is printed. Sample labels for vascular species sheets and for nonvascular species envelopes is contained in SOP 4 Appendix A. Vascular specimens are then mounted onto archival herbarium paper using conventional techniques, and non-vascular species are placed into acid-free archival specimen packets. After mounting, specimens are submitted to the appropriate museum curator for inclusion in the DEPO, SEKI, or YOSE herbarium. As part of this process, specimen data is entered into ANCS+, the NPS cataloging database.

Literature Cited

USDA NRCS. 2017. The PLANTS Database (<http://plants.usda.gov>, 05 January 2017). National Plant Data Team, Greensboro, North Carolina 27401-4901 USA.

SOP 21. Training

Version 1.0

Jonathan Nesmith

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP lists the training requirements for Wetland Ecological Integrity field crew members. It does not go into detail on the specific training topics, but lists the topics that must be covered and references protocol SOPs and NPS training materials where the information is located. The Project Lead is responsible for coordinating field training and should have an active training role, especially with field sampling, to maximize consistency. However, the lead may delegate some training responsibilities to knowledgeable crew leads or park staff, as appropriate. The Project Lead documents and tracks training completion for their personnel.

Training should begin several weeks prior to field sampling. Approaches to coordinating trainings will vary by year. Attending trainings hosted by the parks is recommended when they meet the Wetland Ecological Integrity Protocol training requirements and can be coordinated with crew schedules. It is strongly recommended that if there are separate field crews (stationed at Sequoia and Kings Canyon and Yosemite national parks), they receive training together at the beginning of the field season.

Training requirements are as follows:

Required Training

- General orientation to the I&M program and Wetland Ecological Integrity monitoring protocol
- Required safety training topics (SOP 22, 23)
- Site selection and establishment (SOP 6, 7, 10)
- Vegetation and ground cover sampling methods (SOP 12, 13, 14, 19)
- Invertebrate sampling methods (SOP 16, 17, 18)
- Well and data logger installation and reading (SOP 8, 9, 15)
- Camera use and photo point documentation (SOP 11)
- Compass use and wilderness navigation (SOP 2)
- GPS Usage (SOP 3)
- Equipment decontamination (SOP 5)
- Quality assurance and quality control procedures (SOP 20 and 26)
- Data entry (SOP 4)
- Data management (SOP 24, 25, 26, 27, 28, 30)
- NPS required trainings (e.g., IT Security Training[FISSA], Whistleblower)
- General NPS and administrative trainings (e.g., vehicle use, ethics, time sheets)

Recommended Training

(trainings may not be available, and/or crew may in backcountry during course dates)

- Recommended safety training topics (e.g., Wilderness First Aid) (Refer to SOP 22)
- Yosemite or Sequoia and Kings Canyon seasonal orientations

SOP 22. Safety

Version 2.1

Alice Chung-MacCoubrey, Jonathan Nesmith, and Linda Mutch

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	01/27/2014	A. Chung-MacCoubrey	Incorporated material from SIEN safety plan & SOPs	SIEN safety plan was written after initial version of this protocol	2.0
2.0	March 2017	J. Nesmith	Added specific elements related to wetland sampling to WEI JHG	Added needed elements related to use of chemicals in the lab for collecting and processing macroinvertebrate samples	2.1

Tables

Page

Table SOP 22.1 Required and Recommended Gear for Backcountry Trips SOP 22.9

Table SOP 22.2 Required and Recommended Safety Training for Field Crews..... SOP 22.10

Appendixes

Page

Appendix SOP 22A. SIEN Job Hazard Guideline: Wetland Monitoring SOP 22.13

Introduction

The Safety SOP summarizes the SIEN safety philosophy, approach, and standards/guidelines for field crews. It includes tables of required gear for backcountry trips (including wetland-specific items) and required safety training, and it references the location of materials to be used during safety training. Protocol-specific material (i.e., the wetlands job hazard guideline) is included as an appendix. This SOP is not intended to be stand-alone, but to be used in conjunction with the SIEN Safety Plan (Chung-MacCoubrey et al. 2012) and other safety related guidelines and materials. To ensure that staff understand and feel empowered to take responsibility for safety and wellness, this SOP starts by articulating safety-related roles and responsibilities of staff.

Roles and Responsibilities

The following roles and responsibilities are an excerpt from the SIEN Safety Plan and are adapted from the NPSafe program.

Field Crew

- Take initiative for their own safety and health and that of coworkers
- Integrate safety into all daily operations, activities, and training
- Comply with safety and other work regulations
- Identify and report hazards, unsafe working conditions, and safety concerns to their supervisor, Project Lead, or Program Manager
- Immediately report near misses and any accident/injury (major or minor) to their supervisor, Project Lead, or Program Manager (no later than the end of the work shift)
- Maintain personal wellness & fitness as needed for assigned tasks
- Participate in establishing a safe working culture and practices, including development and evaluation of related training & supporting materials (e.g., JHAs, SOPs)
- Attend local park safety events and activities when possible
- Attend SEKI RMS division's monthly safety meetings when possible
- Are evaluated for compliance with safety procedures and policies under the performance and conduct management systems

Project Lead

- Lead activities in preparation for Field Readiness Review and Certification
- Facilitate development of a safety culture. Continuously and clearly communicate a personal commitment to the goal of preventing accidents and injuries.
- Monitor compliance with safety standards and procedures using tools such as coaching, performance standards, and performance evaluations.
- Ensure project staff receive appropriate safety training, including instruction on the use of safety equipment
- Develop and update relevant JHAs & SOPs for project field work
- Conduct risk analyses prior to and during field work as needed
- Cultivate a safe climate in which employees feel comfortable voicing safety concerns and comments.
- Take primary responsibility for safety of project field crews and designate an alternate if unavailable for brief periods
- Allocate appropriate time, resources, and attention to project field implementation, including ensuring compliance with SIEN safety policies, guidelines, and SOPs, making time to

interact with field staff, monitoring for communications when staff are in the field, providing support to field staff as needed

- Investigate all accidents and near-misses. Implement corrective actions for identified hazards. Report incidents and near-misses to the SIEN Safety Lead
- Encourage all employees to participate and contribute to evaluation and continuous improvement of our safety program

Network Program Manager

In addition to the roles identified for Project Leads and Employees, the Program Manager will:

- Communicate primary importance of employee safety
- Facilitate development of a safety culture, i.e., a work environment conducive to safety consciousness, through work planning, workload management, resource allocation, performance management, and instituting policies, standards, and procedures to create and sustain a safety culture
- Work with Project Leads to ensure that supervisory training requirements are met (e.g., OL training, 40 hrs supervisory training)
- Ensure network compliance with Field Readiness Review and Certification procedures
- Upload completed Protocol Readiness Reviews to the PWR I&M Safety Sharepoint site
- Work with Project Leads to evaluate workloads, prioritize tasks, and ensure adequate time for field staff training, supervision, and interaction
- Ensure that Project Leads follow through on safety policies, procedures, and responsibilities
- Allocates resources to support the network's safety program (e.g., safety-related equipment, training)
- Works with SIEN Safety Lead to ensure that safety-related policies and updates are communicated and/or discussed, the network regularly evaluates its policies and procedures, and the safety plan is updated accordingly
- Communicates operational integration needs to individual park Superintendents (or to Board of Directors if a network-level discussion is required)

SIEN Approach to Safety

Listed below are the major elements of SIEN's approach to safety. Subsequent sections of this SOP will expand on each element and reference specific sections of the SIEN Safety Plan for more information or training purposes.

SIEN will:

1. Articulate its safety philosophy, standards, guidelines, and acceptable levels of risk so they are understood and agreed upon by SIEN staff
2. Provide training to empower staff to assess risk and make appropriate decisions
3. Reinforce safety principles and their application in the field
4. Integrate its activities at an operational level with parks

SIEN Safety Philosophy

A good safety program first starts with a safety philosophy that is articulated, embraced, and internalized by all staff, ensuring that we all remain mindful, proactive, and vigilant about our

personal safety and that of our team. Below is SIEN's safety philosophy, as articulated in the SIEN Safety Plan.

- Safety is a primary concern and is integrated into all daily operations, activities, and training.
- Nothing in our program mission, project goals, or day-to-day objectives is so important as to compromise employee health and well-being.
- SIEN's organizational culture strives for continuous improvement of policies, procedures, environment, and attitudes to enhance employee safety.
- The commitment to and accountability for safety is a joint responsibility of all employees, from seasonal technicians and volunteers to Project Leads and Supervisors. Accordingly, each of these parties is responsible for following safe work practices and procedures, as well as identifying and reporting unsafe conditions.
- It is the responsibility and right of each individual to speak out when safety concerns are observed and identified. If an individual does not feel that he/she can perform a task safely, this concern should be communicated to a Supervisor or Project Lead immediately.
- Field work in the Sierra is inherently risky. At all times, employees and volunteers shall strive to maximize their margin of safety and practice the concepts of situational awareness and risk management.

Standards and Guidelines for Field Safety

Operational leadership training states that program managers and team leaders are responsible for setting the standards, articulating the standards to employees, enforcing the standards, and following the standards (role model behavior). The staff is responsible for knowing and understanding the standards, following the standards, and encouraging others to follow the standards. Standards may include the standard operating procedures for each monitoring protocol as well as overall programmatic standards of safety that may be common to all protocols and operations (communication procedures, vehicle safety, etc.). To facilitate learning, standards and guidelines relevant to field crews are summarized in the sections below titled Communications, Planning and Operations, and Logistics. The Project Lead should review the full set of standards and guidelines to identify additional information to share with field crews (see SIEN Safety Plan Field Safety chapter).

Communications

This section addresses communications procedures for field personnel entering the backcountry, including check-ins, nonemergency communications, and emergency communications.

Communication Devices

- Each independently-operating unit (individual or team) must carry :
 - 1) a park radio and a spare battery, and
 - 2) a secondary device during all overnight trips and off-trail travel (e.g., GeoPro Satellite Messaging Device-SMD, preferably, or satellite phone).
- Use the park radio as the primary mode of daily check-ins and emergency declaration. Nonetheless, declaring an emergency on the SMD is very quick and easy, and it should be deployed as well in an emergency
- For teams of two or more, split communication devices among crew members
- If a base camp is established, communication devices should be carried to field sites.

Wilderness Travel Policies and Check-in Procedures

- Crews comply with park-specific Field Check-in Procedures, which integrate each park's wilderness travel guidelines.
- Crews will file a Wilderness Travel Plan (WTP) for all overnight trips and comply with each park's wilderness travel policies
- Tracking feature of the GeoPro SMDs will be turned 'ON'

Other Communication

- While it is impossible to identify all the types of information that may need to be relayed, items listed below must be reported as soon as possible to the Project Lead (and Dispatch where appropriate).
 - All illnesses, injuries (major or minor), and close-calls
 - Deviations from planned routes
 - Departures from planned itineraries (e.g., behind or ahead of schedule) and complications (e.g., equipment failure)
 - Environmental hazards encountered or anticipated (e.g., extreme weather conditions)
 - Visitor reports of illness/injury, distress, fire.
- Project Leads and crew members should cultivate a safe environment for individuals to speak freely, particularly on safety issues and concerns.

Planning and Operations

This section addresses the planning of field projects and includes guidelines that ensure that work schedules and field schedules are designed at a sustainable pace, that crews are knowledgeable about, are familiar with, and have ownership of the field schedule and routes, that crews use and/or establish safe and repeatable routes to sampling locations, and that there is a designated lead who is responsible for specific, critical communication functions.

Planning and Operations

- Employees understand and adhere to SIEN safety standards & guidelines. Employees make decisions in the field that are in alignment with the SIEN safety philosophy and risk tolerance guidelines (i.e., SIEN values employee health and safety more than field data).
- Crews exercise risk management during all aspects of planning and operations.
- Employees understand that acceptable levels of risk in a professional, work capacity are different and likely more conservative than in a personal (e.g., recreational) context.
- Risk assessment analyses (GAR, SPE) are conducted throughout the season at different temporal and spatial scales (e.g., prior to first field tour at SEKI).
- At the beginning of the season, crews will review, refine, and adjust routes and tour schedules to match individual and team abilities, needs, and logistic constraints. Final schedules and routes are approved by the Project Lead.
- Crews may refine field tours up until departure based on environmental conditions, logistics, and their physical state. During a field tour, routes and schedules (e.g., tour length) may also be adjusted according to conditions. In these situations, good communication with the Project Lead is critical, especially for crews operating remotely.
- Plan for adequate office time after field tour. This time may be used to enter, organize, and file data, debrief with Project Lead, stow, clean, and maintain equipment, address

administrative paperwork (i.e., timesheets, travel vouchers), and other activities. This time also serves as a buffer should the field tour run long.

- Plan for adequate rest and recovery between field tours.

Route considerations while planning or operating in the field

- Consider and plan miles to be traveled and hours to be worked each day. Generally, regular work days should not exceed 10 hours unless planned and pre-approved.
- Routes should stay on trails (maintained or unmaintained) as much as possible.
- When cross country travel is necessary, cross country routes should not exceed Class 2.
- Routes should be devised to be repeatable by future crews (i.e., routes should not require advanced mountaineering skills).
- Safety of a route is the first and foremost consideration. Expeditionousness (shorter distance or time) is secondary.
- Crews should not hike after dark.
 - Plan for adequate time to reach sampling locations or camp sites before dark.
 - If work necessitates that crews hike in the dark (e.g., bird crew must travel pre-dawn to reach transect starting points), be sure to analyze and mitigate risk via measures such as staying on established trails, use of headlamps, allowing more time to reach the destination, reducing travel speed, etc.

Preparing for the field

- A generally accepted rule of thumb is that backpack weight should not exceed one third of body weight. Crews consider this rule of thumb in their selection of personal gear. Crew members discuss with the project lead or logistics technician any need to mitigate pack weight due to the sampling equipment and supplies.
- Examine radio dead zones and radio repeater locations.
- Familiarize yourself with the 'support network' for that tour (e.g., backcountry ranger, other crews in the area, etc.).
- Complete and submit a Wilderness Travel Plan (per park policy) in advance of each field tour.
- Be sure to carry appropriate navigation equipment, including GPS, map, compass and appropriate maps. Maps should include 1:24,000 topographic quad maps for route identification and smaller scale maps for perspective on spatial relationships among sampling locations and the larger landscape.

While in the field

- While travelling in the backcountry, be sure to carry water, personal identification (e.g., original or copy of state driver's license), an extra day of food, and some form of currency (e.g., a small amount of cash).
- Each crew has a designated lead. Nonetheless, crews may take advantage of shifting 'locations' of expertise (per HRO & OL principles). Communications and check-in responsibilities may be alternated between crew members, but this schedule must be provided in advance to the Project Lead.
- Changes to routes and itineraries:

- Crews may make changes to plans, including extending their field time, for valid reasons, but not for purposes of sightseeing, exploration, peak-bagging, or other personal objectives.
- Some reasons for route changes may include managing unexpected events or managing risk
 - environmental hazards such as bad weather
 - fatigue
 - injuries
 - en-route travel or data collection took longer than expected
 - trails or routes are more challenging than expected or pose unexpected hazards
- SIEN prefers that you err on the side of coming out of the field earlier rather than later
- Crews may skip a sampling location if they deem the situation is unsafe
- Changes for reasons other than safety should be discussed and approved in advance
- All changes to trip itineraries and travel routes must be communicated to the Project Lead ASAP
 - Changes made prior to the start of a tour should be communicated and approved in advance
 - Once in the field, crews should still give advance notice of changes, except for emergencies, imminent danger, and other unexpected situations that require immediate change
- While in the field, employees recognize that safety issues and practices are just as relevant during off-duty hours. Be sure to 1) notify someone of your plans (bring someone with you if possible), 2) bring a radio or SMD, and 3) recognize that whatever happens to you also affects your teammate(s).
- While not preferable, solo travel and/or field work is acceptable in some circumstances. A GAR analysis should be completed and mitigation actions performed.
- Use briefings and AARs on a regular basis and at various temporal scales (e.g., the start of a field tour, the start of the field day, etc.) to review objectives and logistics (schedule, intended routes, caches, vehicles, communication plan), discuss environmental conditions and hazards, discuss individual team member condition (e.g., fatigue, injury, etc.) and responsibilities (if any), and any other relevant information.
- At a minimum, After Action Reviews are conducted after each field tour as an important part of cultivating mindfulness towards safety, establishing it as routine, and the continuous learning cycle.

Logistics

We define logistics as activities performed to coordinate and provide resources and services to field project operations. Here, we identify activities to evaluate equipment requirements and pack weights and provide field staff with appropriate gear for backcountry travel, navigation, and communication.

- SIEN will take all feasible steps within the program's control to minimize backpack weight. Final backpack weight is function of 1) season & weather, 2) trip length, 3) backpacking and camping gear, 4) sampling equipment, 5) personal food selection, 6) personal clothing selection, and 7) other personal items.

- SIEN can only control variables 2-4 and advise crews on 5-7. The generally accepted rule of thumb is that backpack weights not exceed one third of body weight. Mitigation measures for backpack weights exceeding this threshold include:
 - SIEN provides field staff with lightweight camping & backpacking gear
 - Larger individuals may carry more weight than smaller individuals; as such, equipment may be redistributed accordingly among field staff
 - Transport a portion of equipment to the field by other means (e.g., cache transport)
 - SIEN advises crews on food and clothing selection
- Field staff are equipped with appropriate navigation equipment.
- Crews are provided appropriate personal safety gear and protective equipment for the task/project. Table SOP 22.1 lists required safety equipment for backcountry trips and items that are available from SIEN.

Field supplies and equipment

- Table SOP 22.1 provides a basic list of equipment for overnight backcountry trips. Protocol-specific items are listed at the bottom. Items are annotated if they are 1) required safety equipment, 2) available for checkout from SIEN, and/or 3) only required in the quantity of one per crew.

Table SOP 22.1. Checklist of recommended and required gear for backcountry trips. This is an excerpt from the SIEN Safety Plan (Chung-MacCoubrey et al. 2012) that has been customized for this protocol. Items in **bold** are required safety-related items. Protocol-specific safety gear is listed at the end of the table. 'Per crew' indicates one item is needed per crew.

Item	Item
Tent (with rain fly and footprint) or bivy	Toiletries
Sleeping bag	Wide-brim hat/ball cap
Sleeping pad	Sun protection (sunglasses, hat, etc.)
Backpack (appropriate for size of person & amount of field gear)	Sun protection (sunscreen, lip balm)
Bear canister	Pack Towel
Stove and Fuel (Per crew)	Toilet Paper
Cooking Pots (Per crew)	Survival Blanket
Leatherman or other cutting device	Camera
Water Filter (Per crew)	Binoculars
Headlamp w/spare batteries	Mosquito headnet and/or repellent
Batteries for personal gear	Whistle
Sandals (for stream crossings and/or camp)	Book
Bowl, mug, spoon, fork	Parachute Cord
Water Bottles	Duct tape
T-shirts (non-cotton material recommended)	Trekking poles*
Shorts	
Long pants	Park radio & spare battery* (Per crew)
Long underwear	GeoPro SMD or sat. phone^{1*} (Per crew)
Hiking Boots	Topographic and other maps* (Per crew)
Socks	Compass* (Per crew)
Long sleeve shirt	GPS* (Per crew)
Warm Hat	Lighters or Matches*
Gloves	Basic First Aid Kit* customized with personal selection of items (Per crew)
Warm/Fleece pullover	One extra day's ration of food
Rain coat	Signaling device (e.g., compass mirror)
Rain pants	Photo- identification (original or photocopy of ID such as driver's license)
Ziplocs/Plastic bags	Small amount of currency
Watch	
Protocol-specific safety gear (may repeat some items from generic list above)	
Shoes for wetland sampling (Tevas, Crocs)	Work gloves
Waders, hip boots, or rubber knee boots	Wide brim hat
Insect Repellent	Lightweight long-sleeve shirt/pants for sun protection

Field Safety Training

The second element of our safety approach is to ensure that employees receive appropriate field-safety training. Table SOP 22.2 identifies basic field safety training to be received by field staff prior to conducting field work. On an annual basis, these training topics will be taught by a combination of SIEN staff (for network-specific safety information) and others who provide more specialized training (e.g., Operational Leadership, Wilderness First Aid). The table includes protocol-specific training, as needed.

Table SOP 22.2. Field-safety training topics that are required or recommended for SIEN Field Staff. Training provided by other organizations or divisions are in *italicized* text.

Topic	Temporary Field Staff	
	Required	Recommended
Safety philosophy, standards, and guidelines Reference: SIEN Safety Plan	X	
Acceptable Levels of Risk for Work-related vs. Personal activities	X	
Key Concepts and Risk Assessment Tools from Operational Leadership ¹	X	
How to Conduct an After Action Review	X	
<i>Interpersonal Communication</i> ²		X
Field Check-In Procedures Reference: Safety Plan SOP 1	X	
Using the GeoPro Satellite Messaging Device	X	
<i>Introduction to Park Radio Use and the Park Radio System</i>	X	
Emergency Communications Reference: Safety Plan SOP 2	X	
Incident Response & Reporting Reference: Safety Plan SOP 3	X	
Field navigation (by GPS, by map and compass)	X	
GPS use	X	
Job Hazards Guidelines for general field activities: General Backcountry Travel including Stream Crossings and crossing snowfields Motor Vehicle Operation Environmental hazards (animals) Environmental hazards (physical) Encountering Marijuana Gardens	X	
Job Hazards Guideline for protocol-specific activities: Wetland Monitoring	X	
Defining terrain classes	X	
<i>Wilderness Ethics & Leave-No-Trace</i>	X	
Gear/food selection and minimizing backpack weight		X
<i>Wilderness First Aid</i>		X
<i>CPR</i>		X
Preparing your first aid kit		X
Handling public encounters (providing information, addressing injuries)		X
Motor Vehicle Operation & Driving Safety. (Reference: Safety Plan Chapter titled Motor Vehicle and Driving Safety)	X	

¹ When opportunities exist, the full 2-day OL training may be arranged for temporary staff

² Potential topics for communication training include assertiveness, effective listening, and facilitation.

Training Materials

SIEN Safety Plan

The SIEN Safety Plan should be reviewed, updated, and referenced by the Project Leads to support all aspects of safety training. The SIEN Safety Plan is a dynamic document and the latest version may be found on the network drive at J:\sien\admin\safety\SIENSafetyPlan\. The SIEN Safety Plan also contains a specific chapter on Motor Vehicle and Driving Safety that should be reviewed with field staff.

Standard Operating Procedures

As referenced in Table SOP 22.2, the following SOPs from the SIEN Safety Plan must be reviewed during initial safety training. These documents are also dynamic and the latest versions may be found on the network drive at J:\sien\admin\safety\SIENSafetyPlan\SOPs.

- SIEN Safety Plan SOP 1: Field Check-in Procedures
- SIEN Safety Plan SOP 2: Emergency Communications
- SIEN Safety Plan SOP 3: Incident Response and Reporting

Job Hazard Guidelines

Job Hazard Guidelines (JHGs) identify tasks associated with the activity, potential hazards, and safe job practices and procedures. Project Leads shall review and discuss general and protocol-specific job hazard guidelines with field staff prior to initiating field work and as needed throughout the field season (i.e., as a refresher, as new situations arise). All employees have the right and responsibility to contribute to development and refinement of JHGs. Reviews of JHGs will be documented by employee signatures. As referenced in Table SOP 22.2, the following JHGs will be reviewed during safety training. Current versions of field-related JHGs are stored on the network drive at J:\sien\admin\safety\JHGs\. Copies are provided to each park safety officer for inclusion in park records. This protocol's specific JHG is included in this SOP.

General Field Safety JHGs

- Backcountry travel
- Environmental hazards (plants/animals/physical)
- Encountering marijuana gardens
- Driving safety

Protocol-Specific JHG

- Wetlands monitoring (Appendix SOP 22A)

Reinforce Safety Principles

The third element of SIEN's approach to safety is for Project Leads to reinforce safety principles and their application in the field. Project Leads will reinforce safety standards, principles, and procedures by working through training scenarios with employees, observing employees during activities (e.g., in field with crews), discussing safety (e.g., conducting pre-tour briefings and post-tour After Action Reviews), and seeking other opportunities to reinforce safety principles, use of tools, and compliance with procedures.

Operational Integration with Parks

The fourth element of SIEN's safety approach is to ensure that SIEN's field activities are fully integrated with park operations and are conducted in a manner consistent with park operational standards, policies, and procedures. Field readiness reviews ensure that projects are supported to the fullest degree by park and network staff and resources and field staff receive necessary training, logistic, and operational support to ensure their safety.

- Field Readiness Reviews encompass the following project elements:
- Operations planning and field logistics
- Training requirements
- Risk management
- Awareness of and consistency with park safety protocols and emergency procedures
- Supervisory oversight
- Communications

On an annual basis, SIEN Project Leads, the SIEN Program Manager, and park Superintendents perform an integrated examination and certification of field readiness for each protocol within each park where this protocol is implemented. To facilitate this review process, SIEN developed a Field Readiness Review Checklist template that articulates specific actions to be completed by park and network staff prior to certification of field readiness. Appendix A of the SIEN Safety Plan (Chung-MacCoubrey et al. 2012) contains the Field Readiness Review Certification Form and a Field Readiness Review Checklist.

Literature Cited

Chung-MacCoubrey, A. L., S. Graban, A. M. Heard, J. Matsumoto, L. Mutch, J. Nesmith, and J. R. Skancke. 2012. Safety Plan for the Sierra Nevada Inventory and Monitoring Network. National Park Service, Sierra Nevada Network, Three Rivers, CA.

Appendix SOP 22A. SIEN Job Hazard Guideline: Wetland Monitoring

SIEN Job Hazard Guideline

Job Description:		Date of last update:	
Wetland Monitoring		March 30, 2017	
Division with primary responsibility for this JHG:	Last updated by:	Reviewed by:	Approved by:
SIEN Inventory & Monitoring	J. Nesmith		
Required standards & notes:			
Required personal protective equipment:	<p>For work in the sun: long sleeve shirt, light colored clothing, and a wide brimmed hat.</p> <p>For all work: There should be at least one person with a radio and first aid kit that includes an antihistamine such as Benadryl.</p> <p>For well installation: gloves</p>		
Typical tools & equipment:	Well installation: Hand auger, PVC tubing, handsaw to cut PVC, special shovel for soil samples, rebar for vegetation plot installation, insect collecting nets, knives for collecting plant vouchers.		
Activity	Potential Hazards	Safe Action or Procedure	
Working with rebar	Puncture wounds	<p>Debur sharp edges</p> <p>Secure rebar in pack while carrying, or alternatively, carry by hand on the downhill side.</p> <p>Give persons carrying rebar (in hand or attached to pack) extra room on the trail</p> <p>Be cognizant of rebar placement within the fuels plot. Know your location within the plot as well as the location of all rebar stakes. Mark rebar with either bright paint or flagging</p>	
Working with chemicals	Flammable liquid, skin irritation, serious eye irritation, drowsiness or dizziness, suspected of damaging fertility or the unborn child, damage to organs	These are flammable liquids and vapors that can cause skin and serious eye irritation, drowsiness, or dizziness. Use only outdoors or in a well-ventilated area. Wash exposed skin thoroughly after handling. Do not eat, drink, or smoke when using this product. Wear eye protection, face protection, protective clothing, and protective gloves.	
Working with battery powered equipment	Fire hazards	Monitor the condition of batteries within power equipment on a regular basis. If batteries are wet, or appear defective, replace immediately. If you notice an unusual smell, power down equipment and replace batteries.	
Use of auger to install groundwater monitoring wells	Bulky, heavy metal tool can cause back injury	When using auger, use legs to help pull out of ground to avoid back injury.	
	Sharp cutting bit	Take turns carrying and using tool to minimize fatigue.	
		Cover bit when tool is not in use; Use gloves when handling.	

Collecting vouchers	Sharp knives or digging tools	Pay close attention when using sharp knives or small shovels to collect plant vouchers; wear gloves to minimize risk of cutting fingers
	Spiny plants and nettles	Wear gloves and long sleeves and pants when removing plants; avoid hitting face with plant. Wear eye protection when working with spiny plants.

SOP 23. Field Communications for Wilderness Travel

Version 2.0

Alice Chung-MacCoubrey and Linda Mutch

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0	01/27/2014	A. Chung-MacCoubrey	Incorporated material from SIEN safety plan & SOPs	SIEN safety plan was written after initial version of this protocol	2.0

Appendixes

Page

Appendix SOP 23A. Local Contacts for Wetlands Field Personnel..... SOP 23.5

Appendix SOP 23B. Emergency Contact Form. SOP 23.6

Introduction

Regular communication between field crews and frontcountry contacts in the parks and network is critical to: 1) provide a systematic way of tracking the status of employees working in wilderness so that if check-ins are missed, actions are taken to make contact with or locate the employees, and their last known location and travel plans are documented; 2) integrate field crews into park wilderness operations and communication networks; and 3) give SIEN Project Leads and field crews regular opportunities to communicate with each other on logistical or other needs. Check-in and Emergency communication procedures for SIEN field crews are fully documented in SOP 1 and SOP 2 of the SIEN Safety Plan (Chung-MacCoubrey et al. 2012). These SOPs are dynamic, must be updated periodically to comply with changes in park and network procedures, and are thus referenced rather than included in the wetlands protocol. This document (SOP 23: Field Communications for Wilderness Travel) summarizes general concepts and procedures from the SIEN Safety Plan SOPs on Check-in and Emergency Communications, and the SIEN Safety Plan SOPs should be accessed for procedural details. Training on communications procedures and equipment are referenced in SOP 22.

Mandatory Communication Equipment and Supplies

The following items are required when entering wilderness, regardless of trip length or location, by each independently operating unit:

- Fully charged park radio with fully charged spare battery
- If travelling off-trail (day trip or overnight) or if travelling solo overnight, a secondary communication device such as the GeoPro Satellite Messaging Device (SMD) or a satellite phone
- Map of repeaters and radio dead zones (as available from each park)
- Map of ranger station locations in sampling areas
- Call number lists with key contacts (SOP 23 Appendix A)
- Personal cell phones are encouraged en-route to & from trail heads from YOSE or SEKI offices

Pre-season Communication with Park Dispatch

Prior to the start of the general field season, the SIEN Program Manager will contact Dispatch offices at YOSE and SEKI about upcoming field projects, confirm check-in procedures, and confirm how emergency declarations will be handled. For the most current procedures, see SOP2: Emergency Communications of the SIEN Safety Plan (Chung-MacCoubrey et al. 2012). At the start of the season, field crews will complete the emergency contact forms (SOP 23 Appendix B) and submit them to the Project Lead, who will retain one copy for SIEN records and provide the original to SEKI Park Dispatch.

Wilderness Check-in Procedures at Individual Parks

Check-ins between field crews and park Dispatch occur primarily via park radio and follow individual park procedures. General communications between field crews and the Project Lead occur by radio or GeoPro. SEKI and YOSE Wilderness Travel policies require submission of Wilderness Travel Plans and regular check-ins via radio (or GeoPro). SIEN Safety Plan SOP 1 summarizes individual park procedures as they are to be implemented by SIEN projects and

staff, which may vary from park staff; it also includes the most current contact information for Dispatch and Wilderness Offices at each park (Chung-MacCoubrey et al. 2012). Locations are provided below for the park policies and relevant SOPs from the SIEN Safety Plan.

References

- SIEN Safety Plan SOP 1: Check-In Procedures
J:\sien\admin\safety\SIENSafetyPlan\02_Final_2013\SOPs\SOP01_Checkins
- SEKI Management Directive No. 044 (Wilderness Safety Communication)
<http://inpsekisharept/General%20Policy%20and%20Guidelines/Current%20SEKI%20Management%20Directives.Ink>
- YOSE Directive #15 (Wilderness Travel)
<http://sharepoint.yose.nps.gov/supt/Superintendents%20Orders/Yosemite%20Wilderness%20Travel.docx>
- DEPO Management Directive No. 011 (Backcountry Travel)
J:\sien\admin\safety\references\NPS_directives_policies\Park_DEPO\

Emergency Communications

In the event of an emergency, field staff should attempt to communicate via park radio with park Dispatch, the primary contact for emergencies, and activate the emergency panic button on the GeoPro unit as a backup. If crews are unable to talk directly with Dispatch via park radio, the next options are 1) to contact other backcountry personnel that can relay messages or 2) use the GeoPro to text message with Dispatch. Emergency communication procedures for field crews are provided in SIEN Safety Plan SOP2: Emergency Communications (Chung-MacCoubrey et al. 2012).

Reference

- SIEN Safety Plan SOP 2: Emergency Communications
J:\sien\admin\safety\SIENSafetyPlan\02_Final_2013\SOPs\SOP02_EmergencyComm
- SEKI Management Directive No. 044 (Wilderness Safety Communication)
<http://inpsekisharept/General%20Policy%20and%20Guidelines/Current%20SEKI%20Management%20Directives.Ink>
- YOSE Directive #15 (Wilderness Travel)
<http://sharepoint.yose.nps.gov/supt/Superintendents%20Orders/Yosemite%20Wilderness%20Travel.docx>

General Communication with Field Crew

The Project Lead and Logistics Technician will identify the types of information to be provided by field staff and will establish a regular communication schedule. Crews should take advantage of the GeoPro SMD's text messaging to communicate more frequently with Project Leads or other crews. The GeoPro creates the opportunity for SIEN staff and field crews to communicate on how the sampling is going, issues with travel routes or sampling sites, and equipment needs, inquire on methods, weather conditions, and fire activity, report communication problems (no radio reception, dead batteries, down repeaters), and request support (e.g., relay check-in information, request equipment). Crews will communicate all injuries, illnesses, and route deviations as soon as possible and in sufficient detail to the Project Lead.

Monitoring of Communications

The SIEN Project Lead has overall responsibility for maintaining communications with his or her field staff, ensuring that field staff are complying with park check-in procedures, monitoring for their GeoPro communications, providing or arranging support to field staff as needed, and arranging an alternate if the Project Lead will be unavailable for a period. When a Wilderness Travel Plan is filed, the park Dispatch or Wilderness Office has primary responsibility for monitoring for radio check-ins.

Reporting of Incidents and Accidents

In the event of an accident or incident, get immediate medical attention, if required. Prior to entering the field, crews must be familiar with how to obtain emergency assistance while in Wilderness, which is detailed in the SIEN Safety Plan: SOP2 on Emergency Communications (Chung-MacCoubrey et al. 2012). All incidents, accidents, and close-calls must be reported to the Project Lead. Reporting ideally occurs as soon as possible after the incident and should occur by the end of the work shift, at the latest. The reporting procedures depend on the severity, nature, and location of the incident. Prior to initiating field work, crews will receive training on accident reporting obligations and procedures (SOP 22) and the SIEN Safety Plan: SOP3 (Incident Reporting and Response; Chung-MacCoubrey et al. 2012). Employees should discuss and evaluate close calls so that learning occurs within the crew, project, and organization.

Literature Cited

Chung-MacCoubrey, A. L., S. Graban, A. M. Heard, J. Matsumoto, L. Mutch, J. Nesmith, and J. R. Skancke. 2012. Safety Plan for the Sierra Nevada Inventory and Monitoring Network. National Park Service, Sierra Nevada Network, Three Rivers, CA.

Appendix A SOP 23. Local Contacts for Wetlands Field Personnel

Park		Name	Telephone
YOSE	YOSE Natural Resource Mgr	Victoria Hartman	209-379-2174
	YOSE Hydrologist	Jim Roche	209-379-1446
	Emergency	Dispatch	911
SEKI	SIEN Program Manager	Sylvia Haultain	559-565-3788
	SIEN Data Manager	Alex Eddy	559-565-3709
	SIEN Ecologist	Jonathan Nesmith	559-565-3765
	SIEN Physical Scientist	Andi Heard	559-565-3786
	SIEN Administrative Technician	Jenny Matsumoto	559-565-3787
	SEKI Plant Ecologist	Erik Frenzel	559-565-4248
	SEKI Wildlife Biologist	Daniel Gammons	559-565-3124
	Emergency	Dispatch	559-565-3195 or 911
DEPO	Superintendent	Deanna Dulen	760-924-5505
	Ecologist	Monica Buhler	760-924-5505
	Ranger Station	Various staff	760-924-2289
	Emergency		911

Appendix B SOP 23. Emergency Contact Form (Office).

This form is used by the SEKI Dispatch Office. Dispatch answers all incoming calls and is responsible for keeping a database of Park Employees. In keeping this information up to date, they request this form be completed. This information facilitates the proper routing of emergency and non-emergency calls, memos and other related topics to Park Employees.

NAME: _____ SUPERVISOR: _____

[PLEASE PRINT]

POSITION TITLE: _____ WORK AREA: _____

RADIO CALL NUMBER _____

STATUS: Permanent: _____ Seasonal: _____ BEGINNING OF SEASON: _____

ANTICIPATED END OF SEASON: _____ Work Phone Ext. _____

CURRENT ADDRESS: _____

CONTACT PHONE # HOME _____ CELL _____

WILL YOU BE OCCUPYING PARK HOUSING: YES / NO (Temporary / Permanent)

VEHICLE MAKE: _____ COLOR _____ LICENSE/STATE # _____

EMERGENCY CONTACT INFORMATION

(Please list two contacts)

Name _____ Relationship _____

Address _____ Phone (H) _____

City _____ State _____ Zip _____ (W) _____

Name _____ Relationship _____

Address _____ Phone (H) _____

City _____ State _____ Zip _____ (W) _____

Please list all Medical Conditions or special medications a medical provider might need to be aware of in an emergency: _____

Physician Name/Phone #: _____

In accordance with the Privacy Act and Office of Personnel Management regulations, home telephone numbers and/or home addresses of employees are not given out over the phone unless there is a signed release on file with this office. Please be assured that if for any reason you wish to change your release you may do so at any time. By regulation this memo will remain on file. If you have any questions please contact Dispatch at Ext. 3196. Thank you for your assistance.

"I authorize the release of my home phone number and/or home address to callers requesting it."

(Green all callers – Yellow only NPS personnel - check one)

SIGNATURE: _____ DATE: _____ GREEN _____ YELLOW _____

"I Do Not authorize the release of my home phone number and/or home address to callers requesting it."

SIGNATURE: _____ DATE: _____ RED (DO NOT) _____

SOP 23.6

SOP 24. End-of-Season Procedures

Version 1.0

Les Chow

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP describes the end-of-season procedures that are carried out once sampling is complete.

Field Season Debriefing

The Project Lead conducts a post-season debriefing session with all crew members. The purpose is to discuss the season and any departures from protocol procedures (missed sites, samples, etc.) and identify successes and areas that require improvement. Trip routes (e.g., travel time, difficulty, alternate routes) are discussed and documented.

The Project Lead follows standard seasonal check-out procedures on the technicians' final day.

Post-season Data Procedures

- Crews verify that all data are accounted for and complete.
- All data sheets and field notebooks are photocopied or scanned and the originals are filed.
- Location information is typed up in a word document and stored on the network as part of the crew leads required end of season report.
- Photos are downloaded, renamed, and organized properly.
- GPS points are downloaded and saved.
- Plant vouchers that have not been mounted are completed and prepared for archival or shipment to subject matter experts for identification following instructions in SOP 14 and SOP 28.
- Macroinvertebrate samples are sorted and cleaned following instructions in SOPs 16 – 18.

Post-season Equipment Procedures

Crews return, inventory, clean, and store equipment for the winter. Batteries are removed from electronics. Equipment is stored in large plastic containers that are stored at the Sequoia and Kings Canyon I&M office or warehouse space. Broken equipment is fixed or replaced. The crew lead submits a list of equipment to the Project Lead that requires replacing.

1. Crews clean and return all personal and group backpacking equipment.
 - a. Ensure equipment is in good condition and make repairs when necessary.
 - b. Clean out backpacks and wash with soap and water.
 - c. Inventory first aid kit and make a note of missing items.
 - d. Dry and prepare drinking water filter for winter storage per manufacturer instructions.
 - e. Unzip and air out sleeping bags in preparation for professional cleaning.
 - f. Set up and air out tents, remove any debris, and ensure they are completely dry. Patch any holes in tents and stuff sacks.
 - g. Thoroughly clean pots and stove. Take stove apart, soak in white gas for a couple hours, and then reassemble.

- h. Wipe out bear canisters.
- 2. Crews return, clean, and store sampling equipment for the winter.
 - a. Remove batteries from electronics.
 - b. Rinse and clean sampling equipment.
 - c. Set equipment in a clean and protected location and allow to air dry completely.
 - d. Pack equipment into labeled Rubbermaid containers stored at the Sequoia and Kings Canyon I&M office.
- 3. Crews inventory all sampling equipment. Broken equipment is fixed or replaced. The crews submits a list of equipment to the Project Lead that requires replacing.
- 4. Crews prep equipment for next season.

Post-field Season Data Entry and Documentation

Field observations and results are downloaded or entered into the SIEN Wetlands Ecological Integrity Monitoring Database. Refer to SOP 4 for data entry procedures.

The Crew Lead documents logistics and strategies from the season that may be used as a reference for future field season planning (routes, mileages, approximate time taken, etc.) as part of the end of season report.

SOP 25. Data Deliverable Standards

Version 1.0

Les Chow

Change History

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

Introduction

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 as appropriate. To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data.

Specific Instructions for Delivering Certified Data and Related Materials

The following deliverables should be delivered as a package:

- Certified working database: Database in Microsoft® Access format containing data for the current season that has been through the quality assurance checks.
- Certified geospatial data: GIS themes in ESRI coverage or shapefile format.
- Data certification report: A brief questionnaire in Microsoft® Word that describes the certified data product(s) being submitted.
- Metadata interview form: The metadata interview form is a Microsoft® Word questionnaire that greatly facilitates metadata creation.

After the quality review is completed, the Project Lead should package the certification materials for delivery as follows:

1. Open the certified back-end database file and compact it (in Microsoft® Access, Tools > Database Utilities > Compact and Repair Database). This will make the file size much smaller. Back-end files are typically indicated with the letters “_be” in the name (for example, WEI_be_2013.mdb).
2. Rename the certified back-end file with the project code, the year or span of years for the data being certified, and the word “certified”. For example: WEI_2013_certified.mdb.
3. Create a compressed file (using WinZip® or similar software) and add the back-end database file to that file. **Note:** The front-end application does not contain project data and as such should not be included in the delivery file.
4. Add the completed metadata interview and data certification forms to the compressed file. Both files should be named in a manner consistent with the naming conventions described elsewhere in this document.
5. Add any geospatial data files that aren’t already in the possession of the GIS Specialist. Geospatial data files should be developed and named according to SIEN Data Management Plan (Cook and Lineback 2008).
6. Upload the compressed file containing all certification materials to the new submissions folder J:\sien\I_M\monitoring\wetlands\data\tabular\products. If the Project Lead does not have intranet access to this directory, then certification materials should be delivered as follows:
 - If the compressed file is under 20 mb in size, it may be delivered directly to the NPS Lead and Data Manager by email.

- If the compressed file is larger than 20 mb, it should be copied to a CD or DVD and delivered in this manner. Under no circumstances should products containing sensitive information be posted to an FTP site or other unsecured web portal.
- Notify the Data Manager and Project Lead by email that the certification materials have been uploaded or otherwise sent.

Upon receiving the certification materials, the Data Manager will:

1. Review them for completeness and work with the Project Lead if there are any questions.
2. Notify the GIS Specialist if any geospatial data are submitted. The GIS Specialist will then review the data, and update any project GIS data sets and metadata accordingly.
3. Store the certified products together in
J:\sien\I_M\monitoring\wetlands\data\tabular\products
4. Upload the certified data to the master project database.
5. Notify the Project Lead that the year's data have been uploaded and processed successfully. The Project Lead may then proceed with data summarization, analysis and reporting.
6. Develop, parse and post the XML metadata record to the NPS Data Store.
7. After a holding period of 2 years, the Data Manager will upload the certified data to the NPS Data Store. This holding period is to protect professional authorship priority and to provide sufficient time to catch any undetected quality assurance problems.

Specific Instructions for Reports and Publications

Annual reports and trend analysis reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft® Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report template, and trend analysis and other peer-reviewed technical reports will use the Natural Resource Report template. Instructions for acquiring a series number and other information about NPS publication standards can be found at: <http://www.nature.nps.gov>.

In general, the procedures for reports and publications are as follows:

1. The document should be formatted using the NPS Natural Resource Publications template. Formatting according to NPS standards is easiest when using the template from the very beginning, as opposed to reformatting an existing document.
2. The document should be peer reviewed at the appropriate level. For example, I&M Annual Reports should be reviewed by other members of the appropriate project work group. The Network Program Manager also will review all annual reports for completeness and compliance with I&M standards and expectations.
3. Upon completing the peer review, acquire a publication series number from the NPS Technical Information Center or the appropriate local or regional key official (currently the Regional I&M Program Manager).
4. Upload the file in PDF and Microsoft® Word formats to:
J:\sien\monitoring\wetlands\data\tabular\products.

5. Send a printout to each Park Curator.
6. The Data Manager or a designee will create a bibliographic record and upload the PDF document to NatureBib according to document sensitivity.

Naming Conventions

In all cases, file names should follow these guidelines:

- No spaces or special characters in the file name.
- Use the underbar (“_”) character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Dates should be formatted as YYYYMMDD.
- Correspondence files should be named as YYYYMMDD_AuthorName_subject.ext.
- As appropriate, include the project code (for example, “WEIa02”), network code (“SIEN”) or park code, and year in the file name.

Examples

- SIEN_WEIa02_2007_Annual_report.pdf
- SIEN_WEIa02_2007_Field_season_report.doc
- SIEN_WEIa02_2007_Certification_report.doc

Literature Cited

Cook, R. R., and P. Lineback. 2008. Sierra Nevada Network data management plan. Natural Resource Report NPS/NRPC/NRR—2008/070. National Park Service, Fort Collins, Colorado

SOP 26. Metadata Development

Version 1.0

Les Chow

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Appendixes

Page

Appendix SOP 26A. Metadata Interview Form..... SOP 26.4

Metadata Development

Data documentation is a critical step toward ensuring that data sets are usable 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, condition and other characteristics of a given data set. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all SIEN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized.

Updated metadata are a required deliverable that should accompany each season's certified data. 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 then only need to be updated to reflect changes in contact information and taxonomic conventions, to include recent publications, to update data disposition and quality descriptions, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for creating, parsing and posting the metadata record are found in the SIEN Data Management Plan (Cook and Lineback 2008). The general flow is as follows:

1. After the annual data quality review has been performed and the data are ready for certification, the Project Lead (or a designee) updates the Metadata Interview Form.
 - a. The Metadata Interview Form (Appendix SOP 26.A) greatly facilitates metadata creation by structuring the required information into a logical arrangement of 15 main questions, many with additional sub-questions.
 - b. The first year, a new copy of the NCCN Metadata Interview Form should be downloaded. Otherwise the form from the previous year can be used as a starting point, in which case the Track Changes tool in Microsoft® Word should be activated in order to make edits obvious to the person who will be updating the XML record.
 - c. Complete the Metadata Interview Form and maintain it in the project workspace. Much of the interview form can be filled out by cutting and pasting material from other documents (for example, reports, protocol narrative sections, and SOPs).
 - d. The Data Manager can help answer questions about the Metadata Interview Form.
2. Deliver the completed interview form to the Data Manager following guidelines outlined in SOP 24.
3. The Data Manager (or GIS Specialist for spatial data) will then extract the information from the interview form and use it to create and update an FGDC- and NPS-compliant metadata record in XML format. Specific guidance for creating the XML record is contained in SIEN Data Management Plan (Cook and Lineback 2008).

4. The Data Manager will post the record and the certified data to the NPS Data Store, and maintain a local copy of the XML file for subsequent updates. The NPS Data Store has help files to guide the upload process.
5. The Project Lead should update the metadata interview content as changes to the protocol are made, and each year as additional data are accumulated.

Identifying Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which is partly defined as the specific locations of rare, threatened, or endangered species. Prior to completing the Metadata Interview Form, the Data manager and Project Lead should work together to identify any sensitive information in the data. Their findings may be documented and communicated to the Data Manager through the Metadata Interview Form.

Literature Cited

Cook, R. R., and P. Lineback. 2008. Sierra Nevada Network data management plan. Natural Resource Report NPS/NRPC/NRR—2008/070. National Park Service, Fort Collins, Colorado

SOP 26 Appendix A. Metadata Interview Form

SIEN Metadata Interview Form

Type responses directly into this document using a different font color or into a separate text or Word document file and send to the project metadata contact.

1. Title of project and SIEN-assigned project code
2. Originator/ Project Lead Contact information: Include address, email and telephone number
 - a. Additional contacts for project (address, email and telephone number)
 - b. Other individuals/organizations to receive credit for project support (e.g. funding, data collection and analysis)
3. Is the data set published? If yes, provide the reference
4. Brief description of the data set (just a few sentences)
5. Purpose of data collection
6. Time period represented by the data set
7. Primary method of data set development
 - a. Field visits?
 - b. Remote instrumentation (e.g. temperature recorders, remote cameras, etc)?
 - c. Existing data sources?
8. Status of the data set
 - a. Is it complete, in progress, or planned?
 - b. Will the data set be updated? If so, how frequently?
9. Location of data collection. Include place names/descriptions and longitude and latitude bounding coordinates (need values for the four cardinal directions - N, S, E, and W). If UTM's are known, provide those as well.
10. Keywords for searching on this data set
 - a. Thematic
 - b. Place
 - c. Temporal
 - d. Taxonomic
 - e. Strata
 - f. If a controlled vocabulary or thesaurus was used, provide the reference
11. List all related data sets for cross-reference. This includes any tabular and spatial (GIS) data as well as reports.

12. Biological data: the Federal Geographic Data Committee (FGDC) Biological Profile for metadata provides the means to document tabular data sets, taxonomy, field methods, and the use of analytical tools or models.

- a. Was data set developed using a model or other analytical tool?
 - i. If yes, reference
 - ii. If the model or tool is available include a contact and/or URL
- b. Does the data set contain biological information? If no, skip to item 13.
 - i. What species or communities were examined?
 - ii. Was a taxonomic authority or field guide used for identification? If yes, reference
 - iii. Briefly summarize field methods (copy and paste from other documents)
 - iv. If existing protocols or methods were used, provide the references
 - v. Were voucher specimens collected? If yes, list names of repositories and all contact information for each repository

13. Information needed for archiving all data sets (tabular, spatial and biological)

- a. Describe quality assurance and quality control measures taken
- b. Identify items excluded from data collection: (e.g. stems less than a certain diameter or streams without surface flow)
- c. Type/format(s) of data set – list all that apply (spreadsheet, ascii text file, database, GIS attribute table, etc)
- d. What is the filename (and directory path if available) for data set?
- e. Field/attribute information:
List the fields (columns) in the data set for *each* file or table (if available, a data dictionary should contain this same information and can be referenced instead)

For each field list:

- i. Definition of the field (brief description), field size, and type (e.g. numeric, date, text, etc.)
- ii. Domain - each attribute is described by a domain of allowable values:
 - Enumerated** – a finite list of codes or values - list the codes and definitions
 - Range** – measured or calculated values - identify the units as well as the minimum and maximum values (“0 - no limit” is acceptable)
 - Codeset** – codes that come from a published code set or from another file or table - list the reference
 - Unrepresentable** – anything that does not fit into the above three domains (e.g. open ended list of landowners, site IDs, comments fields) - briefly describe what is in the field
- iii. If in an Access database, indicate if the field is a primary key or link field

14. Is this a GIS data set? If not, skip to item 15

- a. Identify a pathway to where the data can be accessed over a network or send a copy of the ArcInfo export file or the ArcMap shapefile and indicate the following:

- i. Projection and datum parameters (e.g. Projection: UTM Zone 11, Datum: NAD 1983)
 - ii. Map units (e.g. meters)
 - b. Brief description of what the data set contains and how it is to be used
 - c. List any source data sets used. For each source list:
 - i. Source name, originator and publication date
 - ii. Source time period and scale
 - iii. Source presentation form and media type
 - iv. Contribution of source to the analysis
 - d. List the processing steps used to create the data set, and for each include:
 - i. Who (and contact information)
 - ii. Approximate date of processing
 - e. Data quality:
 - i. Status - planned, in progress, complete
 - ii. Logical consistency (e.g. are lines snapped, polygons closed, etc.)
 - iii. Positional accuracy (estimate of distance from true location and reason for discrepancy - e.g. GPS accuracy limitations)
 - iv. Attribute accuracy
15. For all data sets: is the data set available for distribution? Indicate to whom it can be distributed: Public, NPS Only, SIEN Only or Park Only
- a. Is there sensitive information (specific locations of rare, threatened or endangered species)?
 - i. Can the resolution of those specific locations be ‘degraded’ to allow distribution?
 - b. Are there legal restrictions on who may use the data?
 - c. Any advice/caveats for potential users of the data set?
 - d. What are the distribution instructions?

*Adapted from “Electronic Metadata Interview” (Lienkaemper, 03/2003).

SOP 27. Data Quality Control

Version 1.0

Les Chow

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Data Quality

Data Review, Verification, and Validation

This section was excerpted from the Sierra Nevada Network Data Management Plan (Cook and Lineback 2008).

Data quality is appraised by applying verification and validation procedures as part of the quality control process. These procedures are more successful when preceded by effective quality assurance practices (i.e., planning). Data verification checks that the digitized data match the source data, while data validation checks that the data make sense. Although data entry and verification can be handled by personnel who are less familiar with the data, validation requires in-depth knowledge about the data.

Validation is the process of reviewing computerized data for range and logic errors and may accompany data verification only if the operator has comprehensive knowledge of the data and subject. More often, validation is a separate operation carried out after verification by a project specialist who can identify generic and specific errors in particular data types. It is essential that we validate all data as truthful and do not misrepresent the circumstances and limitations of collection. Invalid data commonly consist of misspelled species names or site codes, wrong dates, or out-of-range errors in parameters with well-defined limits. More interesting and often puzzling errors are detected as unreasonable metrics or impossible associations (e.g., a tree 2 feet in diameter and only 3 feet high). These types of erroneous data are called logic errors because they produce illogical (and incorrect) results. The discovery and correction of logic errors has direct, positive consequences for data quality and provides important feedback to the methods and data forms used in the field. Histograms, line plots, and basic statistics can reveal possible logic and range errors.

Verification and Validation Methods

Verification

The WEI Protocol will follow guidelines for data verification outlined in the Sierra Nevada Network Data Management Plan (Cook and Lineback 2008):

- Project leaders are responsible for specifying in the project protocol one or more of the data verification methods available and ensuring proper execution. At the discretion of the Project Lead, additional verification methods may be applied.
- Data verification is carried out by staff thoroughly familiar with data collection and entry.
- All records (100%) will be verified against original source data.
- A subset of randomly selected records (10%) will be reviewed after initial verification by the Project Lead. If errors are found, the entire data set will be verified again.
- A record of the verification process for each dataset, including number of iterations and results, will be prepared by the Project Lead as part of formal metadata generation.
- Spatial data collected as part of the project will be viewed in a GIS and visually inspected for accuracy (e.g., points located outside park boundaries, upland locations occurring in forest).

The method we are using to verify the wetlands data is *visual review after data entry*. Upon completion of data entry, all records are printed and compared with the original values from the hard copy. Errors are clearly marked and corrected in the database as soon after data entry as possible. The review is performed by someone other than the person keying the data or by two technicians – one reading from the original data and one checking the entered data.

Additional data verification methods include calculating summary statistics and identifying duplicate or omitted records. For example, the number of known constant elements, such as the number of sampling sites or dates per sample can be evaluated. The SIEN Wetlands Databases has built in controls to prevent duplicate records. Specific queries must be performed to identify missing records.

Validation

The WEI Protocol will follow guidelines for data validation outlined in the Sierra Nevada Network Data Management Plan (Cook and Lineback 2008):

- Project protocols will address a process for data validation that includes at least one of the available methods.
- Corrections or deletions as a result of data validation require notations in the original paper field records about how and why the data were changed, with the editor's initials.
- Modifications of the field data will be clear and concise while preserving the original data entries or notes (i.e., no erasing).
- Validation efforts will also include a check for the completeness of a data set since field sheets or other sources of data could easily be overlooked.
- Use of automated routines and/or data summary and visualization (e.g., histograms, line plots, and basic statistics) will be maximized to identify possible logic and range errors.
- Use of database programming will be maximized to control data entry. This will be achieved via the use of lookup tables and/or field-type design in a database (e.g., yes/no field-types).

We use the following three validation methods:

1. **Data Entry Application Programming:** Certain components of data validation are built into data entry forms. This method is essentially part of the database design. Not all fields, however, have appropriate ranges known in advance. Caution must be exercised when using lookup tables to constrain variable values. Values occurring outside the range set by a lookup table (established during database design) may not always be invalid. As part of data validation procedures, the Project Lead is responsible for correct use of lookup tables or other automated value range control.
2. **Outlier Detection:** According to Edwards (2000), “the term outlier is not (and should not be) formally defined. An outlier is simply an unusually extreme value for a variable, given the statistical model in use.” Any data set will undoubtedly contain some extreme values, so the meaning of ‘unusually extreme’ is subjective. The challenge in detecting outliers is in deciding how unusual a value must be before it can (with confidence) be

considered ‘unusually’ extreme. Data quality assurance procedures should not try to eliminate outliers. Extreme values naturally occur in many ecological phenomena; eliminating these values simply because they are extreme is equivalent to pretending the phenomenon is ‘well-behaved’ when it is not. Eliminating data contamination is perhaps a better way to explain this quality assurance goal. When an outlier is detected (via GIS, database, graphic, and statistical tools for ad-hoc queries and displays), the possibility of contamination will be evaluated and noted.

3. Other Exploratory Data Analyses: Palmer and Landis (2002) suggest calculations for assessments of precision, bias, representativeness, completeness, and comparability may be applicable and, for certain types of measurements, evaluation of detection limits may also be warranted. Normal probability plots, Grubb’s test, and simple and multiple linear regression techniques may also be used (Edwards 2000).

Literature Cited

Cook, R. R., and P. Lineback. 2008. Sierra Nevada Network data management plan. Natural Resource Report NPS/NRPC/NRR—2008/070. National Park Service, Fort Collins, Colorado.

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Palmer, C. J., and E. B. Landis. 2002. Draft. Lake Mead National Recreational Area Resource Management Division: Quality System Management Plan for Environmental Data Collection Projects.

SOP 28. Archival and Records Management

Version 1.0

Les Chow

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP describes the procedures for archiving and managing data collected by the Wetlands Ecological Integrity Monitoring project.

Preseason Preparations

Prior to the field season, the Network Data Manager will create the project workspace on a network client computer accessible to project staff. The project workspace will include a link to the subdirectory: J:\sien\monitoring\wetlands\data\tabular\working_data\20xx to store files generated by that year's data collection activities. Prior to archiving, all project files should be reviewed, cleaned up, and organized by the Project Lead on a regular basis (for example, annually in January).

Archiving Procedures

The Project Lead should prepare digital data files for archiving as follows:

- Comply with SIEN electronic file naming standards.
- Verify that all electronic files are organized on an NPS server according to SIEN file directory hierarchy standards.
- Comply with SIEN data documentation standards described in the Sierra Nevada Network Data Management Plan Chapter 8 (Cook and Lineback 2008).
- Include all related documents listed in the SIEN project deliverables guidance document.
- Assure that hardcopy records are printed for all mission critical or permanent records.
- Make a clear distinction between public and sensitive information.
- Ensure that the I&M Project Tracking Database has been updated and is complete.

The data manager or other designated staff is responsible for the following:

- Archive project information on a SIEN server according to SIEN file directory hierarchy standards.
- Assure that proper securities are assigned to electronic files.
- Complete a project backup on CD or DVD that is placed in an approved location.
- Integrate deliverables, such as final reports, into appropriate catalogs, electronic libraries and NPS clearinghouses, as described in this plan or specific project protocols.

The Project Lead should package non-digital records and objects as follows:

- Complete a coversheet listing contact information, project abstract and purpose, sensitivity, use of materials, and all materials included in the package.
- Clearly label materials with park acronym, date(s), accession number, project number.
- Comply with paper and folder type requirements (e.g., acid free paper).

- Print and document selected photos.
- Label voucher specimens according to the Museum Handbook and complete loan paper work if necessary. Specimens not residing in NPS repositories should be stored in a selected facility that meets NPS museum collection standards.
- Address specimen curation in project protocols and specify name and address of facility, Memorandum of Agreement (if applicable), list of items to be curated or loaned.
- Create a CD or DVD of all related, electronic materials and label with park acronym, date created, date(s) of information, accession number, project number, list of contents.

Post-season Activities

Every year, a set of ASCII comma-delimited text files will be created for each data table comprising the dataset. These files will be accompanied by a *readme.txt* file that explains the contents of each file, file relationships, and field definitions. The SIEN will employ a utility created by the Gulf Coast Network called *Access_to_ASCII.mdb*, which automates the creation of these ASCII files from Access databases. All ASCII files created from databases will undergo quality control to ensure the number of records and fields correspond to the source data set and that conversion has not created errors or data loss. A second reviewer (preferably the Project Lead) will evaluate the ASCII files and documentation to verify that tables, fields, and relations are fully explained and presented in a way that is useful to secondary users. All finalized files will be stored in the archive section of the project directory folders.

In addition to creating ASCII files, the SIEN Data Manager will also update completed and archived data sets that may be in older versions of MS Access, with the goal of having no dataset more than two versions behind the current version used by the Network. Converted databases will require thorough quality control if they are actively being used for data entry or analysis and if no documentation of prior quality assurance/quality control measures is available. Forms, queries, reports, and data entry will be thoroughly tested, and corrected where any problems occur. All previous versions of the data set will be saved.

GPS data

Both uncorrected and corrected GPS data (e.g., .ssf and .cor files) will be archived in their native format in addition to the corresponding GIS files that are created.

Physical Objects and Records

The guidelines in this section apply to physical objects and records (e.g., draft and final reports, field notes, data collection forms, maps, photographs, audio and video recordings, natural and cultural history specimens) collected or produced by staff and cooperators.

The long term management of physical objects and records will require the close cooperation of the individual collectors (whether NPS personnel, contractors, or permitted researchers) and local park museum personnel. Much of the responsibility will rest with the collector who remains the sole source for all curated documentation and the principal authority for essential collection information.

Voucher Specimens

The most explicit direction for the management of natural history collections is found in NPS Management Policies, Directive 4.2. It reads: "Specimens that are not authorized for consumptive analysis remain federal property and will be labeled and cataloged into the NPS cataloging system (ANCS+, or its successor) in accordance with applicable regulations (36 CFR 2.5)".

36 CFR 2.5 further states that collected specimens "placed in displays or collections will bear official National Park Service museum labels and their catalog numbers will be registered in the National Park Service National Catalog" and that the specimens and any derived data be made available to the public.

Natural history specimens collected under the auspices of the SIEN will be transferred to the Network park in which they were collected for either inclusion in the parks' museum collections or for transfer to a repository approved by the park. In this latter case, the park will enter into a formal, documented relationship with the repository and the specimens will be considered to be "on loan" with clearly stated terms and responsibilities. All loans are subject to the approval of the park superintendent.

Ideally, park curators will be involved at an early stage in the permitting or agreements process; early cooperation between curators and collectors will facilitate compliance with the current NPS Management Policies. Park curators can provide the collector with a pre-formatted Access database template, the use of which will greatly simplify eventual importation of catalog data into the Automated National Catalog System (ANCS+). At a minimum, parks will need such data in comma-delimited format (.csv) for automated uploading into ANCS+.

Photographs

Archiving procedures for digital images associated with this protocol are described in SOP 30.

Literature Cited

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SOP 29. Data Analysis and Reporting

Version 2.0

Leigh Ann Harrod Starcevich and Jonathan C.B. Nesmith

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

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Introduction

This SOP provides guidance for data analysis methods and reporting requirements for which the Project Lead is responsible. This project addresses multiple vital signs in a multi-trophic, community context. Hence a broad suite of variables are measured and analyzed for both status and trend (Table SOP 29.1). Graphical, descriptive, trend modeling, and hypothesis testing procedures will all need to be employed to adequately address the project's objectives.

Suggested Reading

Crawley, M. J. 2007. *The R book*. John Wiley and Sons, Ltd., West Sussex, England.

Ellison, A. M. 1996. Exploratory data analysis and graphic display. Pp. 37-62 in S. M. Scheiner and J. Gurevitch (eds.). *Design and analysis of ecological experiments*, 2nd ed. Oxford University Press, New York, USA.

Elzinga, C. L., D. W. Salzer, J. W. Willoughby, and J. P. Gibbs. 2001. *Monitoring plant and animal populations*. Blackwell Science, Inc., Malden, Massachusetts, USA.

Gotelli, N. J., and A. M. Ellison. 2004. *A primer of ecological statistics*. Sinauer Associates, Inc., Sunderland, Massachusetts, USA.

Legendre, P., and L. Legendre. 1998. *Numerical ecology*, 2nd ed. Elsevier, Amsterdam, The Netherlands.

Sokal, R. R., and F. J. Rohlf. 1995. *Biometry: the principle and practice of statistics in biological research*, 3rd ed. W. H. Freeman and Company, New York, USA.

Thompson, S. K. 2002. *Sampling*, 2nd ed. John Wiley and Sons, Inc., New York, USA.

Table SOP 29.1. Relationship among objectives, data, and inference.

Objective	Raw	Data	Trend	Inference Goal
		Summarized		Statistic(s) for Status
Describe and compare the status of wet meadow and fen wetlands Compare rates of change in wetland characteristics between fen and wet meadows	- Identify temporal change in wetland hydrology	Groundwater	Y	$\bar{x}$ depth (cm)
	- Estimate temporal change in wetland plant communities	Herbaceous spp	Y*	$\bar{x}$ % cover/sp; p plots/sp
		spp richness	Y	$\bar{x}$ richness
		Total herbaceous	Y	$\bar{x}$ % cover
		PI	Y	$\bar{x}$ index value
		Non-vascular spp	Y*	$\bar{x}$ % cover/sp; p plots/sp
		spp richness	Y	$\bar{x}$ richness
		Total non-vascular	Y	$\bar{x}$ % cover; p plots
		Woody spp	Y*	$\bar{x}$ % cover/sp; p plots/sp; $\bar{x}$ no./m ²
		Total woody	Y	$\bar{x}$ % cover; p plots; $\bar{x}$ no./m ²
		Total gymnosperms	Y	$\bar{x}$ % cover; p plots; $\bar{x}$ no./m ²
		Total angiosperms	Y	$\bar{x}$ % cover; p plots; $\bar{x}$ no./m ²
		Invasive spp	Y*	$\bar{x}$ % cover/sp; p plots/sp
		spp richness	Y	$\bar{x}$ richness
		Total Invasives	Y	$\bar{x}$ % cover; p plots
	Litter		Y	$\bar{x}$ % cover p points/plot
	Bare ground		Y	$\bar{x}$ % cover p points/plot
	Peat		N	$\bar{x}$ depth (cm)
	- Estimate temporal change in wetland macroinvertebrate communities	Terrestrial macroinvertebrate Families	Y*	$\bar{x}$ no. indiv./Fam; p plots/Fam
		MFL	Y	$\bar{x}$ MFL
		Aquatic macroinvertebrate Families	Y*	$\bar{x}$ no. indiv./Fam; p plots/Fam
		MFL	Y	$\bar{x}$ MFL
		Ant spp	Y*	$\bar{x}$ no. indiv./sp; p plots/sp
		spp richness	Y	$\bar{x}$ richness

*Trend may be evaluated on key species for which necessary abundance values are known.

$\bar{x}$ is the sample mean; p is the sample frequency (proportion of total); MFL is Margalef's Family richness; PI is National Wetland Inventory prevalence index; sp is species (singular); spp is species (plural); Y is yes; N is no.

Analytical Procedures

Many of the statistical procedures outlined below are described for implementation in the statistical freeware R. R can be downloaded for free from <http://www.r-project.org/>. The R Wiki provides an online forum and documentation found at <http://wiki.rproject.org/rwiki/doku.php>. Other statistical software such as PC-ORD (<https://www.pcord.com/>) may be required to conduct specific analyses.

Descriptive Statistics

Site-level values of the individual variables are summarized into measures of location and spread to quantify and describe the status of Sierra Nevada Network fens and wet meadows (Table SOP 29.1). In most cases, the arithmetic sample mean ($\bar{x}$) will best describe the central tendency of a given data set. The variability of the data set associated with the mean must also be calculated. The sample standard deviation (s) is often used and is useful because it has the same units as the raw data. The standard error of the mean (SE) should be used to describe the variation among sample means obtained from repeated sampling. It too has the same units as the raw data. Frequencies (p) will also be calculated in many cases to describe a given variable's condition. Along with means, frequencies, and variation, the analyst should report the units of the data and the sample size (n) used to calculate the summary statistics. Summary statistics should be calculated after each year of data collection. Both summary tables and figures will be used to present these data.

Some metrics are composite indices such as the California Rapid Assessment Method (CRAM) or National Wetland Inventory Prevalence Index (PI). These indices are derived from multiple metrics. To calculate the wetland PI, each vascular plant species has been placed into a wetland indicator status category by the US Department of Agriculture, Natural Resource Conservation Service. The following site, <http://plants.usda.gov/wetinfo.html> provides detailed information about wetland plant species, including which category each species is assigned to. This site should be visited annually prior to analysis and reporting to verify species category assignments (i.e., a given species may change categories based on expert opinion and analysis).

Graphical Analyses

Displaying and using graphs prior to formal quantitative analyses provides a relatively quick and easy way to identify outliers and errors, to see major trends and relationships, and to reveal unexpected patterns in the data (Gotelli and Ellison 2004). Thus, the project analyst should generate graphs each year to explore the nature of the data prior to analyses. This will be particularly important during the first years of the WEI project as it will be important to evaluate whether the protocol sampling design is producing the anticipated quantity and quality data that can be used to meet the monitoring objectives or whether sampling methodology needs to be altered to better meet these goals. In all years, graphical analyses will be important in determining whether the data meet assumptions of planned subsequent analyses (e.g., using parametric statistics), if transformations of the raw data are needed, or if the data would be more appropriately analyzed with nonparametric statistics.

Box plots and/or stem-and-leaf plots should be used to check for outliers of each single (univariate) variable. Scatterplots should be used to explore two or more variables together, especially if an outlier is suspected. A scatterplot matrix, where each combination of three or

more variables is plotted in matrix fashion, is a good way to check whether unusual values are indeed outliers. Normal probability plots should be made in order to determine if the data approximate a normal distribution. In addition, each single variable data set should be plotted with a histogram to show the frequency distribution of the data set. This distribution should then be visually and quantitatively evaluated to determine which probability distribution best fits the data, and whether any transformations to the raw data are warranted. Most introductory statistics books present procedures for making the above graphs if the analyst is unfamiliar (e.g., Sokal and Rohlf 1995, Gotelli and Ellison 2004).

Graphs are also a powerful way to convey statistical results. The analyst will generate graphs each year during production of the annual report. The choice of graph is determined by the nature and purpose of the data (Figure SOP 29.1). For status estimation of single variables, bar graphs displaying sample means with associated error bars (s if for a single mean, SE if for a mean of means) are sufficient (Figure SOP 29.2). The relationship between two continuous variables is best presented with an x-y scatterplot. When all sites have been sampled (i.e., at the conclusion the fourth panel year), time-series plots (scatterplots of individual variables [y-axis] against time [x-axis]) should be generated. In addition, graphs other than bar and scatterplot should be explored that are appropriate for community-level (multivariate) analyses that may be conducted at this longer interval (Figure SOP 29.3).

DEPO groundwater depth data

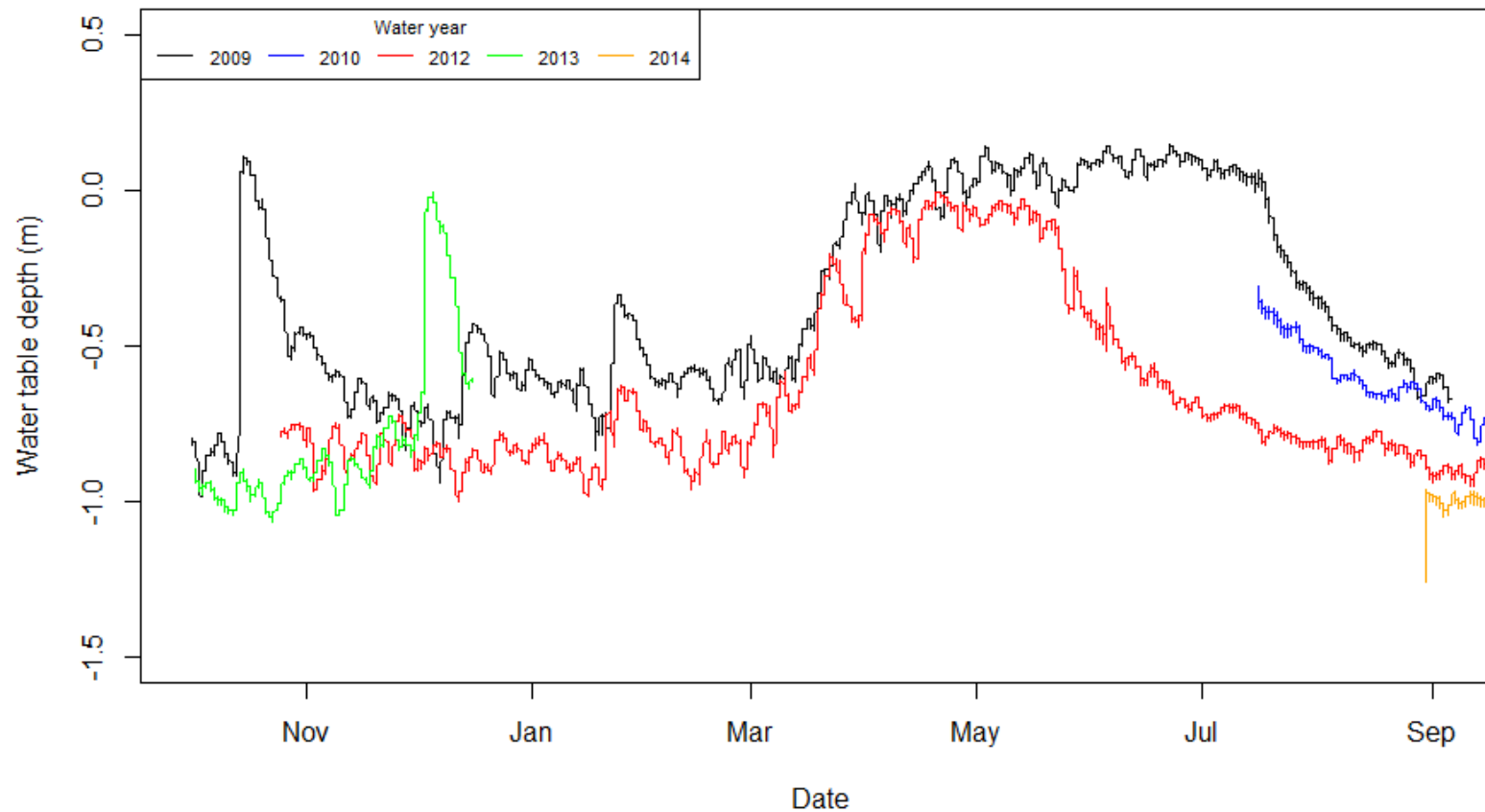


Figure SOP 29.1. Groundwater depth measured hourly at DEPO from 2009 – 2014. Data have not been corrected for barometric pressure, but have been standardized to manual water table depth measurements recorded during logger installation and download.

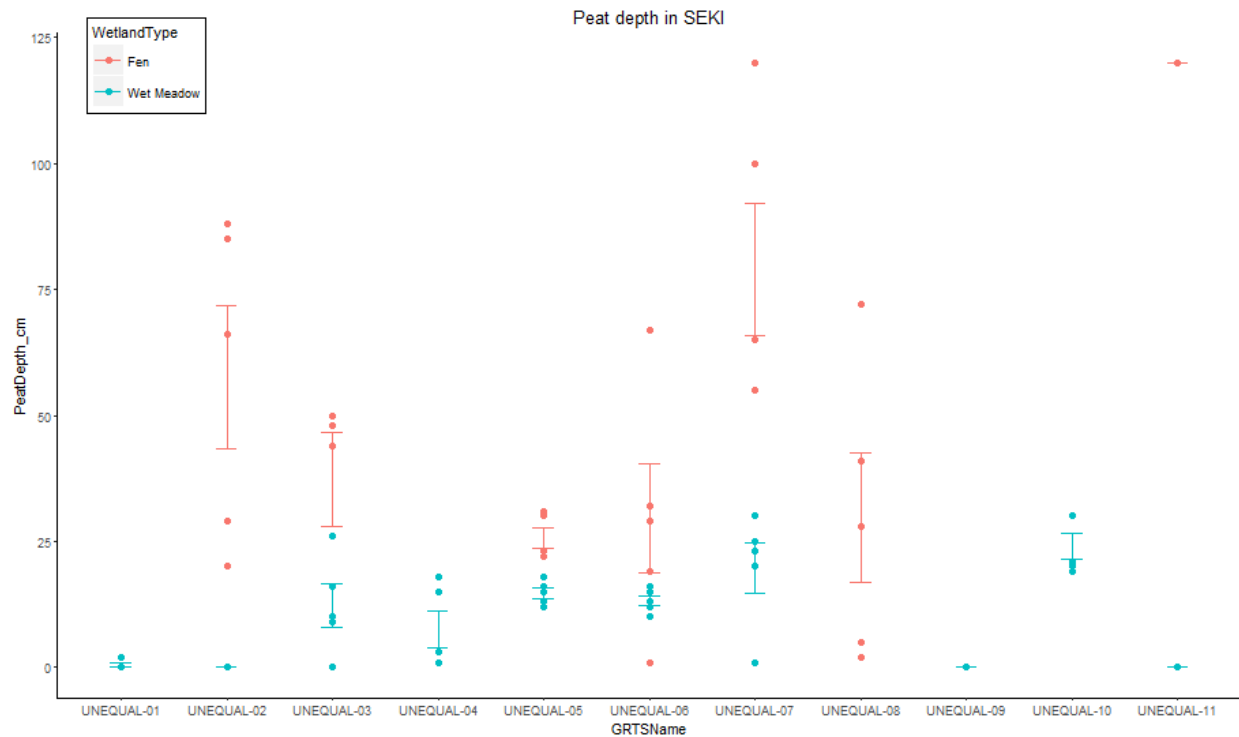


Figure SOP 29.2. Average peat depth within each macroplot (n = 17) by wetland type in SEKI. Line and whisker bars indicate 95% confidence intervals around the mean for each macroplot. Macroplots are grouped by site on the x-axis.

Getting Started in R

The example code for analysis presented in this SOP is provided in the R programming language. Two test data files are provided in Appendix SOP 29.A. These data sets combine the initial GRTS survey results with simulated data based on pilot data. *These data were constructed for illustrative purposes only, and no inference should be made from these results.* The formatting necessary for data analysis can be obtained from examining this data set. The R packages needed for these analyses are *lme4* and *SDrawNPS* and their dependencies and may be downloaded from the following web sites:

SDrawNPS: <https://irma.nps.gov/DataStore/Reference/Profile/2229965>.

lme4: <https://cran.r-project.org/web/packages/lme4/index.html>

To begin the test analysis in R, proceed as follows:

1. Open R and copy/paste the data set commands provided in Appendix SOP 29.A at the prompt.
2. Go to *File/Change dir...* in the R menu and select the appropriate location to save your workspace.
3. Go to *File/Save* and save the workspace.
4. Load libraries for R:
 - `library(SDrawNPS)`
 - `library(lme4)`

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

Estimation under the GRTS Design

The *spsurvey* software for the R software application is one of the required packages within *SDrawNPS*, but may be downloaded separately from the web page for Aquatic Resources Monitoring at the Environmental Protection Agency: <http://www.epa.gov/nheerl/arm/analysispages/software.htm>. The *spsurvey* software package (Kincaid and Olsen 2008) provides the tools needed to draw a GRTS sample and incorporate design structure such as stratification or unequal probability sampling for point, line, and areal sampling frames. The *spsurvey* software package also contains many useful summary functions for estimating the population total, mean, proportion of the population above or below a threshold, and cumulative distribution function from data collected using GRTS designs. In addition, a function is available to adjust inclusion probabilities for changes in the sample or the inclusion of non-target sites.

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:

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

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 Jr. and Olsen 2003, Stevens Jr. 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.

Weight Adjustment

In general, inclusion probabilities are derived from the sampling design and are necessary for design-based estimation (see Thompson 1992 for more discussion on inclusion probabilities). Several factors affect the design weights and require that design weights be adjusted for unbiased estimation. When sample sizes are larger or smaller than originally intended, the design weights must be adjusted for the change in the sample size. When sites are missing due to inaccessibility or other reasons not related to the indicators of interest, design weights may be adjusted. Sometimes sites included in the sample are not members of the target population, and design weights must be adjusted for these non-target sites.

Design weights can be adjusted either directly in *spsurvey* or using the R package *SDrawNPS* (Starcevich et al. 2016). This package implements the *spsurvey* software package in a graphical-user interface (GUI). Adjustments are made in different steps to ensure that different factors affecting design weights are properly accounted for. Proper weight adjustment requires that sampled sites maintained the GRTS order and that any site-replacement was conducted appropriately.

Unequal probability sampling by multi-density categories (*mdcaty*) based on wetland classification was used to calculate inclusion probabilities. Weights may need further adjustment for each year of the survey. A common reason for this additional level of adjustment is variability in survey resources from year to year causing lower sample sizes if observer teams are unable to visit all sites. The R code in Appendix SOP 29.A can be amended to account for these design weights adjustments within a given year. For this example, we will proceed as if all samples were fully realized each year.

For estimating status annually, design weights are further adjusted to account for unsurveyed panels. Status estimates may be obtained for a wetland type within a given year using the *SDrawNPS* package in R (Starcevich et al. 2016).

Status Estimation

Estimates of the status of wetlands indicators will be reported annually. Status estimates are calculated to reflect the complex survey design used to draw the sample of wetlands (Table SOP 29.2). When the generalized random tessellation stratified (GRTS) design (Stevens Jr. and Olsen 2003, Stevens Jr. and Olsen 2004) is accounted for in the estimation process, variance estimates reflect the spatial balance of the sites over the population of interest for more precise estimation.

Table SOP 29.2. Data format for wetland ecological integrity analysis.

Data Column	Description
Y	The outcome of interest
Year	The survey year
SiteID	Unique site identifier
Panel	Revisit design panel index
Long	UTM x-coordinate in NAD83
Lat	UTM y- coordinate in NAD83
mdcaty	Multi-density category for unequal or continuous selection sampling
stratum	Name of the stratification variable in the data frame
EvalStatus	Survey status of the site used for weighting adjustment
EvalReason	Description of why site was assigned indicated EvalStatus
InclProb	Inclusion probability from GRTS selection of wetlands
PanelProb	Panel inclusion probability
AdjInclProb	Adjusted inclusion probability for panel design
Indicator measurements	Columns of measurements of macroinvertebrate, vegetation, and hydrology indicators

An estimate of the status of a resource can be obtained from the SDrawNPS package that accounts for sample frame error and other design elements such as stratified or unequal probability sampling. Estimates can be measured as a mean, median, percentile, proportion or cumulative distribution function (Figure SOP 29.4).

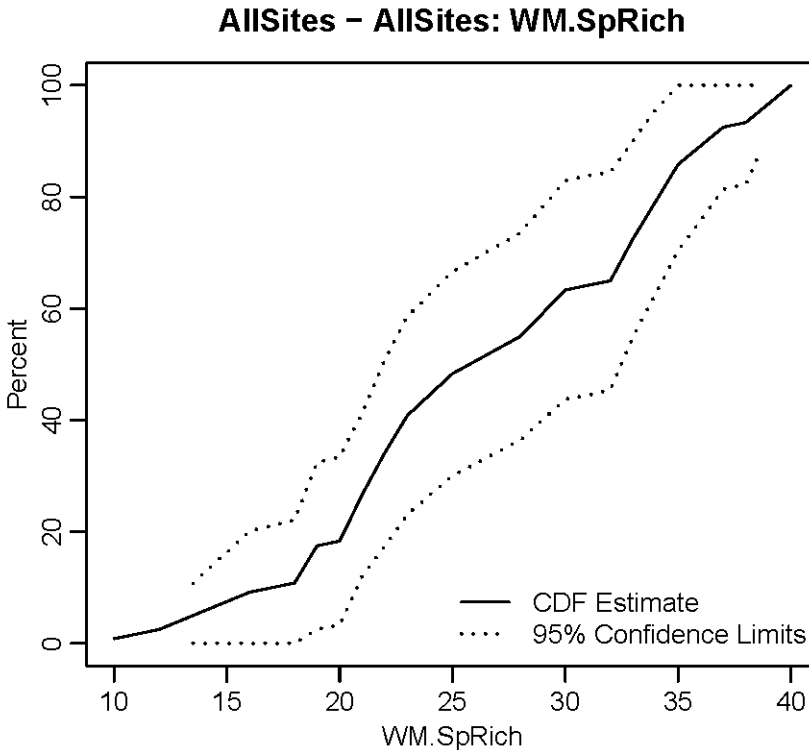


Figure SOP 29.4. Cumulative distribution function of wet meadow species richness (WM.SpRich) from wetland plots in SEKI. *These data were constructed for illustrative purposes only, and no inference should be made from these results.*

Trend Estimation

The GRTS neighborhood variance estimator was developed for design-based methods; a GRTS specific variance estimator for model-based approaches has not been developed. Because GRTS samples provide more precision than independent random samples (Stevens and Olsen 2003), the use of model-based methods with the GRTS sample will produce conservative estimates of variance and corresponding confidence intervals.

Trend Analysis Approaches

Several methods of estimating trend are available for estimating annual and net multiplicative trends 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. For an extensive discussion of trend estimation using complex survey designs see Starcevich et al. (*In preparation*).

Linear Mixed Model

A linear mixed-model is used to test for trend at extensive sites ($\alpha = 0.10$). Van Leeuwen et al. and Piepho and Ogutu (1996, 2002) developed this method specifically to address trend estimation for correlated data. 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 (wetlands) and over time (years). Restricted maximum likelihood (REML) is used to obtain the estimates for fixed and 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) improve the estimator proposed by Van Leeuwen et al. (1996) in that the effect of wetlands on the intercept of the linear regression may be modeled as fixed or random. If this effect is assumed random, it may also be modeled to be correlated with the random slope associated with wetlands. The ability to modify the assumptions provides additional benefits of invariance and model flexibility. In general, the random intercept for wetlands is modeled as random if the sample of wetlands has been chosen using a probability sample and modeled as a fixed effect otherwise. However, Piepho and Ogutu (2002) recommend modeling the wetland intercept as fixed so that convergence problems are avoided and to optimize test power when residual variance is large. Because REML provides similar results for tests of trend regardless of how the wetland intercept is modeled, we will adopt the recommended approach of Piepho and Ogutu (2002) and model the intercept as fixed.

The mixed model proposed in both articles is:

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

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

m_a = the number of sites in the sample;

m_b = the number of consecutive years in the sample;

m = the number of measurements taken within a site and 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 $N(0, \sigma_t^2)$;

c_{ij} = random effect of site by year, independent and identically distributed as $N(0, \sigma_c^2)$; and

e_{ijk} = 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 the model given above, the response y_{ijk} is actually the natural log of the response being modeled, i.e. $\log(y_{ijk})$. 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 ($\beta\neq0$):

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

As defined above, β is the coefficient of the WYear variable 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 $\delta=0.4$ implies a 40% increase of the population parameter over the specified period of time, whereas $\delta=-0.4$ 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).

Trend Analysis in R

The linear mixed model is a flexible tool for trend modeling. The model provided above may be used for site-level responses or means, amended for the repeated measurements taken within a site, or used without the random site effects to analyze annual estimates from GRTS analysis across sites. For illustration, the trends of site-level responses from measurements of species richness is analyzed in R using the *lme4* package and a graph of mean species richness through time in YOSE is provided in Figure SOP 24.4. *These data were constructed for illustrative purposes only, and no inference should be made from these results.*

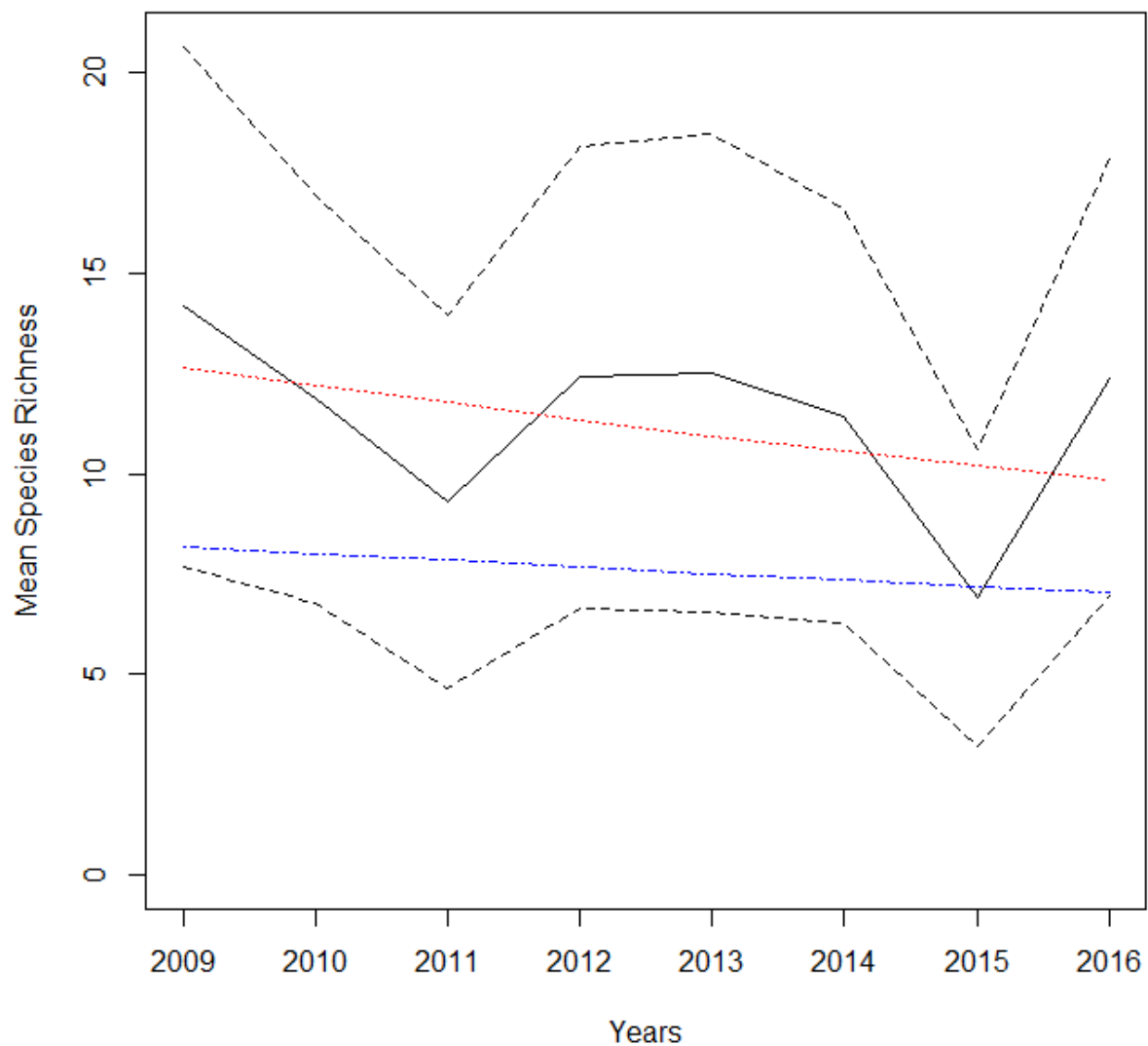


Figure SOP 29.5. GRTS status estimates by year with 95%-confidence intervals and trend lines for OLS regression of GRTS estimates (in red) and linear mixed model trend results from site-level data (in blue). *These data were constructed for illustrative purposes only, and no inference should be made from these results.*

Reporting

Two types of reports differing in frequency and detail will be produced routinely by the Project Lead. Annual Reports are produced following each year of sampling and will therefore be based on data collected in sites from the annual panel and one of the four extensive panels. The purposes of the Annual Report are to archive annual data and document monitoring activities for the year, describe current observations of fen and wet meadow wetlands, document changes in the protocol, and communicate annual results within each park and across the network. Park resource managers, the network staff, and external scientists constitute the main audience for Annual Reports. The NPS Natural Resource Data Series Report template should be used for Annual Reports, and it can be found at <http://www.nature.nps.gov/publications/NRPM/index.cfm>.

Status and Trend Reports are produced following one full panel rotation (i.e., after four seasons of data collection). The primary purpose of this report is to provide results and interpretation of status and trend analyses. Interpreting and contextualizing results at both park- and network-levels are necessary to providing recommendations for the management of wetlands, and thus feedback into the adaptive management cycle. Park superintendents, park resource managers, network staff, and external scientists are the report's audience. Status and Trend Reports should use the NPS Natural Resource Report template found at <http://www.nature.nps.gov/publications/NRPM/index.cfm>.

Both Annual Reports and Status and Trend Reports should include:

- A brief *narrative* section highlighting key background information, describing logistical issues encountered, and providing suggestions to overcome these issues in the future.
- A *methods* section summarizing data collection procedures and detailing analytical techniques. Little may change from year to year, but it is still important to include this in each report. This section should highlight any departures or substantive changes from previous methods.
- A *results* section describing the content of the report's tables and figures (see below), and reporting findings from analytical procedures not reported in tables and figures.
- A *discussion* section highlighting and interpreting notable findings. Discussion and results sections will be far more extensive in the Status and Trend Reports. Information on unusual weather, new species (exotic and native) encountered, disturbances, or other relevant events should also be reported and their possible influence on results discussed.
- An *acknowledgements* section thanking all individuals who contributed to the project.
- A list of project personnel and their roles.
- A list of sites that were sampled for the given time period of the report.
- An evaluation of data quality that identifies concerns or deviations from the protocol that may affect data quality and interpretability.
- Statements regarding suggested or required changes to any aspect of the protocol.

Annual Report Summary Tables

Twelve extensive sites are sampled each year in each wetland type (6 from the annual panel and 6 from a rotating panel). Plot-level data from the 12 sites are summarized annually. Note that these data should be summarized for each wetland type: fen and wet meadow by park: YOSE, SEKI, DEPO.

1. Evidence of Land use and wetland features within the assessment area: rows = land use indicators, wetland features, columns = wetland type.
2. Wetland hydrogeomorphology and soils: rows = site, wetland type, columns = hydrogeomorphic type or soil type. These data are only recorded during site installation and are not reported in subsequent annual reports for re-visited sites.
3. Groundwater: rows = site-level data, columns = groundwater depth. A hydrograph displaying hourly groundwater depth measurements should also be provided for each plot where a data logger has been installed (Figure SOP 29.1). The timing and value of max and min water depth, as well as the rate and timing of drawdown should be reported.
4. Macroinvertebrate Families and Ant species recorded in the current year: rows = Family or species name, columns = number of sites present, proportion of total sites present, and delineated by each park category. Summary of macroinvertebrate composition and abundance: rows = site, wetland type, sample type, columns = diversity metrics including family richness, Margalef's family richness, percent family dominance, and percent predators and percent herbivores.
5. Vegetation and groundcover: Native plant species recorded in a given year: rows = species name, columns = number of sites a species was present. Percent cover herbaceous species, percent cover non-vascular species, percent cover woody species, percent cover invasive species, percent cover litter, percent cover bare ground.
6. National Wetland Inventory: rows = site-level data, columns = park unit, mean prevalence index value, percent cover for each of the five NWI categories (obligate wetland, facultative wetland, wetland, facultative upland, obligate upland).
7. Invasive plant species recorded in a given year: rows = species name, columns = number of sites a species was present, proportion of total sites present, average patch size/number of individuals within a wetland.
8. Summary history of plots completed through the current year: rows = sites, columns = park unit, panel membership, wetland type, and year (Table SOP 29.3).

Table SOP 29.3. List of sampling locations for Wetland Ecological Integrity (WEI) monitoring plots in SEKI visited in 2014. MapClass indicates the mapping classification assigned to conduct the GRTS draw of sample locations and EvalStatus indicates whether a site was established, dropped because it was non-target, or if it was not established (not visited) in the field. For sites that were visited, they are listed as either “Rejected” with the reason for rejection listed under EvalNotes, “Scouted” indicating that the site has been ground-truthed but not installed or completed. If the plot was completed, the year it was installed is listed. Note that UTM X and UTM Y for completed sites are the coordinates of the well location as established in the field, and no longer match exactly the coordinates produced by the GRTS algorithm used to navigate to the plot during initial set-up. FieldClass indicates the wetland type of the wetland as observed in the field.

MapClass	Site ID	Well ID	UTM X	UTM Y	Panel	EvalStatus	EvalNotes	FieldClass
Wet_Meadow	UNEQUAL-01	WM-308	360483	4106902	Annual	2014		Wet_Meadow
Fen_Meadow	UNEQUAL-02	WM-305	357069	4083609	Annual	2014		Wet_Meadow
Fen_Meadow	UNEQUAL-02	F-306	357071	4083522	Annual	2014		Fen
Fen_Meadow	UNEQUAL-03	F-319	344579	4057409	Annual	2014		Fen
Fen_Meadow	UNEQUAL-03	WM-320	344661	4057417	Annual	2014		Wet_Meadow
Wet_Meadow	UNEQUAL-04	WM-310	356852	4022212	Annual	2014		Wet_Meadow
Fen_Meadow	UNEQUAL-05	F-345	338591	4086749	Annual	2014		Fen
Fen_Meadow	UNEQUAL-05	WM-348	338518	4086674	Annual	2014		Wet_Meadow
Wet_Meadow	UNEQUAL-06	WM-314	374892	4057773	Annual	2014		Wet_Meadow
Wet_Meadow	UNEQUAL-06	F-315	374672	4057131	Annual	2014		Fen
Fen_Meadow	UNEQUAL-07	WM-316	344280	4059989	Year_1	2014		Wet_Meadow
Fen_Meadow	UNEQUAL-07	F-317	344251	4059962	Year_1	2014		Fen
Wet_Meadow	UNEQUAL-08	F-309	367407	4034561	Year_1	2014		Fen
Wet_Meadow	UNEQUAL-09	WM-307	352756	4085450	Year_1	2014		Wet_Meadow
Wet_Meadow	UNEQUAL-10	WM-318	358218	4060359	Year_1	2014		Wet_Meadow
Fen_Meadow	UNEQUAL-11	F-311	349233	4026690	Year_1	2014		Fen
Fen_Meadow	UNEQUAL-11	WM-312	349208	4026916	Year_1	2014		Wet_Meadow
Wet_Meadow	UNEQUAL-12				Year_1X	Rejected	Soils too shallow	Wet_Meadow

Status and Trend Report Summary Tables

These will be similar to the Annual Reports except that four-year (i.e., one full panel rotation) means and associated standard deviations will be reported and rows = park unit categories YOSE, SEKI, and SIEN (instead of sites). Tables of species lists (see point 2, 3, and 6 above) should list all species recorded over the four-year (full sample) period. Beginning with the second Status and Trend Report, an additional column should be included that identifies if a given species was not present in the previous panel rotation. Also, a separate section (at the bottom of the table for example) should be included that lists species recorded in previous panel rotations but not in the current reported rotation.

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SOP 29 Appendix 29.1. Example Data for R Code

Copy these commands directly into R to use the example analysis code. Text files containing the data and analysis scripts can also be found on the Sierra Nevada Network server at:

J:\sien\monitoring_projects\wetlands\protocol\2017Draft\SOP29_R_files\.

```
## Wetlands R script ##
## Status Estimate Data ##
SEKI.Status <-
structure(list(siteID = structure(c(1L, 2L, 3L, 4L, 5L, 6L, 7L, 8L, 9L, 10L, 11L, 12L,
13L, 14L, 15L, 16L, 17L, 18L, 19L, 20L, 21L, 22L, 23L, 24L, 25L,
26L, 27L, 28L, 29L, 30L, 31L, 32L, 33L, 34L, 35L, 36L, 37L, 38L,
39L, 40L, 41L, 42L, 43L, 44L, 45L, 46L, 47L, 48L, 49L, 50L, 51L,
52L, 53L, 54L, 55L, 56L, 57L, 58L, 59L, 60L, 61L, 62L, 63L, 64L,
65L, 66L, 67L, 68L, 69L, 70L, 71L, 72L, 73L, 74L, 75L, 76L, 77L,
78L, 79L, 80L, 81L, 82L, 83L, 84L, 85L, 86L, 87L, 88L, 89L, 90L),
.Label = c("UNEQUAL-01", "UNEQUAL-02", "UNEQUAL-03", "UNEQUAL-04",
"UNEQUAL-05", "UNEQUAL-06", "UNEQUAL-07", "UNEQUAL-08", "UNEQUAL-09",
"UNEQUAL-10", "UNEQUAL-11", "UNEQUAL-12", "UNEQUAL-13", "UNEQUAL-14",
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"UNEQUAL-90"), class = "factor"),
xcoord = c(360443.7781, 357042.4229, 344554.6259, 356905.3344, 338555.6739,
374798.3306,
344284.2171, 367399.82, 352747.3379, 358139.2385, 349249.477, 359940.9305,
366579.0962, 347022.454, 351943.1367, 371915.5053, 349736.0852, 361224.3815,
345859.138, 354829.8578, 346467.6785, 377851.1836, 350645.9882, 366421.7081,
373854.5357, 360024.8168, 350357.0827, 380529.714, 359597.1602, 349266.4266,
354561.0306, 382101.364, 346706.6611, 366454.5786, 348133.2682, 362838.8414,
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367059.0337, 350974.4915, 360545.2998, 368516.0092, 374330.6288, 347820.3451,
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365136.758, 352096.3491, 378752.9677, 362482.9266, 353948.7932, 350630.4074,
374336.7234, 370380.4591, 349436.0797, 354818.1564, 344697.3216, 324680.2418),
ycoord = c(4106858.382, 4083633.399, 4057556.188, 4022190.116, 4086687.895,
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4060007.957, 4034565.55, 4085492.309, 4060468.389, 4026745.714, 4038111.362,
4098351.574, 4068310.99, 4038173.283, 4032318.503, 4114724.476, 4084622.118,
4053365.933, 4022047.199, 4097077.849, 4055764.578, 4033226.082, 4035975.342,
4093636.036, 4058125.675, 4031232.308, 4040130.847, 4088890.959, 4067829.652,
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4101480.655, 4051942.449, 4024654.934, 4029261.141, 4093592.595, 4079002.167,
```

SOP 29.23

```

    "Not Eval"), class = "factor"),

EvalStatus_F = structure(c(3L, 1L, 1L, 3L, 1L, 1L, 1L, 1L, 3L, 3L, 1L, 3L, 3L, 3L, 3L,
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    1L, 1L, 3L, 1L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L,
    4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L,
    4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L, 4L,
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    .Label = c("Target - Surveyed", "Target - Not Surveyed",
    "Non-Target", "Not Eval"), class = "factor"),

Notes = structure(c(1L, 1L, 1L, 1L, 1L, 2L, 1L, 1L, 1L, 1L, 1L, 2L, 1L, 2L, 1L, 1L,
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    6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L,
    6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L,
    6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L, 6L,
    6L, 6L, 6L, 6L, 6L),
    .Label = c("Target wetland, correctly classified", "Target wetland,
    misclassified", "Target wetland - shallow soils", "Non-target,
    grazing", "Only WM plot installed", ""), class = "factor"),

WM.SpRich = c(40L, 30L, 30L, 34L, 11L, 16L, 22L, NA, 19L, 37L, 10L, NA, 35L, NA, 28L,
    23L, NA, 17L, 20L, 21L, 22L, 21L, 33L, 25L, NA, 25L, 12L, 18L, 21L, 31L, 33L, 32L,
    30L, 38L, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA,
    NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA,
    NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA,
    NA, NA, NA, NA),

F.SpRich = c(NA, 16L, 23L, NA, 12L, 21L, 20L, 28L, NA, NA, 17L, NA, NA,
    NA, NA, NA, NA, NA, 25L, NA, NA, NA, NA, 24L, NA, NA, 14L, 17L, 20L, 28L, 12L,
    21L, NA, 19L, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA,
    NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA,
    NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA,
    NA, NA, NA, NA, NA),

.Names = c("siteID", "xcoord", "ycoord", "mdcaty", "wgt", "panel", "panel_yr",
    "Field.Wetland.Type", "EvalStatus_WM", "EvalStatus_F", "Notes", "WM.SpRich",
    "F.SpRich"), class = "data.frame", row.names = c(NA, -90L))

### Weight Adjustment ###
# Adjust weights of WM GRTS units #

library(SDrawNPS)

df.wm<-SEKI.Status
popn<-"Target - Sampled"
df.wm$oldwgt<-df.wm$wgt
df.wm$wgt<-Adjwgt_FrameNR(dat=df.wm, popn=popn, evalstatus="EvalStatus", wgt="oldwgt")
df.wm$wgt

the.sites<-data.frame(siteID=df.wm$siteID, df.wm$EvalStatus=="Target - Sampled")
the.subpop<-data.frame(SiteID=df.wm$siteID, Popn1=rep('AllSites', nrow(df.wm)),
    Popn2=df.wm$mdcaty)
names(the.subpop)<-c('SiteID', 'AllSites', 'mdcaty')
the.design<-data.frame(siteID=df.wm$siteID, wgt=df.wm$wgt, xcoord=df.wm$xcoord,
    ycoord=df.wm$ycoord)
the.data.cont<-data.frame(siteID=df.wm$siteID, WM.SpRich=df.wm$WM.SpRich)
the.popsiz<-list("AllSites"=1582, "mdcaty"=list("Wet_Meadow"=1407, "Fen_Meadow"=175))
# There are were 1582 wetlands in the original sample frame.
# 1407 were classified as wet meadows and 175 were classified as fens.

ans.cont<-cont.analysis(sites=the.sites,
    subpop=the.subpop,
    design=the.design,
    data.cont=the.data.cont,

```

SIEN Wetlands Ecological Integrity Protocol
SOP 29. Data Analysis and Reporting

```

5L, 6L, 8L, 9L, 13L, 15L, 16L, 17L, 18L, 19L, 20L, 22L, 35L,
36L, 37L, 38L, 39L, 47L, 1L, 2L, 3L, 4L, 5L, 6L, 8L, 9L, 13L,
17L, 21L, 22L, 23L, 24L, 25L, 26L, 40L, 41L, 42L, 43L, 44L, 47L,
1L, 2L, 3L, 4L, 5L, 6L, 8L, 9L, 13L, 17L, 22L, 28L, 29L, 30L,
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.Label = c("YOSE_wets07-001",
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mdcaty = structure(c(12L, 11L, 13L, 12L, 8L, 14L, 12L, 1L, 3L, 14L, 10L, 14L, 12L,
10L, 3L, 5L, 9L, 13L, 9L, 7L, 6L, 5L, 12L, 11L, 13L, 12L, 8L, 14L,
1L, 3L, 12L, 11L, 11L, 3L, 15L, 12L, 14L, 5L, 5L, 4L, 5L, 5L,
13L, 5L, 12L, 11L, 13L, 12L, 8L, 14L, 1L, 3L, 12L, 3L, 12L, 5L,
9L, 12L, 13L, 12L, 4L, 3L, 3L, 7L, 5L, 5L, 12L, 11L, 13L, 12L,
8L, 14L, 1L, 3L, 12L, 3L, 5L, 12L, 9L, 11L, 11L, 10L, 3L, 2L,
5L, 10L, 4L, 5L, 12L, 11L, 13L, 12L, 8L, 14L, 12L, 1L, 3L, 14L,
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13L, 12L, 8L, 14L, 1L, 3L, 12L, 11L, 11L, 3L, 15L, 12L, 14L,
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11L, 11L, 10L, 3L, 2L, 5L, 10L, 4L, 5L),
.Label = c("Fen_High", "Fen_Highest", "Fen_Low", "Fen_Lowest",
"Fen_Med", "Fen_MedHigh", "FenMdw_Low", "FenMdw_Lowest", "FenMdw_Med",
"Mdw_High", "Mdw_Low", "Mdw_Lowest", "Mdw_LowMed", "Mdw_Med", "Mdw_MedHigh")),
class = "factor"),
Wetland.classification = structure(c(3L, 3L, 3L, 3L, 2L,
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3L, 3L, 1L, 1L, 1L, 1L, 1L, 1L, 3L, 1L, 3L, 1L, 3L, 3L, 2L, 3L,
1L, 1L, 3L, 3L, 3L, 3L, 3L, 1L, 1L, 2L, 3L, 2L, 2L, 1L, 1L,
3L, 3L, 3L, 3L, 2L, 3L, 1L, 1L, 3L, 3L, 3L, 1L, 3L, 3L, 3L,
1L, 1L, 1L, 1L, 1L, 3L, 1L, 3L, 3L, 3L, 3L, 2L, 3L, 1L, 1L,
3L, 1L, 3L, 1L, 2L, 3L, 3L, 3L, 1L, 1L, 1L, 2L, 1L, 1L, 3L,
3L, 3L, 3L, 2L, 3L, 1L, 1L, 3L, 1L, 1L, 3L, 2L, 3L, 3L, 3L,
1L, 1L, 1L, 3L, 1L, 1L),
.Label = c("F", "F_WM", "M")), class = "factor"),
Weight.Stage1 = c(7, 6, 8.33, 5.33, 7, 7, 5.33, 6, 7, 5.33,
5.33, 8.33, 6, 5.33, 8.33, 5.33, 8.33, 7, 8.33, 6, 5.33,
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8.33, 5.33, 7, 7, 6, 7, 6, 8.33, 5.33, 5.33, 8.33, 6, 8.33,
6, 6, 7, 7, 8.33, 8.33, 8.33, 7, 6, 8.33, 5.33, 7, 7, 6,
7, 6, 8.33, 5.33, 6, 8.33, 7, 8.33, 6, 7, 5.33, 8.33, 5.33,
5.33, 5.33, 7, 6, 8.33, 5.33, 7, 7, 5.33, 6, 7, 5.33, 5.33,
8.33, 6, 5.33, 8.33, 5.33, 8.33, 7, 8.33, 6, 5.33, 8.33,
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6, 7, 7, 8.33, 8.33, 8.33, 7, 6, 8.33, 5.33, 7, 7, 6, 7,
6, 8.33, 5.33, 6, 8.33, 7, 8.33, 6, 7, 5.33, 8.33, 5.33,
5.33, 5.33),
Weight.Stage2 = c(5.7, 5.91, 4.87, 5.7, 1.93,

```

```

5.4, 5.7, 0.96, 1.51, 5.4, 5.46, 5.4, 5.7, 5.46, 1.51, 1.52,
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1.93, 5.4, 0.96, 1.51, 5.7, 5.91, 5.91, 1.51, 5.78, 5.7,
5.4, 1.52, 1.52, 1.62, 1.52, 1.52, 4.87, 1.52, 5.7, 5.91,
4.87, 5.7, 1.93, 5.4, 0.96, 1.51, 5.7, 1.51, 5.7, 1.52, 3.85,
5.7, 4.87, 5.7, 1.62, 1.51, 1.51, 3.85, 1.52, 1.52, 5.7,
5.91, 4.87, 5.7, 1.93, 5.4, 0.96, 1.51, 5.7, 1.51, 1.52,
5.7, 3.85, 5.91, 5.91, 5.46, 1.51, 2.89, 1.52, 5.46, 1.62,
1.52, 5.7, 5.91, 4.87, 5.7, 1.93, 5.4, 5.7, 0.96, 1.51, 5.4,
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1.52, 1.52, 4.87, 1.52, 5.7, 5.91, 4.87, 5.7, 1.93, 5.4,
0.96, 1.51, 5.7, 1.51, 5.7, 1.52, 3.85, 5.7, 4.87, 5.7, 1.62,
1.51, 1.51, 3.85, 1.52, 1.52, 5.7, 5.91, 4.87, 5.7, 1.93,
5.4, 0.96, 1.51, 5.7, 1.51, 1.52, 5.7, 3.85, 5.91, 5.91,
5.46, 1.51, 2.89, 1.52, 5.46, 1.62, 1.52),
panel = structure(c(1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 2L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 2L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 2L, 2L, 2L, 2L, 2L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 2L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 2L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 2L, 2L, 2L, 2L, 2L), .Label = c("Main",
"OverSamp"), class = "factor"),
EvalStatus = structure(c(1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 2L, 2L, 2L, 2L, 2L, 5L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 3L, 3L, 3L, 3L, 3L, 5L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 2L, 2L, 2L, 2L, 4L,
4L, 4L, 4L, 4L, 5L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 2L, 2L, 2L, 2L, 3L, 5L, 5L, 5L, 5L, 5L, 5L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 2L, 2L,
2L, 2L, 2L, 5L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 3L, 3L, 3L, 3L, 3L, 5L, 1L, 1L, 1L, 1L,
1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 2L, 2L, 2L, 2L, 4L, 4L, 4L,
4L, 4L, 5L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 2L,
2L, 2L, 2L, 3L, 5L, 5L, 5L, 5L, 5L, 5L), .Label = c("Eval_09",
"Eval_10", "Eval_11", "Eval_12", "Eval_13"), class = "factor"),
True.wettype = structure(c(3L, 3L, 3L, 3L, 3L, 3L, 3L, 1L,
1L, 3L, 3L, 3L, 1L, 3L, 1L, 2L, 1L, 2L, 1L, 1L, 1L, 3L,
3L, 3L, 3L, 3L, 3L, 1L, 1L, 1L, 3L, 3L, 3L, 3L, 3L, 3L, 1L, 1L, 1L,
1L, 3L, 1L, 2L, 3L, 3L, 3L, 1L, 1L, 1L, 1L, 1L, 1L, 3L, 3L,
3L, 3L, 3L, 3L, 1L, 1L, 1L, 1L, 1L, 3L, 3L, 3L, 3L, 3L, 1L,
1L, 1L, 1L, 1L, 1L, 3L, 3L, 3L, 3L, 3L, 3L, 3L, 3L, 1L, 1L, 3L,
3L, 3L, 1L, 3L, 1L, 1L, 1L, 1L, 3L, 3L, 1L, 3L, 3L, 1L, 1L,
1L, 1L, 1L, 1L, 3L, 3L, 3L, 3L, 3L, 3L, 3L, 3L, 1L, 1L, 1L, 3L,
1L, 2L, 3L, 3L, 3L, 1L, 1L, 1L, 1L, 1L, 1L, 1L, 3L, 3L, 3L, 3L,
3L, 3L, 1L, 1L, 1L, 1L, 1L, 1L, 3L, 2L, 3L, 3L, 3L, 1L, 1L, 1L,
1L, 1L, 1L), .Label = c("F", "F_WM", "M"),
class = "factor"),
Eval_notes = structure(c(2L, 2L, 2L, 2L, 1L, 2L, 2L, 2L,
2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 1L, 2L, 2L, 2L, 2L, 2L,
2L, 2L, 2L, 1L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L,
2L, 2L, 2L, 2L, 1L, 2L, 2L, 2L, 2L, 2L, 1L, 2L, 2L, 2L, 2L,
2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L,
2L, 2L, 1L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L, 2L,

```

```

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                2L, 2L, 2L), .Label = c("Misclassified", "Target complex,
                correctly classified wetland type"), class = "factor"),
Wet.meadow.panel = c(1L, 1L, 1L, 1L, 1L, 1L, 2L, NA, NA, 2L, 2L, 2L, NA, 2L, NA, NA,
                    4L, NA, 5L, NA, NA, NA, 1L, 1L, 1L, 1L, 1L, 1L, NA, NA, NA, 3L,
                    3L, NA, 3L, 3L, 3L, NA, NA, NA, NA, NA, NA, 1L, 1L, 1L,
                    1L, 1L, 1L, NA, NA, NA, NA, NA, 4L, 4L, 4L, 4L, NA, NA,
                    NA, NA, NA, NA, 1L, 1L, 1L, 1L, 1L, 1L, NA, NA, NA, NA, NA,
                    5L, 5L, 5L, 5L, 5L, NA, NA, NA, NA, NA, NA, 1L, 1L, 1L, 1L,
                    1L, 1L, 2L, NA, NA, 2L, 2L, 2L, NA, 2L, NA, NA, 4L, NA, 5L,
                    NA, NA, NA, 1L, 1L, 1L, 1L, 1L, 1L, NA, NA, NA, 3L, 3L, NA,
                    3L, 3L, 3L, NA, NA, NA, NA, NA, NA, NA, 1L, 1L, 1L, 1L, 1L,
                    1L, NA, NA, NA, NA, 4L, NA, 4L, 4L, 4L, NA, NA, NA, NA, NA,
                    NA, NA, 1L, 1L, 1L, 1L, 1L, 1L, NA, NA, NA, NA, 5L, 5L,
                    5L, 5L, 5L, NA, NA, NA, NA, NA, NA),
Fen.panel = c(NA, NA, NA, NA, NA, NA, NA, 1L, 1L, NA, NA, NA, 1L, NA, 1L, 1L, 2L,
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              NA, 1L, NA, NA, NA, 1L, 3L, 3L, 3L, 3L, 3L, 1L, NA, NA, NA,
              NA, NA, NA, 1L, 1L, 1L, 1L, NA, 1L, 2L, NA, NA, NA, 4L, 4L,
              4L, 4L, 4L, 1L, NA, NA, NA, NA, NA, NA, 1L, 1L, 1L, 1L, 1L,
              NA, 2L, NA, NA, NA, 5L, 5L, 1L, 5L, 5L, 5L, NA, NA, NA, NA,
              NA, NA, NA, 1L, 1L, NA, NA, NA, 1L, NA, 1L, 1L, 2L, 2L, 2L,
              2L, 2L, 1L, NA, NA, NA, NA, NA, NA, 1L, 1L, 1L, NA, NA, 1L,
              NA, NA, NA, 1L, 3L, 3L, 3L, 3L, 3L, 1L, NA, NA, NA, NA, NA,
              NA, 1L, 1L, 1L, 1L, NA, 1L, 2L, NA, NA, NA, 4L, 4L, 4L, 4L,
              4L, 1L, NA, NA, NA, NA, NA, 1L, 1L, 1L, 1L, NA, 2L,
              NA, NA, NA, 5L, 5L, 1L, 5L, 5L, 5L),
SpRich = c(2L, 11L, 7L, 12L, 12L, 6L, 5L, 11L,
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            1L, 16L, 1L, 9L, 6L, 11L, 9L, 4L, 9L, 35L, 3L, 9L, 3L, 12L,
            6L, 2L, 4L, 17L, 5L, 10L, 5L, 16L, 17L, 14L, 2L, 12L, 6L,
            12L, 11L, 5L, 8L, 24L, 2L, 9L, 9L, 19L, 18L, 20L, 21L, 9L,
            1L, 2L, 4L, 17L, 13L, 12L, 2L, 14L, 7L, 14L, 12L, 5L, 9L,
            32L, 2L, 12L, 19L, 4L, 9L, 7L, 8L, 5L, 29L, 2L, 13L, 19L,
            1L, 19L, 2L, 14L, 6L, 10L, 9L, 4L, 3L, 9L, 29L, 20L, 10L,
            3L, 3L, 13L, 11L, 20L, 12L, 15L, 5L, 30L, 1L, 14L, 1L, 10L,
            6L, 8L, 10L, 5L, 10L, 30L, 2L, 10L, 4L, 12L, 9L, 2L, 5L,
            17L, 6L, 12L, 3L, 13L, 18L, 14L, 1L, 10L, 6L, 9L, 10L, 5L,
            7L, 15L, 1L, 7L, 6L, 15L, 16L, 13L, 15L, 9L, 1L, 1L, 3L,
            14L, 9L, 9L, 1L, 9L, 5L, 8L, 9L, 4L, 10L, 25L, 3L, 12L, 19L,
            4L, 6L, 6L, 6L, 4L, 36L, 2L, 15L, 18L, 2L, 15L)),
.Names = c("WetType", "Year", "WYear", "siteID", "xcoord", "ycoord",
"mdcaty", "Wetland.classification", "Weight.Stage1", "Weight.Stage2", "panel",
"EvalStatus", "True.wettype", "Eval_notes", "Wet.meadow.panel", "Fen.panel",
"SpRich"), class = "data.frame", row.names = c(NA, -176L))

```

```
### Trend Analysis ###
```

```

Years<-sort(unique(YOSE$Year))
mb<-length(Years)
StatusEst.F.SpRich<-vector("list",mb)
YOSE.F<-YOSE[YOSE$WetType=="F",]
for (i in 1:mb) {
  YOSE.F.year<-YOSE.F[YOSE.F$Year==Years[i],]
  StatusEst.F.SpRich [[i]]<- total.est(YOSE.F.year$SpRich,
YOSE.F.year$InclWt,x= YOSE.F.year $xcoord, y= YOSE.F.year $ycoord, conf=95)
}

```

```
Mean.F.SpRich<- Mean.F.SpRich.CIlow<- Mean.F.SpRich.CIhigh<-rep(0,mb)
```

```

for (i in 1:mb) {
  Mean.F.SpRich[i]<- StatusEst.F.SpRich[[i]][2,3]
  Mean.F.SpRich.CIlow[i]<- StatusEst.F.SpRich[[i]][2,5]
  Mean.F.SpRich.CIhigh[i]<- StatusEst.F.SpRich[[i]][2,6]
}

# Estimate the trend from a linear model using ordinary least
# squares and a logarithmic transformation on the GRTS estimate
# of the mean of annual species richness

WYear<-Years-min(Years)
fit.F.SpRich.lm<-lm(log(Mean.F.SpRich) ~ WYear)
summary(fit.F.SpRich.lm)

# Linear mixed model analysis on site-level data

YOSE.F.lmer<-data.frame(cbind(SpRich=YOSE.F$SpRich, Site= YOSE.F$siteID, Year=
YOSE$Year, WYear= YOSE$Year-2009))

fit.F.SpRich.lmer<-lmer(log(SpRich) ~ WYear + (1+WYear|Site) + (1|Year), data=
YOSE.F.lmer)
summary(fit.F.SpRich.lmer)

# Plot the results

plot(Years, Mean.F.SpRich.CIhigh, pch="", ylim=c(0,max(Mean.F.SpRich.CIhigh)),
ylab="Mean Species Richness")
lines(Years, Mean.F.SpRich.CIhigh, lty=2)
lines(Years, Mean.F.SpRich.CIlow, lty=2)
lines(Years, Mean.F.SpRich, lty=1)

lines(Years, exp(fit.F.SpRich.lm$coef[1]+fit.F.SpRich.lm$coef[2]*(Years-2009)),
lty=3, co=2)
lines(Years,
exp(fixef(fit.F.SpRich.lmer)[1]+fixef(fit.F.SpRich.lmer)[2]*(Years-2009)), lty=4,
co=4)

```

SOP 30. Photographic Image Processing and Management

Version 1.0

Peggy E. Moore
(adapted from Woodward et al. 2009)

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Introduction

This SOP describes procedures for downloading, processing, and naming images collected by project staff or volunteers during the course of conducting project-related activities. Images that are acquired by other means – e.g., downloaded from a website or those taken by a cooperating researcher – are not project records and should be handled separately.

Managing Data Photos

Care should be taken to distinguish data photos from incidental or opportunistic photos taken by project staff. Data photos are those required to document the plot and are listed in SOP 11, Photo Point Documentation.

These photos are taken from specified locations for the following reasons:

- to document plot features
- to document perspective for the purpose of site relocation
- to capture plot vegetation characteristics
- to document gross structural changes over time

Data photos are linked to specific records within the database, and are stored in a manner that permits the preservation of those database links. Other photos – e.g., of field crew members at work, or photos documenting a plant species – may also be retained but are not necessarily linked with database records.

Effectively managing hundreds of photographic images requires a consistent method for downloading, naming, editing and documenting. The general process for managing data photos proceeds as follows:

1. File Structure Setup: Set up the file organization for images prior to acquisition
2. Image Acquisition
3. Download and Process
 - a. Download the files from the camera
 - b. Copy and store the original, unedited versions
 - c. Rename the image files according to established protocol
 - d. Review and edit or delete selected photos
 - e. Move into appropriate folders for storage
4. Establish Database Links
5. Deliver Image Files for Final Storage

File Structure Setup

Prior to data collection for any given year, project staff will need to set up a new folder under the Images folder in the project workspace as follows:

[Year]	The appropriate year (e.g., 2008, 2009, etc.)
[Park code]	Arrange files by park (use four-letter code)
1_Originals	Unedited image file copies
[Site_code]	Arranged in folders by plot for images taken at plots
[Date]	Arranged by date, for images not taken at plots
2_Processing	Temporary processing workspace

3_Recon_Plots	Required data images for reconnaissance work
[Site_code]	Arranged in folders by plot for images taken at plots
[Date]	Arranged by date, for images not taken at plots
4_Permanent_Plots	Required data images for permanent plots
[Site_code]	Arranged in folders by plot for images taken at plots
[Date]	Arranged by date, for images not taken at plots
5_Methods	Non-data images of methods taken by project staff
[Site_code]	Arranged in folders by plot for images taken at plots
[Date]	Arranged by date, for images not taken at plots
6_Miscellaneous	Non-data images taken by project staff
[Site_code]	Arranged in folders by plot for images taken at plots
[Date]	Arranged by date, for images not taken at plots
7_Non-NPS	Images acquired from other sources

This folder structure permits data images to be stored and managed separately from non-record and miscellaneous images collected during the course of the project. It also provides separate space for image processing and storage of originals.

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- No spaces or special characters in the folder name
- Use the underbar (“_”) character to separate words in folder names
- Try to limit folder names to 20 or fewer characters
- Dates within folder names should be formatted as YYYYMMDD (for better sorting)

Image Acquisition

For details on image acquisition refer to SOP 11. Capture images at an appropriate resolution that maximizes resolution while working within image storage space limitations. Although photographs taken to facilitate future navigation to the site do not need to be stored at the same resolution as those that may be used to indicate gross environmental change at the site, it may be more efficient to capture all images at the same resolution initially. A recommended minimum resolution is 2048 x 1024 pixels (approximately 2 megapixels).

Downloading and Processing

1. Download the raw, unedited images from the camera into the “1_Originals” folder.
2. Copy the images to the “2_Processing” folder, and then set the contents in the “1_Originals” folder as read-only by right clicking in Windows Explorer and checking the appropriate box. These originals are the image backup to be referred to in case of unintended file alterations (e.g., file deletion, loss of resolution, or loss of image quality upon rotation of image).
3. In the “2_Processing” folder, rename the images according to protocol (refer to the image file naming standards section below). If image file names were noted on the field data forms, be sure to update these to reflect any changes to image file names prior to data entry.
4. Process the photos in the “2_Processing” folder. At a minimum, the following processing steps should be performed on all image files:

- Delete any poor quality photos, repeats, or otherwise unnecessary photos. Low quality photos might be retained if the subject is highly unique, or the photo is an irreplaceable data photo.
 - Rotate the image to make the horizon level.
 - Photos of people should have “red eye” glare removed.
 - Non-data photos may be cropped to remove edge areas that grossly distract from the subject.
5. When finished, move the image files that are to be retained and possibly linked in the database to the appropriate folder. Data images are moved to the “4_Permanent Plots” folder, methods images to the “5_Methods” folder, and other images to the “6_Miscellaneous” folder. Photos of interest to a greater audience should be provided to the park digital image library. To minimize the chance for accidental deletion or overwriting of needed files, no stray files should remain in the processing folder between downloads.

Large groups of photos acquired under sub-optimal exposure or lighting can be batch processed to enhance contrast or brightness. Batch processing can also be used to resize groups of photos for use on the web. Batch processing may be done in ThumbsPlus, Extensis Portfolio or a similar image processing software package.

Image File Naming Standards

In all cases, image names should follow these guidelines:

1. No spaces or special characters in the file name
2. Use the underbar (“_”) character to separate file name components
3. Try to limit file names to 30 characters or fewer
4. Park code and year should either be included in the file name or be obvious from the folder structure

The image file name should consist of the following parts:

1. The 4-character park code (DEPO, SEKI, YOSE) followed by an underbar
2. The three digit plot number (e.g. 007), followed by an underbar
3. A brief descriptive code (Table 11.1), word or phrase, followed by an underbar
4. Four digits representing year
5. Optional: a sequential number if multiple images were captured

Example: SEKI_007_C_2008.jpg: a SEKI plot view taken from south of the south macroplot corner of the entire macroplot

Renaming photos may be most efficient as a three part event:

1. Insert the park code and plot number at the beginning of the photo name as a batch process for a group of data images from a plot.
2. Insert year at the end of the photo as a batch process.
3. Individually add a descriptive component to each file name.

To rename files in batches use ThumbsPlus, Extensis Portfolio or a similar image software package. A somewhat less sophisticated alternative is to batch rename files in Windows Explorer by first selecting the set of files to be renamed and then selecting File > Rename. The edits made to one file will be made to all others, although with the unpleasant side effect of adding spaces and special characters (e.g., parentheses) which will then need to be removed manually.

Linking Images to the Database

During data entry and processing, the database application will provide the functionality required to establish a link between each database record and the appropriate image file(s). To establish the link, the database prompts the user to indicate the root project workspace directory path, the specific image folder within the project workspace, and the specific file name. This way, the entire workspace may be later moved to a different directory (i.e., the SIEN digital library) and the links will still be valid after changing only the root path. Note: It is important that the files keep the same name and relative organization once these database links have been established. Users should not rename or reorganize the directory structure for linked image files without first consulting with the Data Manager.

Final Storage

At the end of the season, and once the year's data are certified, data images for the year may be delivered along with the working copy of the database to the Data Manager. To do this, simply copy the folder for the appropriate year(s) and all associated subfolders and images onto a CD, DVD or a network location indicated by the Data Manager.

Prior to delivery, make sure that all processing folders are empty. Upon delivery, the delivered folders should be made read-only to prevent unintended changes.

Literature Cited

Woodward, A., K. M. Hutten, J. R. Boetsch, S. A. Acker, R. M. Rochefort, M. M. Bivin, and L. L. Kurth. 2009. Forest vegetation monitoring protocol for national parks in the North Coast and Cascades Network: U.S. Geological Survey Techniques and Methods 2-A8, 228 p.

SOP 31. Protocol Revisions

Version 1.0

This SOP has been adapted from the multi-network white pine monitoring protocol (McKinney et al. 2012).

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #

Procedures

This monitoring protocol is an actively evaluated and updated document that reflects the latest procedures of the monitoring program. Revisions are expected, and can involve only minor changes with little overall impact or occasional major revisions and course corrections.

Evaluation and revision of the protocol is directed by the Project Lead on an annual basis in association with season close-out. The narrative as well as each SOP has a revision history log whereby changes can be recorded. Older versions of the narrative and SOPs should be archived to ensure proper legacy of past work is maintained. Each revision will require the updating of the version number. Minor changes are recorded as decimal numbers (e.g., 1.0, 1.1, 1.2, etc...). Major changes are recorded as a change in the primary number of the protocol version (e.g., 1.0, 2.0, 3.0, etc...). In some cases, major revisions to the protocol may prompt the need for additional peer-review. The Project Lead and Program Manager will coordinate this with the Pacific West Region (PWR) I&M Program Manager.

Timing

SOPs can be changed at any time, however it is often most convenient for the changes to be made during reporting and project close-out and to take effect at the beginning of the next calendar year. Changing an SOP during a data collection period should be avoided. However, testing of proposed new methodologies with the existing approaches is highly desirable and provides invaluable information necessary for evaluating whether the new methods are superior and how their measurements will correlate with the previous methods.

Instructions

The following procedures will ensure that both minor and major revisions to this document will align with the monitoring protocol and data management.

1. Discuss proposed changes with other project staff prior to making modifications. It is important to consult with the Data Manager prior to making changes because certain types of changes may jeopardize dataset integrity unless they are planned and executed properly. Also, because certain changes may require altering the database structure or functionality, advance notice of changes is important to minimize disruptions to project operations. Consensus should be reached on who will be making the changes and in what timeframe.
2. Make the agreed-upon changes in the appropriate protocol document. Note that the protocol is split into separate documents for each appendix and SOP. Also note that a change in one document may necessitate other changes elsewhere in the protocol. For example, a change in the narrative may require changes to several SOPs; similarly, renumbering an SOP may mean changing document references in several other documents. Also, the project task list and other appendices may need to be updated to reflect changes in timing or responsibilities for the various project tasks.
3. Document all edits in the Revision History Log embedded at the beginning of the protocol narrative and each SOP. Record changes only in the document being edited (i.e., if there is a change to an SOP, log those changes only in that document and not in the narrative). Record the date of the changes (i.e., the date on which all changes were finalized), author of the revision, a change description and the paragraph(s) and page(s) where changes are made, a brief reason for making the changes, and the new version

number. Version numbers increase incrementally by tenths (e.g., version 1.1, 1.2) for minor changes. To ensure that minor errors noted or recommendations are not lost, changes should be made within 30 days of when they are noted, once the network team has reviewed and approved the recommended changes. Major revisions will be designated with the next whole number (e.g., version 2.0, 3.0).

4. Circulate the changed document for internal review among project staff and cooperators. Minor changes and clarifications will be reviewed in-house. When significant changes in methodology are suggested, revisions will first undergo internal review by the project staff. Additional external review, including, but not limited to, National Park Service staff with appropriate research and statistical expertise, will be required.
5. Upon ratification and finalizing changes:
 - a. Ensure that the version date (last saved date field code in the document header) and file name are updated properly throughout the document.
 - b. Make a copy of each changed file to the protocol archive folder (i.e., a subfolder under the Protocol folder in the project workspace).
 - c. The copied files will be renamed by appending the revision date in YYYYMMDD format. In this manner, the revision date becomes the version number and this copy becomes the “versioned” copy to be archived and distributed.
 - d. The current, primary version of the document (i.e., not the versioned document just copied and renamed) does not have a date stamp associated with it.
 - e. To avoid unplanned edits to the document, reset the document to read-only by right-clicking on the document in Windows Explorer and checking the appropriate box in the Properties popup.
 - f. Inform the Data Manager so the new version number(s) can be incorporated into the project metadata.
6. As appropriate, create PDF files of the versioned documents to post to the Internet and share with others. These PDF files will have the same name and be made from the versioned copy of the file.
7. Send a digital copy of the revised monitoring protocol to the Project Lead. The revised monitoring protocol should also be forwarded to all individuals who had been using a previous version of the affected document. Ensure that field staff has a hardcopy of the new version.
8. The Network Data Manager will place a copy of the revised protocol in the proper folder on Network shared drives. In addition, the Network Data Manager will archive the previous version on the archive drives.

The Network Data Manager will post the revised version and update the associated records in the proper I&M databases, including but not limited to Reference Services, Network Intranet and Internet websites, and the Protocol database.

Literature Cited

McKinney, S. T., T. Rodhouse, L. Chow, A. Chung-MacCoubrey, G. Dicus, L. Garrett, K. Irvine, S. Mohren, D. Odion, D. Sarr, and L. A. Starcevich. 2012. Monitoring white pine (*Pinus albicaulis*, *P. balfouriana*, *P. flexilis*) community dynamics in the Pacific West Region - Klamath, Sierra Nevada, and Upper Columbia Basin Networks: Narrative version 1.0. Natural Resource Report NPS/PWR/NRR—2012/532. National Park Service, Fort Collins, Colorado.

National Park Service
U.S. Department of the Interior



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