



Eastern Rivers and Mountains Network Rare Riparian Prairie Monitoring Program Standard Operating Procedures

Version 1.0 (October 2017)

List of Standard Operating Procedures

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Protocol Revision History

As part of the National Park Service (NPS) Inventory and Monitoring Program, the ERMN Rare Riparian Prairie Monitoring Protocol consists of a narrative (Perles et al. 2018) that describes the monitoring objectives and sampling design, Standard Operating Procedures (SOPs; contained in this report) that outline specific data collection details of the monitoring protocol, and a Quality Assurance Plan (QAP) that documents the standards and procedures used in the collection, processing, storage, analysis, and publication of monitoring data. The latest versions of the protocol, QAP, and additional supporting information can be accessed online at the ERMN website (<http://science.nature.nps.gov/im/units/ermn/monitor/riparianplants.cfm>), or the NPS Data Store (<https://irma.nps.gov/DataStore/Reference/Profile/2227683>).

Each SOP includes a revision history log to document changes in the protocol. Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.3 to Version 1.4) when there are minor modifications that do not affect requirements or procedures included in the protocol. For simplicity, all SOPs have the same version number at the same time so that the set of SOPs used in a particular field season can be referenced as a group. As a result, the revision log for each SOP may not include notes for every version since changes may not have been made to that SOP during that revision. Some SOPs that have not been changed substantially since the monitoring program began have no notes in their revision history.

SOP #1
Field Season Preparation
Version 1.0 (October 2017)

Overview

This SOP describes preparations for field data collection and includes a list of necessary field equipment.

Staff

The field crew for rare riparian prairie monitoring should be composed of three people, but can vary from two to six people. At least one person sampling each transect and plot should be skilled in botany, with a strong knowledge of the flora of Pennsylvania and West Virginia. This role could be filled by the ERMN Plant Ecologist, ERMN Vegetation Crew Leader, contract botanists from the state natural heritage programs, or other qualified botanists. Depending on the availability of botanically-qualified crew members, additional field assistants, such as ERMN Vegetation Monitoring Crew Members, other ERMN staff, park natural resource staff, or park SCA interns may be needed to complete the field work. The composition of the field crew should be determined by May to ensure that crew members reserve time for this project during the busy field season.

Schedule

Data collection will occur in late August when the river levels are low and the plants on the riparian prairies are fully developed. In the event of floods or prolonged high water levels, field work will be delayed. The field crew leader should carefully consider logistics, weather, and the crew's capabilities and motivation levels when setting a weekly work schedule. Flex-time (e.g. four 10-hour days/week) may be more efficient given difficult site access.

Planning and Coordination

The ERMN Plant Ecologist should ensure that each ERMN park natural resource manager has knowledge of the sites slated for the current year, the anticipated field work schedule, and the protocols that will be followed.

Logistics

The ERMN Plant Ecologist should reserve a field vehicle for transport to and within parks. For DEWA, the sites can be accessed via a regular car and reasonable hiking. In GARI and NERI, a four wheel drive vehicle with high clearance and a skid plate is necessary to access several riparian sites. In addition, using rafts or inflatable kayaks to access prairie sites may be necessary in NERI and GARI. Coordinate with the park's river rangers to determine the best access.

ERMN personnel should contact the natural resource manager and/or research coordinator at each park to discuss the timing of field visits and reserve park lodging, if available. If no park lodging is available, make alternative lodging reservations. Wherever possible, lodging should include kitchen facilities and internet access.

Maps

Prior to each field season, prepare maps showing the year's sampling locations. Mapping the prairie onto several base layers, such as park leaf-off aerial photography, USGS topo maps,

Google Earth historical and current photography, and Bing photography, will provide additional information on the extent of the prairie and on the surrounding vegetation. Line and point symbols for roads, trails, park boundaries, streams, baseline transect markers, and other features should be clearly visible, but not large enough to obscure other features. Include a scale on all maps showing distances in meters or kilometers. If necessary, prepare a smaller park-wide location map inset to show where in the park the site is located. Print all field maps on waterproof paper using a color LaserJet printer.

Supply the crew with atlases for Pennsylvania and West Virginia, as well as the Emergency Response map for the Gauley River (available at the Cathedral Café, 134 S. Court Street, Fayetteville, WV, 25840, 304-574-0202), and the National Geographic map of New River Gorge National River (also includes Gauley and Bluestone Rivers).

Download site polygon boundaries or centroid points for the polygons into the ERMN GPS unit (see the Using the Global Positioning System SOP). Immediately after downloading the plot coordinates, check the GPS map page to ensure that the uploaded data are shown correctly on the GPS.

Training

Prior to data collection, ERMN must ensure all field personnel fully understand the field protocols by conducting in-situ training sessions. Field crew preparation should involve careful review and discussion of all SOPs, as well as field sessions completing transects and plots. Crew members must read the entire protocol and all SOPs thoroughly. Training should cover:

- job hazards and safety procedures;
- proper use of all equipment, including GPS, compass, measuring tape, dbh tape, digital camera, and NPS radio;
- declination settings on compasses;
- estimating percent cover classes;
- collecting and labeling unknown plant specimens;
- procedures for careful data collection and quality control;
- minimizing site and plot trampling;
- accurate diameter-at-breast-height measurement;
- how the data are used and what information is gained from each type of data collected (i.e. why each type of data is important);

Training should include demonstration and practice of all measurement procedures. The critical importance of careful, accurate, and steady data collection to this long-term monitoring program must be emphasized. Trainers must stress the importance of exact adherence to SOP instructions to prevent bias in measurements among years, which will inhibit ERMN's ability to detect long-term trends. Encourage trainees to discuss with their supervisors any concerns that arise over field procedures, the datasheets, or the database during training and later during the field season. The crew should never deviate from established protocols or alter the datasheet or database without first consulting with their supervisor. Any changes in procedures must be clearly documented in the SOP revision history and the project database.

Communication and Crew Oversight

At all times, the crew should carry a National Park Service radio programmed to the appropriate frequencies in each park. Crew members should know which frequencies work in which sections of each park, how to contact park radio dispatch, and be familiar with proper radio etiquette. In parks with cell phone coverage, crew members should carry a cell phone in the field for safety and to call their supervisor concerning protocol questions.

Equipment

Required equipment and supplies for vegetation monitoring are listed below. Equipment should be organized and maintained in good working condition. Mark each piece of equipment with a piece of brightly colored flagging to assist with locating it during data collection. At the end of each season the crew leader will inventory the condition of all equipment and prepare a list of required repairs or replacements. All equipment will be cleaned and thoroughly dried before storage. Batteries will be removed from all electronic equipment before storage.

ERMN Rare Riparian Prairie Monitoring Equipment List:*General:*

Maps showing site locations on waterproof paper
Atlases for Pennsylvania and West Virginia
Copies of Protocol and Standard Operating Procedures on waterproof paper
Full-size plant press
Newspaper for pressing plant samples
Pencils (1 – 2 boxes, with extra lead and erasers)
Black Sharpies – medium point
Daypacks (1 per crew member)
Large dry bags (3)
First aid kit
Sunscreen
Hats (1 per crew member)
Insect repellent
Poison ivy soap
Water bottles and water
Lunch and snacks
Park radio and charger
Personal locator beacon

Baseline Establishment and Data Collection:

GPS unit and spare AA batteries
GPS antennae and associated cords / connectors
Compass (3)
50-m tape (3)
30-m tape (3)
Chaining pins (12) with leather sheath
Small carabiners or twist ties to connect multiple tapes on long transects
Flagging
24" long $\frac{3}{4}$ " diameter rebar (1 rebar per 50 meters of baseline + 1 additional)

Small metal sledge hammer

Claw hammer

Tree nails, galvanized steel, about 2.5 inches long

Numbered tree tags

Loggers Tape

Datasheets on plain and Rite-in-the-Rain paper

Random number tables or random number generator

Enclosed clipboard (3)

1-m² square quadrat, painted to mark 1% of square

(DEWA: quadrat is 0.5 m x 2 m rectangle; NERI and GARI: quadrat is 1 m x 1m square)

Hand lens (1 per botanist)

Gallon-size Ziploc bags for plant specimens

Flora of West Virginia and/or Flora of Virginia

Digital camera

Spare batteries

Revisit Data Collection:

Yellow metal detector

Site reports including baseline, transect, and plot locations, lengths and azimuths

Revision History

SOP #2
Baseline and Transect Establishment for NERI and GARI
Version 1.0 (October 2017)

Overview

This SOP describes the establishment of the baseline and transects for monitoring riparian prairies in NERI and GARI. Transects are placed along the baseline, using restricted randomization.

Baseline Establishment

In consultation with park resource managers and river rangers, determine the best land or water route to the selected prairie location. Navigate to the site using GPS, maps and compass. Upon arrival at the site, verify that the site is occupied by the target community type and is of sufficient size (i.e., greater than 40 meters in length and greater than 10 meters in width for at least half of its length).

For NERI, prairie grasses such as *Andropogon gerardii* (big bluestem), *Panicum virgatum* (switchgrass), and *Sorghastrum nutans* (Indiangrass) should be common, growing on predominantly cobbles or in rare cases, bedrock outcrops. Other typical species include: *Apocynum cannabinum* (Indianhemp), *Baptisia australis* (blue wild indigo), *Chasmanthium latifolium* (Indian woodoats), *Coreopsis tripteris* (tall tickseed), *Solidago juncea* (early goldenrod), *Symphyotrichum laeve* (smooth blue aster), *Viola cucullata* (marsh blue violet), and *Zizia trifoliata* (meadow alexanders). While the prairie may contain short trees and shrubs, and may be considered woodland in sections, tall forest canopy and mature trees are typically absent.

For GARI, dominant plants are a mixture of woody and herbaceous species. Woody plants are often growing as battered shrubs, including river birch (*Betula nigra*), American sycamore (*Platanus occidentalis*), common ninebark (*Physocarpus opulifolius* var. *opulifolius*), persimmon (*Diospyros virginiana*), and buttonbush (*Cephalanthus occidentalis*). Characteristic herbs include big bluestem (*Andropogon gerardii*), Rand's goldenrod (*Solidago racemosa*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium* var. *scoparium*), wild blue indigo (*Baptisia australis*), balsam groundsel (*Packera paupercula*), royal fern (*Osmunda regalis* var. *spectabilis*), and birdfoot violet (*Viola pedata*). The diversity of each prairie sites is driven by the type of substrate and the mosaic of wet and dry microsites.

Establish the baseline origin and terminus in the forest edge, with the prairie between the baseline and the river (Figure 1). The baseline should be positioned parallel to the river flow, preferably far enough into the forest to be at least somewhat sheltered from the main force of the floods that overwash the open prairie. The baseline should span the length of the prairie.

When placing the baseline, stretch 50 m tape(s) so they are straight, through the forest, parallel to the river flow. In dense vegetation or when the view is obstructed, two crew members should work together to sight and back-sight successive short sections of baseline to stay on a consistent bearing. Care should be taken to keep metal objects, such as the rebar or surveyors stakes, away from the compass while measuring bearing.

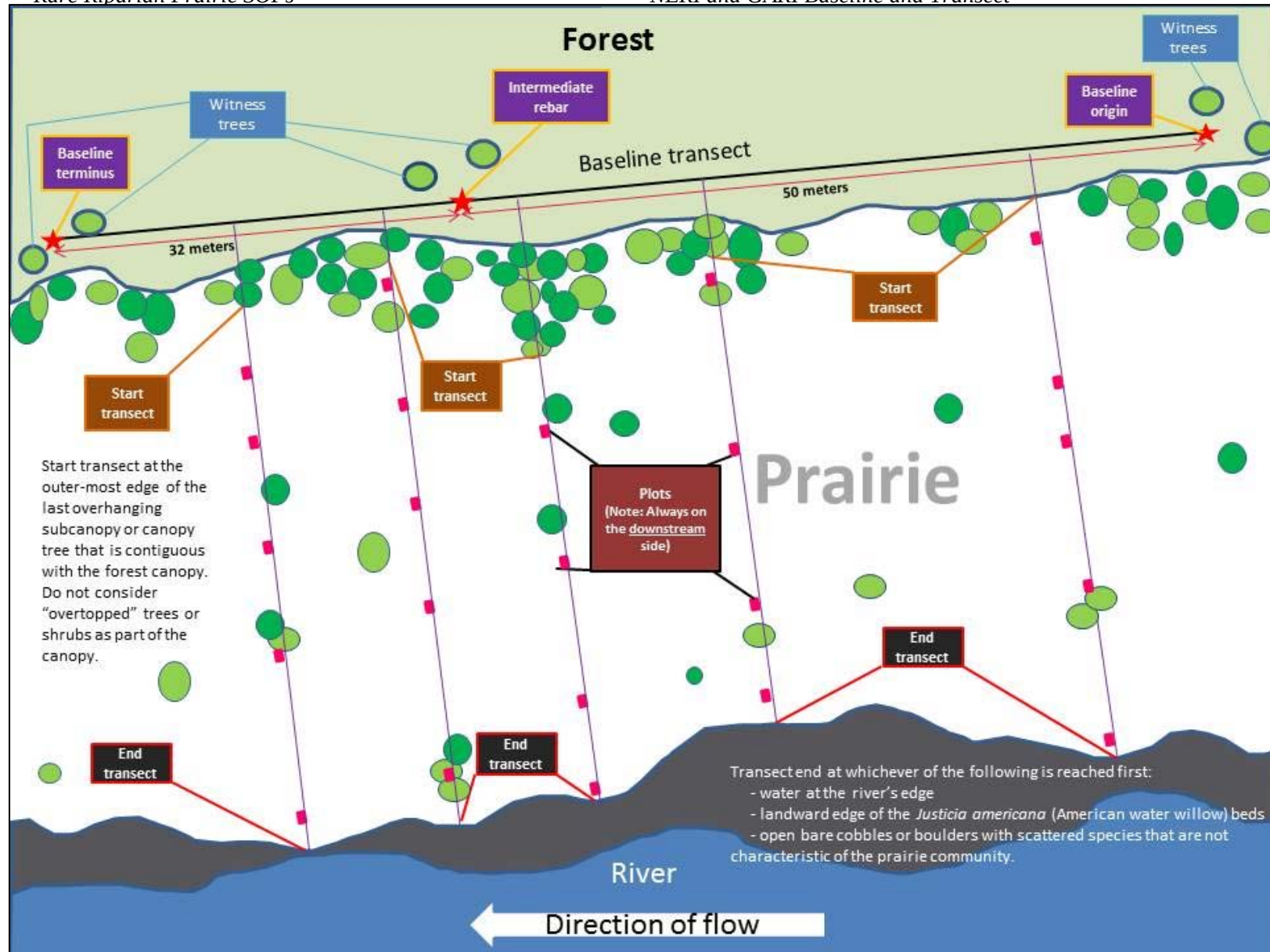


Figure 1. Diagram of transect and plot positions for rare riparian prairie monitoring in NERI and GARI.

Compasses should be declinated according to the table below. Adjust the declination dial on the faceplate to the nearest degree. For 2017, the declination for NERI and GARI is:

Park	Declination	Compass Adjustment
NERI	7.94° West	8° West
GARI	8.27° West	8° West

Source: <http://www.ngdc.noaa.gov/geomag-web/#declination>

Record the bearing of the baseline from origin to terminus. If the prairie bends, the bearing may change in different sections of the baseline. In this case, record a bearing for each 50-m section of baseline and draw a clear diagram on the Baseline Establishment datasheet depicting the baseline sections with lengths, bearings, rebar, prominent landmarks, prairie extent, river flow, etc.

The baseline origin and terminus are marked with 24 - inch rebar driven into the ground, so that approximately 3-4 inches of the rebar are exposed above the ground surface. Intermediate rebar stakes are placed every 50 meters along the baseline to facilitate re-establishing the baseline during subsequent sampling visits. If the rebar cannot be driven into the rocky ground, try nearby locations within 3 m of the actual baseline section end. If the rebar can be driven in a nearby location, record the distance and bearing from the rebar to the actual baseline section end. If no suitable locations can be found, use the closest tree and record the distance and bearing from the tree to the actual baseline end.

Record the location of the baseline origin, terminus, and intermediate stakes with the GPS unit and external antennae, averaging at least 150 points per location to improve accuracy. Record coordinates and accuracy for each rebar stake on the Baseline Establishment datasheet.

Near the origin, terminus, and intermediate rebar stakes locate two healthy trees to serve as witness trees. Tag each tree with a numbered aluminum tree tag. Nail a galvanized steel nail into each tree at approximately 2 m above the ground on the downstream side of the tree. Angle the nail head slightly down and leave approximately 2 cm of the nail sticking out of the trunk so that the tag naturally slides away from the tree bark, and the tree can grow without the tag being lost in the bark. DO NOT NAIL THE TAGS FLAT AGAINST THE TREE. Select more flood-resistant tree species whenever possible: sycamore, river birch, black gum, sweet gum, elm. Avoid hemlock, ash, and other species with current pest infestations unless there are no other suitable trees for tagging. Record the DBH (diameter at breast height = 1.37 m above the ground) and species of both tagged trees. Record the bearing in degrees and distance in tenths of a meter from each tagged tree to the rebar stake.

Data Collection

Record the following fields on the Baseline Establishment datasheet:

Park: 4 letter code of park.

Date: month, day and year sampling occurred.

Site Name: name of prairie (see Table 1 below).

Observers: first and last name of all crew members.

Directions to Site: detailed instructions on how to access site.

Baseline Azimuth: compass bearing of the baseline transect from origin to terminus.

Baseline Length: length of baseline in meters.

GPS Datum: use UTM NAD 83.

Zone: for NERI and GARI, the zone is 17.

Site Diagram: a sketch of the site showing the baseline, origin, terminus, intermediate stakes, landmarks, prairie extent, river flow, lengths and azimuths of baseline sections, sampling transects with their locations and lengths, and any other important features of the site.

For the rebar marking the baseline origin, terminus, and any intermediate rebar stakes:

X: East Universal Transverse Mercator value of the rebar from the GPS unit, determined using the average position function.

Y: North Universal Transverse Mercator value of the rebar from the GPS unit, determined using the average position function.

Error: Estimated error shown on the GPS unit BEFORE the OK button was pressed to stop averaging points.

Upstream / Downstream: circle the corresponding location of the baseline origin and terminus.

For each rebar, record the following from two witness trees:

Species: Genus and species name of the tree. Plant taxa follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for NERI and GARI. The Master Plant List in the Riparian Prairie Monitoring Database was created from the PLANTS Database (USDA, NRCS 2007) and updated to match Weakley (2015) and Rhoades et al. (2000) as necessary.

Tag Number: the number on the aluminum tag nailed to the tree.

DBH: Diameter at breast height of the tree in centimeters, measured at 1.37 m above the ground on the uphill side of the tree.

Bearing from tree to stake: azimuth measured from tree to rebar.

Table 1. Sampling sites for rare riparian prairie monitoring in NERI and GARI.

Site	Approximate Dimensions (m)	Area (ha)	Number of Transects	Number of Plots	First Sample Year	Panel	Effort (~10-12 hour field days)
NERI							
Terry 1	113 x 35	0.260	5	24	2012	2	1
Dowdy Creek 2	42 x 13	0.040	5	10	2012	2	0.5
Dowdy Creek 1	68 x 15	0.059	5	17	2012	2	0.5
Manns Creek	268 x 48	0.698	8	36	2012	2	2
Plateau	294 x 13	0.285	9	38	2015	3	1
Keeney Creek	70 x 26	0.131	6	25	2015	3	1
Glade Creek	147 x 27	0.230	5	20	2015	3	0.5
Glade Creek Island	83 x 46	0.226	5	23	2015	3	0.5
Camp Brookside	82 x 23	0.142	6	17	2015	3	0.5
GARI							
PSH	80 x 30	0.406	6	22	2016	4	0.5
Woods Ferry	38 x 12	0.073	5	10	2016	4	0.5
Pyramid Rock	72 x 15	0.181	5	12	2016	4	0.5
Kevins Folly Right	75 x 20	0.162	5	17	2016	4	0.5
Swiss	67 x 90	0.419	5	25	2016	4	1
Stairstep Lower Left	44 x 12	0.203	5	11	2016	5	1 (raft)
Ruh Roh	77 x 15	0.193	6	15	2016	5	0.5
Carnifex Ferry	40 x 20	0.093	5	15	2016	5	0.5
Spillway	232 x 15	0.406	8	19	2016	5	1
Tunnel	244 x 30	0.668	8	32	2016	5	1
Junkyard	69 x 14	0.097	5	10	2017	6	0.5
Rock Garden	337 x 33	0.754	10	37	2017	6	1
Kevins Folly Left	92 x 18	0.185	5	16	2017	6	1
Stairstep Upper Right	265 x 27	0.636	10	40	2017	6	1
Iron Curtain	40 x 11	0.056	5	10	2017	6	0.5

Transect Establishment

In NERI and GARI, the number of transects varies depending on measurement of the prairie extent in the field. The number of transects per site is determined by site length as shown in Table 2.

Table 2. Guidelines for number of monitoring transects to be installed based on site length. These guidelines can be adjusted based on site configuration and logistical constraints.

Site Length	Approximate Number of Monitoring Transects
40 – 150 m	5 - 6
151 – 250 m	7 - 8
251 – 350 m	8 - 10

Once the required number of monitoring transects has been determined, divide total baseline length into the same number of equal length sections as the required number of transects. Use a random number generator to determine the location of each monitoring transect within each section along the baseline. These random numbers are the Transect Positions along the baseline. This design, known as restricted random sampling, ensures better interspersed sampling units than with simple random sampling, as well as resulting in more precise estimates of density (Elzinga et al. 2001).

Monitoring transects run perpendicular to the baseline from the forest to the edge of the river. At the randomly-assigned Transect Position within each section, stretch a measuring tape that will serve as the transect from the baseline to the river. The crew member walking towards the river should hold the reel end of the tape and walk on the upstream side of the tape.

The start of the monitoring transect is the edge of the contiguous forest canopy (generally this is not at the baseline). Consider subcanopy and canopy trees in the adjacent forest as the canopy. The canopy ends at the point along the transect where the outer edge of the overhanging subcanopy or canopy tree is directly above the transect (in other words, if the sun was directly overhead, the point along the transect where the shade from the outermost tree branch hits the transect). There may be short trees (“overtopped” as defined in the ERMN forest monitoring protocol) or shrubs at the start of the transect. Do not consider these short trees or shrubs as part of the canopy. Trees of canopy height that are not contiguous with the forest canopy are not used to determine the transect start. See Figure 1 for examples of transect starts.

Measure the distance from the baseline tape to the monitoring transect start position and record it on the datasheet. Then move the zero end of the tape to the baseline start, ensuring that you remain on the correct bearing.

The end of the transect is whichever of the following is reached first: the water at the river’s edge, landward edge of the *Justicia americana* (American water willow) beds, or open bare cobbles or boulders with scattered *Justicia americana*, *Apocynum* spp., or riverside annual species that are not characteristic of the prairie community. Once the transect is secured at the start and end, record the transect length.

Data Collection

The following fields are recorded on the Plot datasheet:

Park: 4 letter code of park.

Date: month, day and year sampling occurred.

Site Name: name of prairie (see Table 1 above).

Observers: first and last name of all crew members.

Transect Number: number assigned to that transect within the site. Transects are numbered sequentially from the origin to the terminus of the baseline.

Transect Position: position of the transect along the baseline, in meters from the baseline origin.

Distance from Baseline to Transect Start: distance in meters from the baseline to the start of the transect at the edge of the contiguous canopy (see explanation above).

Transect Azimuth: A compass bearing, taken from woodland edge looking toward the river. This azimuth is 90 degrees difference from the baseline azimuth.

Transect Length: Length in meters of transect. See Transect Establishment above for criteria on determining the location of transect start and end.

Site Revisits

When revisiting a previously monitored site, read the directions and site notes that were recorded during the original and all subsequent sampling events. Check river gauge levels. Sampling cannot occur at high water levels. If the lower third of the site's transects' previous lengths are covered by water, postpone sampling until water levels drop. Use the notes and field maps to find the safest and most efficient route to the site. Bring the most recent data on locations and species of witness trees, witness tree tag numbers, baseline bearing and length, GPS coordinates of baseline origin and terminus, etc. Update the directions if a new or better route to the site is discovered.

Once at the site, use the GPS to locate the rebar marking both ends (origin and terminus) and the intermediate markers of the baseline. If the rebar is missing, identify its proper location using the witness trees, distances and bearings recorded during the previous sampling event. Replace the rebar.

If one or more witness trees are missing or in serious decline (this is not uncommon on cobble bar sites that are subjected to frequent, high velocity floods), locate new healthy trees, tag them, and record the appropriate data (see Transect and Plot Establishment SOP). Verify that existing tags remain solidly attached to the tree and are useable. Replace if needed.

Once the origin, terminus, and intermediate rebar stakes have been located, run measuring tapes that will serve as the baseline. Because the position of the transects should be constant, it is important that the baseline be relocated correctly along its entire length. Double-check to make sure the positions of origin and terminus have not been switched.

Using data recorded from the latest sampling event, position the transects at the original locations and bearings along the baseline.

Repeat the steps described in Plot Location and Data Collection for NERI and GARI, Line Intercept Sampling, Photographs, and Site-wide Invasive Exotic Plant Assessment to collect monitoring data. Before pulling up the baseline and leaving the site, review the data sheets to be sure all data has been recorded accurately and legibly, and check that all equipment has been retrieved.

SOP #3

Baseline and Transect Relocation for DEWA

Version 1.0 (October 2017)

Overview

This SOP describes the methods to relocate the Locations and transects for monitoring riparian prairies in DEWA.

Background

Since the rare riparian prairies in DEWA extended more than 0.5 kilometers, a single baseline was not established in 1998 when research began on these prairies. Instead, the length of the prairie was divided into subsections called “Locations”, roughly based on substrate type, which served as sections of the site’s baseline. The boundaries of the Locations were tagged witness trees. See Figure 2 for an illustration of the baseline, locations, transect and plot positions.

The Dingmans Ferry site was divided into 18 Locations based on four substrate types (i.e., solid limestone outcrop, latticed outcrop, cobbled sections of shoreline, and alluvial shoreline). The Locations were delineated because it was hypothesized that substrate type significantly affected the plant species composition and the distribution of rare plants within the site. Then, 50 transects were stratified across the Locations, with the number of transects proportionally allocated based on the length of the Location. Each Location received at least one transect, with the longest Location receiving 10 transects. The intensive rare plant species surveys in 1997 at the three Calcareous Riverside Outcrop and Calcareous Riverside Seep sites in DEWA indicated that the rare species were not restricted to nor found more commonly on any particular substrate type (Shank and Shreiner 1999). Additional analysis of the 1998 plot data revealed no distinct patterns in community composition among substrate types (Perles et al. 2011). Thus, the original stratification of transects by Location was unnecessary, and simple restricted random sampling across equal-length baseline sections was employed at the Montague and Smith Ferry sites.

Baseline Relocation

Determine the best route to the selected prairie site and navigate to it using GPS, maps and compass. Different access points may be used for different section of a site depending on the length of the prairie. Bring the most recent data on GPS coordinates of Locations, species of witness trees, witness tree tag numbers, baseline bearing and length, etc.

Locate the southern boundary point for the Location. Use previously documented GPS coordinates, tree tags, and Location descriptions to locate the tagged trees that mark the Location boundary. Replace the witness tree tag if the tag is obscured by the tree or is loose. If the witness tree is missing or in serious decline, locate a new one, tag it, and record its species, DBH, and its distance and bearing to the Location boundary.

In general, the Location boundary is directly in line with the marked tree, unless otherwise noted. The Location boundary along the shoreline can be located by running a tape from the marked tree (or other noted location) directly towards the shoreline.

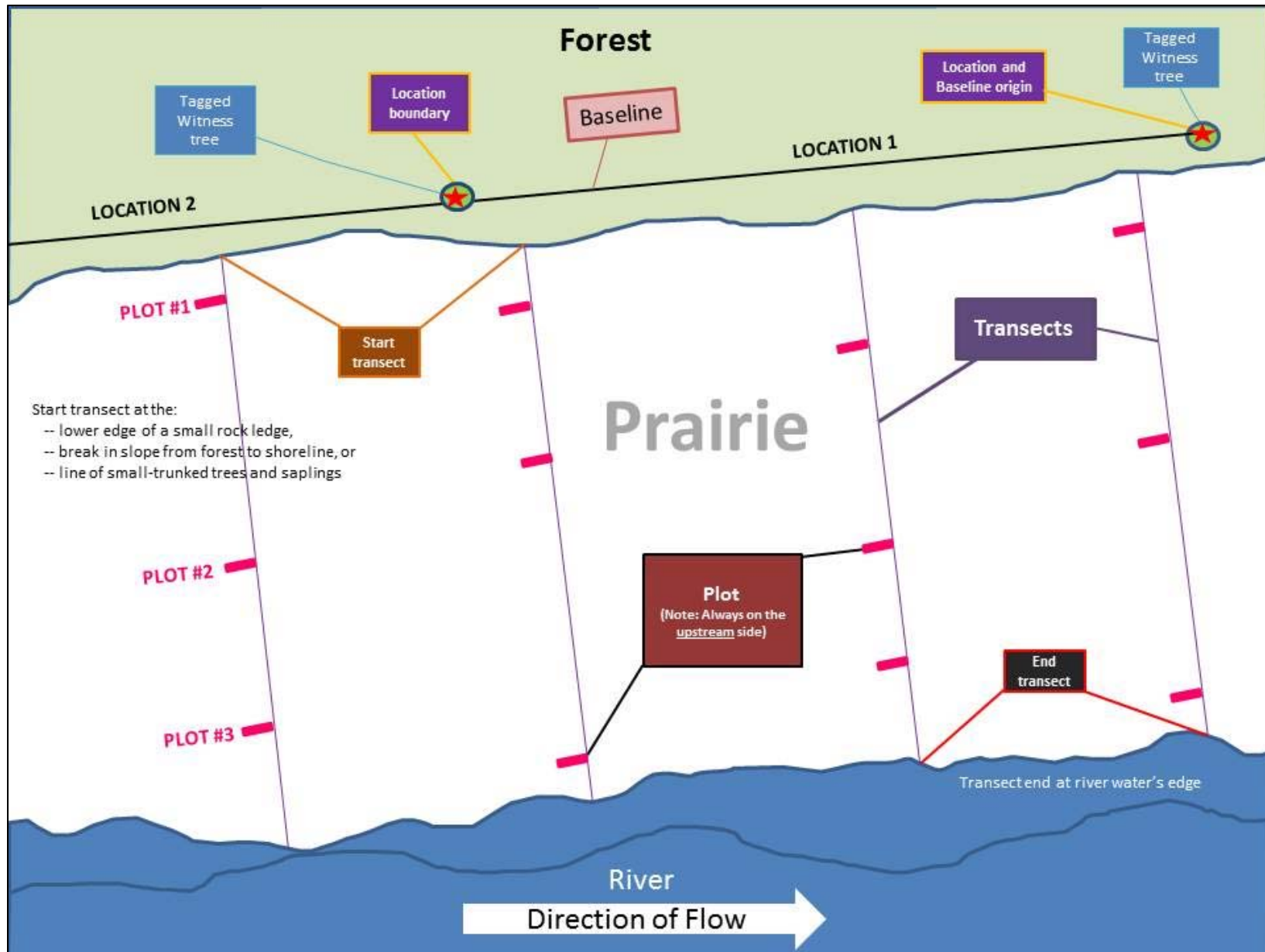


Figure 2. Diagram of transect and plot positions for rare riparian prairie monitoring in DEWA.

Along the shoreline (where it is much easier to walk), place a surveyor's stake at the southern Location Boundary. Attach the zero end of the baseline tape to the surveyor's stake. In the direction of the baseline azimuth (parallel to the river), stretch the baseline tape to distance specified by the Transect Position along the baseline tape.

Transect Relocation

At the Dingmans Ferry site, the number and position of transects and plots was determined in 1998 using restricted random sampling within each Location. Transect density for Montague and Smith Ferry sites was calculated in order to maintain similar sampling density as the Dingmans Ferry site (Table 4, approximately one transect per 50 meters of baseline). At the Montague and Smith Ferry sites, restricted random sampling was used to place transects along equal length section of the entire baseline, not within Locations based on substrate.

Potential transect positions occur every two meters along the baseline tape (e.g., 0 meters, 2 meters, 4 meters, and so forth). From a random number table, an even number between 0 and (total Location or baseline section length – 2) is selected and provides the transect position, in meters, from the beginning of the Location or baseline section.

Table 4. Sampling plan for rare riparian prairie sites in DEWA.

Site	Approximate Dimensions (m)	Number of Transects	Number of Plots	First Sample Year	Panel	Effort (~10-12 hour field days)
Dingman's Ferry	2,470 x 15	50	150	(1998) 2010	1	6
Montague	820 x 15	16	48	2018	2	2
Smith Ferry	977 x 20	19	66	2018	2	4

Transects are aligned perpendicular to the river shoreline at the Transect Position along the baseline tape. At the Transect Position, stretch a measuring tape that will serve as the transect upslope towards the woods, walking only on the downstream side of the transect tape to avoid trampling vegetation. The crew member walking towards the woods should have the zero end of the tape and a declinated compass. At the edge of the woods, determine the location of the upper end of the transect. Since the upper end of the transect is not permanently marked, the location of the transect end will be subjectively determined based on these three criteria:

- lower edge of a small rock ledge
- break in slope from a steeper slope in the woods to a shallower slope on the shoreline
- a line of small-trunked trees and saplings

Once the upper end of the transect has been determined, use a declinated compass to sight the crew member standing at the Transect Position along the shoreline. For 2017, declination was 12.49° West (source: <http://www.ngdc.noaa.gov/geomag-web/#declination>). Move left or right until the crew member is sighted in the compass at the appropriate transect azimuth. Secure the zero end of the tape with a surveyor's stake at this point.

[Note: At Dingmans Ferry, an undecimated compass was used in 1998 and 2010. For Latitude 41.218182 N and Longitude -74.86000 W, on Aug 15, 1998, the declination was 12° 54'W. On August 15, 2010, the declination was 12° 46'W. During the next sampling in 2019, transects will

be located using an undeclinated compass, but transect azimuths will be recorded using a declinated compass to standard those measurements. Declinated compasses will be used for all subsequent sampling events at the Dingmans Ferry site.]

Once the upper end of the transect is secured at the appropriate azimuth, stretch the tape to the water's edge. Crew members should walk only on the downstream side of the transect tape to avoid trampling vegetation. The distance to the water's edge is the Transect Length. Record the Transect Length on the datasheet. This may be different than the Transect Length recorded previously. Record the Transect Number, Transect Position, and Transect Azimuth on the datasheet. These should be the same as recorded during the last visit.

Data Collection

The following fields are recorded on the Plot datasheet:

Park: 4 letter code of park.

Date: month, day and year sampling occurred.

Site Name: name of prairie (see Table 4).

Observers: first and last name of all crew members.

Location: [Dingmans Ferry site ONLY] number assigned to the Location within the site.

Transect Number: number assigned to that transect within the site. Transects are numbered sequentially from the origin to the terminus of the baseline.

Transect Position: position of the transect along the baseline, in meters from the baseline origin.

Distance from Baseline to Transect Start: for DEWA prairies, this value is zero.

Transect Azimuth: A compass bearing, taken from woodland edge looking toward the river. This azimuth is 90 degrees different from the baseline azimuth.

Transect Length: Length in meters of transect. See criteria above to determine the transect start and end.

SOP #4
Plot Location and Data Collection
Version 1.0 (October 2017)

Overview

This SOP describes methods for plot sampling during rare riparian monitoring in DEWA, NERI, and GARI to quantify the site substrate and the plant species composition of the community. The locations of the plots along the transects are determined during the first sampling visit to a site. During subsequent sampling visits, plots are relocated using the monumented baseline transect and monitoring transects.

Plot Location

During the first visit to a site, refer to Table 3 to determine how many plots should be established on each transect, depending on the length of each transect. Divide total length of a transect into the same number of equal length sections as number of required plots. One plot is placed in each section, with Plot #1 in the upper section closest to the woods and the highest numbered plot closest to the river. At the Dingmans Ferry site, three plots were established along each transect regardless of transect length. The length of each transect was divided by 3, creating three sections of equal length: upper (#1, closest to the woods), middle (#2), and lower (#3, closest to the water).

Table 3. Number of plots required for different transect lengths.

Transect Length	Number of Plots
5 – 9 m	1
10 – 14 m	2
15 – 19 m	3
20 – 24 m	4
25 m +	5

Use a random number generator to determine the location of each plot within each section. In NERI and GARI, potential plot positions occur every 1 meter along the transect, beginning at the transect start (e.g. 0m). The randomly generated number is the plot position, in meters, as measured from the upper end of the transect section. In DEWA, potential plot positions occur every 0.5 meters along the transect (e.g., 0 meters, 0.5 meters, 1 meters, 1.5 meters, and so forth). The randomly generated number is divided by two (so that half-meters are possible) to generate the plot position, in meters, as measured from the upper end of the transect section. However, for all parks, plot position is recorded as total distance from the transect start, not the distance within a section.

In NERI and GARI, the crew member sampling the plots should walk on the upstream side of the transect tape to avoid trampling the vegetation in the plots. At the specified plot position in each transect section, place the plot on the downstream side of the transect, with the up-slope edge of the plot aligned on the randomly selected plot position point. For example, if the plot position is “3”, place the quadrat on the downstream side of the tape extending from 3 – 4 m along the tape. Align the outer edge of the quadrat with the outer edge of the transect tape. The plot is a 1-m x 1-m square quadrat constructed from PVC pipe. Along each side, 10-cm length

sections are marked with purple PVC primer, creating visual guides that represent 1% of the plot area and assist with percent cover estimation.

In DEWA, the crew member sampling the plots should walk on the downstream side of the transect tape to avoid trampling the vegetation in the plots. At the specified plot position in each transect section, place the plot on the upstream side of the transect, with the up-slope edge of the plot aligned on the randomly selected plot position point. Align the outer edge of the short side of the quadrat with the outer edge of the transect tape. Place the plot as close to perpendicular with the transect as possible. The plot is 1-m² and measures 2 meters by 0.5 meter. In 1998, four narrow (1.25 cm in diameter) wooden poles were used to demarcate the four sides of the plot. In 2010, 1.25 cm PVC pipe with elbow joints was used to construct the plot. Along each side, 10-cm length sections are marked with purple PVC primer, creating visual guides that represent 1% of the plot area and assist with percent cover estimation.

Site Revisits

Along the transect, locate the plot position from the previous visit. Crew members should walk only on the correct side of the transect tape to avoid trampling vegetation (i.e., upstream side for NERI and GARI; downstream side for DEWA). If the current transect is shorter than the previous transect length, and the previous plot position for the last plot exceeds the current transect length, then place the last plot as close to the current water level as possible, such that:

- a) the majority of the plot does not contain river water, and either
- b) the plot is located at a whole meter distance along the transect in NERI and GARI, or
- c) the plot is located at a whole or 0.5 meter distance along the transect in DEWA.

Sampling cannot occur at high water levels. If the lower third of the transect's previous length is covered by water, postpone sampling until water levels drop.

Record the plot position on the Plot datasheet. If a new plot position was necessary, record a "Y" in the "New" column, otherwise, record "N".

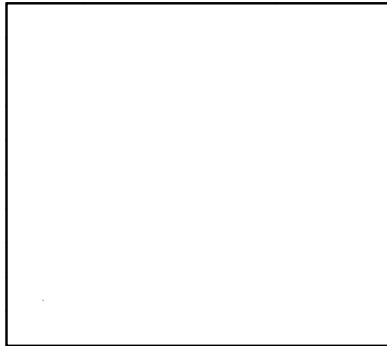
Percent Cover Categories

Within a plot, percent cover will be recorded using the following cover class categories:

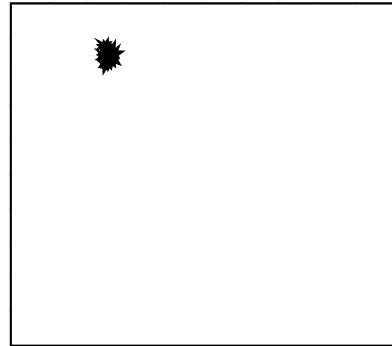
Percent Cover Range	Cover Class	Class Midpoint
Absent	0	0
0–1%	1	0.5
1–2%	2	1.5
2–5%	3	3.5
5–10%	4	7.5
10–25%	5	17.5
25–50%	6	37.5
50–75%	7	62.5
75–95%	8	85.0
95–100%	9	97.5

(from Peet et al. 1998)

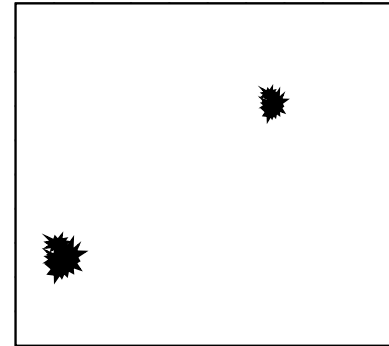
Graphic representations of these cover classes and their midpoints are provided on the following page. Imagine the percent cover of each plant as its shadow on the ground if the sun were directly overhead. Moss or vines growing on a vertical surface (trunk or rock) have little percent cover.



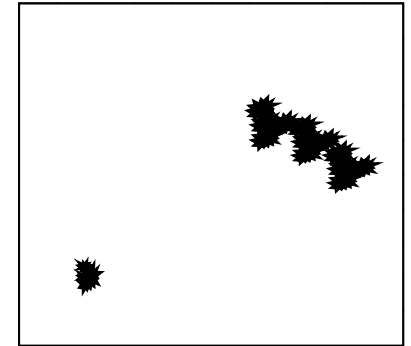
Class 0: Absent



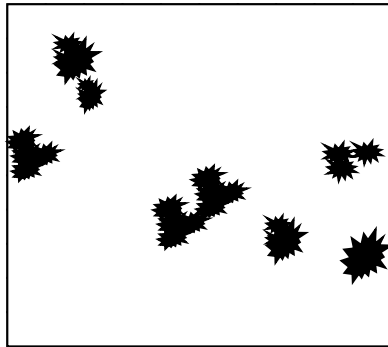
Class 1: 0 – 1 %



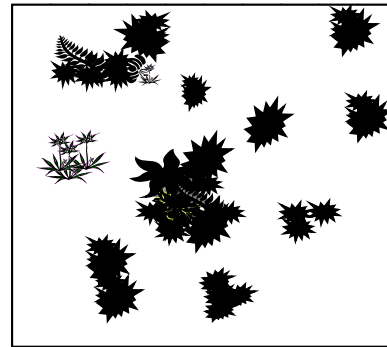
Class 2: 1 – 2 %



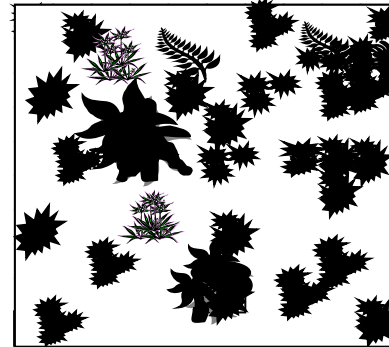
Class 3: 2 – 5 %



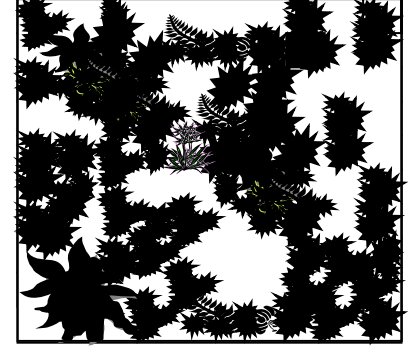
Class 4: 5 – 10 %



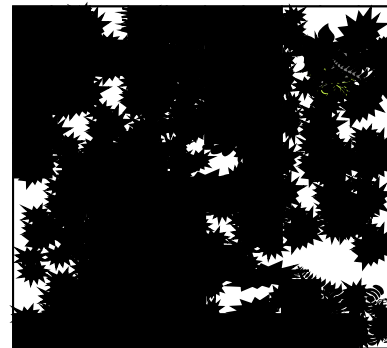
Class 5: 10 – 25 %



Class 6: 25 – 50 %



Class 7: 50 – 75 %



Class 8: 75 – 95 %



Class 9: 95 – 100 %

(modified from Peet et al. 1998)

Use the 10×10-cm purple and white square sections painted on the quadrat poles to help determine percent cover. Each purple or white square illustrates 1% of the quadrat.

Notice the exact breakpoints (e.g., 25%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake. The most suitable class should be assessed and recorded as rapidly as possible while maintaining accuracy.

Data Collection

Record the following fields on the Plot datasheet:

Plot Position: position of the plot along the transect. This number is the distance in meters to the plot as measured from the transect start. Use the plot position specified during previous visit unless the water level prohibits it.

New (revisits only): N for plots in the same position as last visit. Y for plots in a different position compared with last visit.

Substrate: Estimate the cover of each of the following categories using the cover classes described above. Cover is counted for the top layer (upper-most) substrate only. For example, water flowing over sand counts only as water, not sand. Likewise, the portion of boulders covered by moss counts only as moss, not boulders. The sum of the percent cover values for all the categories should add up to approximately 100%. Lichen cover is not recorded since it is difficult to reliably assess lichen cover on the silt-covered rocks.

boulders (> 30.5 cm)	moss	wood
cobbles (7.6 – 30.49 cm)	litter	trash (not windblown)
gravel (4.8mm – 7.59cm)	trunk	
sand or soil (0.07 – 4.79mm)	water	

Hydrology: Use the following codes:

1 – seep: water or damp areas in rivulets, cracks or drainages down the slope of the shoreline, typically originating from the edge of the wooded slope or cracks in the bedrock. Dampness from rain does not count as a seep.

2 – dry: no current evidence of water seeping from or over the ground.

3 – shoreline: plots that contain water from the current level of the River, including any Plot #3 that had to be moved to due higher current water levels.

4 – seep, now dry: obvious evidence that seeps occurred in the plot earlier in the year.

Drainage patterns from rainfall do not count as seeps.

5 – combination of seep and dry within the plot

6 – combination of dry and shoreline within the plot

Purple Loosestrife: If purple loosestrife (*Lythrum salicaria*) occurs in the plot, two additional values are recorded.

Number of Stems: Record the number of stems of purple loosestrife contained within the plot. Number of stems is a unit of identification that is clearly defined, easy to identify,

and is a reproducible measure between individual surveyors and different years of sampling. It also does not require a distinction between ramets and genets.

Average Percent Foliar Damage: Consider all purple loosestrife leaves that are overhanging or within the plot. Estimate the average percent defoliation or visible damage among all the leaves. Use the following percent categories: 0-1; 1-5; 5-25; 25-50; 50-75; and 75-100%.

Species: Identify each plant within the plot to the most specific taxonomy possible. All vascular plant species that have any living part overhanging or rooted within the plot, within 2 meters of the ground, should be recorded.

Plant taxa identified as part of the Riparian Prairie Monitoring Protocol follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads et al. 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Riparian Prairie Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoads et al. (2000) as necessary. Refer to the Master Plant List for proper nomenclature.

If a plant cannot be identified to species quickly and confidently, assign the species a specimen number, and record genus or family, if possible. If family identification is not possible, record one of the following categories of unknowns: dicot, monocot, grass, or sedge, and include a short description of key characteristics. Follow these guidelines below to determine whether and how to collect a specimen for subsequent identification:

- Do not collect any plants represented by 5 or fewer individuals (i.e., locally sparse) in the general vicinity of the plot. If an unknown plant is not locally sparse, it can be collected from the site, outside the plots.
- Remove as little as possible from the plant to obtain characteristics necessary for identification. Do not remove entire plants (including roots) from within plots. If the plant occupies greater than 2 % cover and is sufficiently robust, a portion of the plant may be removed from within the plot such that the overall cover of the plant within the quadrat is not significantly affected.
- Anytime it is not possible to collect a specimen, collect a photograph. Place a ruler in the photograph for scale, and allow the camera to automatically select the appropriate aperture for the given light conditions. Use the Macro setting or Super Macro setting to take detailed close up photographs of smaller plants.

Plant material and photographs of plants collected for identification purposes are not retained for future reference since they were not collected in a manner to serve as herbarium voucher specimens or photovouchers.

Confidence: Record your level of confidence in the species identification for each plant. Your confidence in the identification is independent of the level of taxonomic specificity. You could be very confident in a plant identified only to family, (e.g. Species = Orchidacea; Confidence = 1) because you are sure that it is in that family, but have no idea which genus it is. Similarly, you could be not very confident in a genus- or species-level identification (e.g. Species = Dryopteris sp.; Confidence = 3) for obscure, small, or un-collectable individuals. Use the following codes:

- 1 = confident
- 2 = somewhat confident
- 3 = not very confident

Percent Cover: After identifying all species within the plot, estimate the percent cover of each species using the cover categories described above. Consider all living plant parts overhanging or rooted within the plot, within 2 meters of the ground. The purple and white squares painted on the quadrat poles each represent 1%. These should be used to help visualize the percent cover of species. Total percent vegetation cover greater than 100% is possible due to the structural complexity of the vegetation. Total percent cover less than 100% is also possible in sparse vegetation.

Notes: Record if the species was collected, identifying characteristics of unknowns, or other notable information about the plant.

References Cited

- Peet, R.K., T.R. Wentworth, and P.S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. *Castanea*. 63(2): 262-274.
- Rhoads, A. F., T. A. Block, and A. Aniško. 2000. The plants of Pennsylvania: An illustrated manual. Philadelphia: University of Pennsylvania Press.
- United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS). 2007. The PLANTS Database (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge, LA 70874-4490.
- Weakley, A. 2015. Flora of the Southern and Mid-Atlantic States. North Carolina Botanical Garden, University of North Carolina at Chapel Hill.

Revision History

Revisions pertaining to data collected at the Dingmans Ferry site in DEWA in 1998 and 2010, before Version 1.0 of this SOP was published

Remove Canopy Cover estimates

In 2011, the estimation of Canopy Cover for each plot was removed from the protocol based on the difficulties in accurately estimating hanging canopy cover. In addition, the line intercept sampling provides a much more accurate and repeatable measure of woody plant cover.

Removed: “**Canopy Cover:** Estimate to the nearest percent the percent cover of canopy over the plot. Canopy cover includes any woody species greater than 2 meters in height that is overhanging the edges of the plot.”

Standardize Percent Cover Categories

In 1998 and 2010, the percent cover of each plant species substrate category was recorded to the nearest 1%. If a species covered significantly less than 1%, but was present in the plot, “P” was

recorded in 1998 for these “present” or “trace” species. In 2010, trace species were assigned 0.5% cover, and all 1998 data recorded as “P” were updated to 0.5%.

In 2017, the 1998 and 2010 data from the Dingmans Ferry site were updated to the standard cover classes used in the West Virginia rare riparian prairies and throughout the ERMN Vegetation Monitoring program. For all data collected after 2017, the standard percent cover categories will be used for all ERMN rare riparian monitoring. The standard cover class categories are more repeatable and accurate than cover estimates to the nearest 1%.

Standardize Substrate Characterization

In 1998 and 2010, the substrate within each plot at the Dingmans Ferry site was characterized to the 1% cover using the categories in the right hand column below. In order to standardize these data with the other sites in the ERMN rare riparian monitoring, the 1998 and 2010 data were updated to use the categories listed in the left hand column below. The percent cover estimates were also updated to use the standard cover class categories discussed above. Also note that lichen cover is not recorded since it is difficult to reliably assess lichen cover on the silt-covered rocks.

Categories after 2017	Categories in 1998 and 2010
boulders (> 30.5 cm)	bare rock
cobbles (7.6 – 30.49 cm)	
gravel (4.8mm – 7.59cm)	
sand or soil (0.07 – 4.79mm)	bare soil
moss	moss
litter	litter
trunk	<not assessed>
wood	<not assessed>
trash	garbage
water	water

SOP #5
Line Intercept Sampling
Version 1.0 (October 2017)

Overview

This SOP describes methods for line intercept sampling to quantify cover of woody species at the site during rare riparian monitoring at all sites in DEWA, NERI, and GARI.

Line Intercept Sampling

The line intercept measurements are taken along the same transects used for the plot sampling. Measure the start and end points of cover by woody species over 1.0 meter tall on the transect line. Use a quadrat pole held vertically to determine height as measured directly over (or under) the transect tape. If a branch that crosses the transect is less than 1.0 meter off the ground, don't include that branch as part of the line intercept data. Do not record dead trees or shrubs or dead branches of live woody plants. Do not stand leaning or bent shrubs/trees up to measure them.

Data Collection

Record the following fields on the Line Intercept datasheet:

Park: 4 letter code of park.

Date: month, day and year sampling occurred.

Site Name: name of prairie (see Table 1 in Baseline and Transect Establishment for NERI and GARI, and Table 4 in Baseline and Transect Relocation for DEWA).

Observers: first and last name of all crew members.

Number of Transects on Site: number of transects sampled at the site.

Transect: number assigned to that transect within the site. Transects are numbered sequentially from the origin to the terminus of the baseline. At Dingmans Ferry, record the Location number and the Transect number (e.g., 0-1, or 3-4).

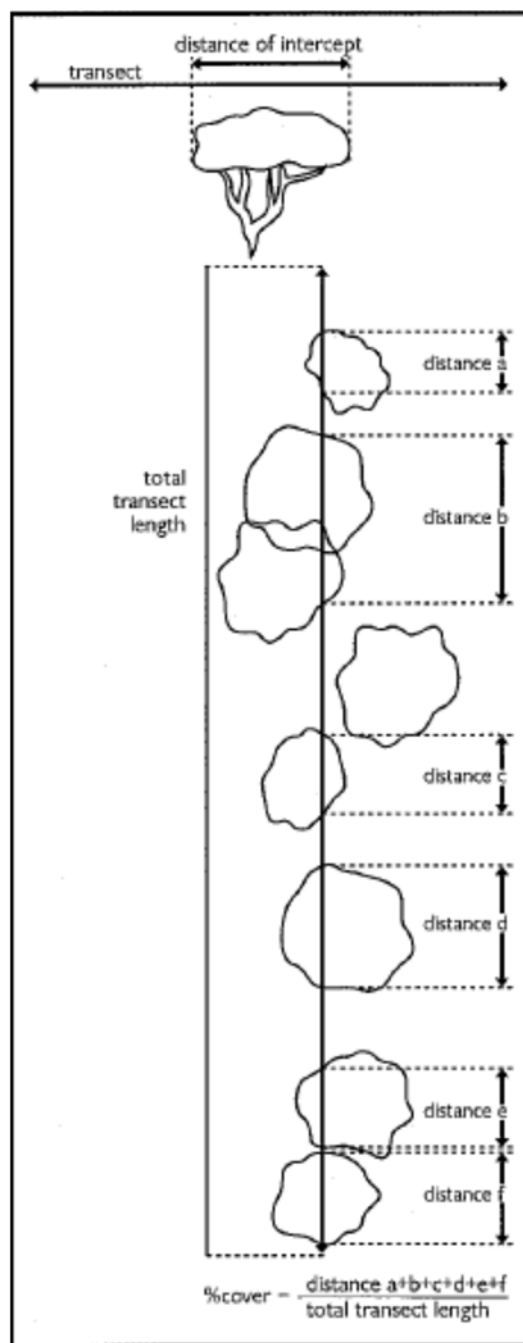


Figure 2. Line intercept method of measuring cover (from Elzinga et al. 2001)

Species: Record the scientific name of the tree or shrub crossing the transect to the most specific taxonomy possible. Plant taxa identified as part of the Rare Riparian Prairie Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Rare Riparian Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades et al. (2000) as necessary. Refer to the Master Plant List for proper nomenclature.

Confidence: Record your level of confidence in the species identification for each plant. Your confidence in the identification is independent of the level of taxonomic specificity. You could be very confident in a plant identified only to family, (e.g. Species = Orchidacea; Confidence = 1) because you are sure that it is in that family, but have no idea which genus it is. Similarly, you could be not very confident in a genus- or species-level identification (e.g. Species = Dryopteris sp.; Confidence = 3) for obscure, small, or un-collectable individuals. Use the following codes:

- 1 = confident
- 2 = somewhat confident
- 3 = not very confident

Start: Record the distance measurement to the 0.1 m on the tape where the tree or shrub branches taller than 1.0 m begin (see Figure 2 for examples).

End: Record the distance measurement to the 0.1 m on the tape where the tree or shrub branches taller than 1.0 m end (see Figure 2 for examples).

If there is a gap of >0.5 m in a single tree's canopy, record two start and end points to exclude the gap.

If branches from two different species are overlapping and both meet the height requirements, do one of the following:

- split the difference within the overlap and record each species as a separate record, if the species overlap for a small portion of their total length, OR,
- consider the relative dominance of both species along the length that they overlap. For example, species A and species B overlap along 1 m of the transect. Species A covers the entire 1 m contiguously and species B is only interspersed, occupying about 20% of the 1 m length. Record the relative proportion of the length that each species occupies (i.e., species A covers 90 cm and species B covers 10 cm).

DO NOT record the same distance along a transect twice for two separate species. Every segment of the transect can only be recorded once.

SOP #6
Photographs
Version 1.0 (October 2017)

Overview

This SOP provides instructions for photographing the site from the ends and the intermediate stakes along the baseline. Photos are taken at each visit to each site. Always bring a **copy** of the photos from the previous visit into the field to facilitate replication of earlier photographs.

Data Collection

Photos are taken in relation to marked points along the baseline transect, such as the origin, terminus, and all intermediate stakes. At a marked point along the baseline, walk directly towards the river to the approximate the middle of the prairie community (half-way between the forest and the river). If the marked point was the origin or terminus, take one photograph looking towards the prairie. If the marked point was an intermediate stake, take one photograph looking upstream, and one photograph looking downstream.

Photograph plot as early in the sampling visit as possible in order to minimize visual impacts of trampling.

Compose the photograph so that the scope of the image matches the photo from the last visit as closely as possible.

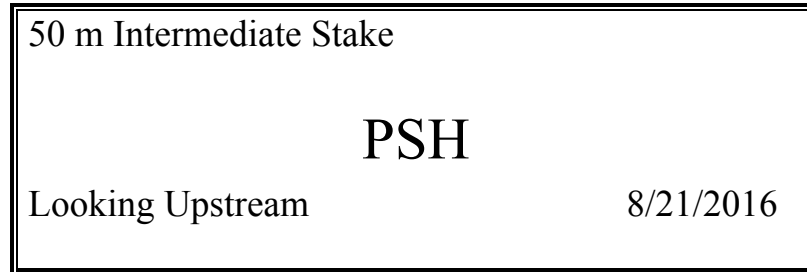
Never prune vegetation from a photograph. If thick vegetation obscures most of the plot, take the photo anyway.

Always hold the labeled photo-card in the lower left corner of the area to be photographed (photo-card labeling instructions provided below). Photos are more useful if they show primarily the vegetation, and space taken up by the photo-card is minimized.

The photo-card should be labeled consistently, according to the following depiction:

Location	
Site	
Up- or Down-stream	Date

For example:



Revision History

Photo protocol will be fully implemented in the 2017 field season. It was partially implemented in 2016. No standardized photos were taken before then.

SOP #7
Site-wide Invasive Exotic Plant Assessment
Version 1.0 (October 2017)

Overview

This SOP describes methods for a site-wide assessment of invasive exotic plants in all rare riparian prairie sites monitored in DEWA, NERI, and GARI. Data collected from this protocol will be used by the park Natural Resource staff for exotic plant eradication and control purposes, not for long-term monitoring.

Assessment

After plot sampling is completed at a site, crew members should walk through the entire site looking for invasive exotic plant species. Focus on the target species listed on the exotics datasheet, however, other species known to be invasive can be recorded as well if they are present. Invasive exotic species observed during baseline establishment, plot sampling or line intercept sampling should be recorded. Only plants that occur in the open prairie should be recorded. Plants that occur under the canopy of the forest (often along the baseline) should not be included. Use the same guidelines that apply to determining the transect start (see Baseline and Transect Establishment for NERI and GARI, and Baseline and Transect Relocation for DEWA for guidelines) to determine whether the plant is in the open prairie or in the forest.

Data Collection

Record the following fields on the Exotics datasheet:

Park: 4 letter code of park.

Date: month, day and year sampling occurred.

Observers: first and last name of all crew members.

Site Name: name of prairie (see Baseline and Transect Establishment for NERI and GARI, and Baseline and Transect Relocation for DEWA).

Scientific Name: For observed invasive exotic plant species not already listed on the datasheet, record the scientific name. If you are unsure whether the species is an invasive exotic, record it. Plant taxa identified as part of the Rare Riparian Prairie Monitoring Protocol follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Rare Riparian Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades et al. (2000) as necessary. Refer to the Master Plant List for proper nomenclature.

Cover: After the entire site has been assessed, record a cover that best estimates the cover of each species across the entire site using the following cover classes:

Percent Cover Range	Cover Class	Class Midpoint
Absent	0	0
0–1%	1	0.5
1–2%	2	1.5
2–5%	3	3.5
5–10%	4	7.5
10–25%	5	17.5
25–50%	6	37.5
50–75%	7	62.5
75–95%	8	85.0
95–100%	9	97.5

(from Peet et al. 1998)