



Population Monitoring Protocol for Lemhi Penstemon (*Penstemon lemhiensis*) and Spotted Knapweed (*Centaurea stoebe*) in Big Hole National Battlefield

Version 1.0

Standard Operating Procedures



Upper Columbia Basin Network

May 2018

Please cite this document as: UCBN-NPS. 2018. Population Monitoring Protocol for Lemhi Penstemon (*Penstemon lemhiensis*) and Spotted Knapweed (*Centaurea stoebe*) in Big Hole National Battlefield. Version 1.0. Standard operating procedures (SOPs). Upper Columbia Basin Network, National Park Service, Moscow, ID.

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Standard Operating Procedure 1: Preparation for the Field Season and Field Season Closeout

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

This SOP describes the step-by-step procedures for preparing for field work and for constructing, preparing, and organizing field equipment prior to the initiation of personnel training and entry into the field. Adequate preparation for the field and of equipment is crucial to a successful monitoring program.

Annual Review

Review protocol and the notes from previous field season in preparation for the current field season. Complete a safety review to address any outstanding safety concerns. Send a management actions query to BIHO staff to document influential activities such as herbicide applications and prescribed fire conducted within sampling frames in the project database.

Planning Fieldwork Schedule

Schedule fieldwork well in advance to secure the necessary staff to complete sampling in a timely and efficient manner. The project lead will coordinate this planning with BIHO park resource and interpretive staff. Network staff and park staff will be available for the sampling effort. A minimum of six people, organized into three teams, are necessary to efficiently complete sampling on the hill slopes within a one-week period.

Arranging Overnight Facilities and Research Permits

Make arrangements for lodging at BIHO as early as possible prior to the field season. Field crew members have typically stayed in park housing at BIHO and it is imperative to secure a reservation in advance. However, a good USFS campsite is available several miles west of the park on Hwy 43 at May Creek, and some limited lodging options are also available in Wisdom. Check to make sure research permits are up to date, and inform the park point-of-contact (usually a resource chief or surrogate) of the plans for the year's field plan by March. Consult the park contact at this time about any potential impediments to plans due to trail, road, or campsite closures, or other planned inconveniences. 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. Because of the active involvement of BIHO staff in this project, research permits may not be necessary.

Sampling Locations

Extensive Sample

Generating Spatially-balanced Sample Locations in R and ArcGIS using GRTS:

In order to generate a Generalized Random Tessellation Stratified (GRTS) sample, ArcView or ArcGIS must be installed and running, as well as R statistical software (R development Core Team 2013). Download and install the *spsurvey* package (Kincaid and Olsen 2012) from the R repository (<https://cran.r-project.org/web/packages/spsurvey/index.html>). The *Tinn-R* text editor available from this same website, or R Studio can be used for manipulating the R scripts, or the script feature available in R can be used (File > New script).

Select new extensive sample plot locations prior to each survey event by using the GRTS spatially-balanced sampling method. The penstemon sampling frame GIS polygon shapefile is required input.

The output is a point shapefile with an ordered list of plot location UTM coordinates that, if the order is maintained, results in a spatially-balanced sample with efficient statistical properties. Load the UTM coordinates, as waypoints, into the GPS units prior to the start of fieldwork as described in SOP 3. Waypoints are the X and Y coordinates (in Universal Transverse Mercator [UTM] coordinate system) for each sample location along with a unique point identifier.

1. Begin by organizing a working directory (e.g., C:\GRTS\temp), and placing the park sample frame polygon shapefile (all associated files including .shp, .dbf, and .prj extensions) in the appropriate subfolder. The sample frame shapefile should be accurate and projected in UTM NAD 83. The sampling frame shapefile is stored on the UCBN's network attached storage (NAS) server located at UCBN headquarters and on the BIHO and NEPE servers in the following penstemon project directory:
Penstemon\3_Implement\GIS_Data_Working\Features\BIHO_PENLEM_ExtensiveSampleFrame_Version1.0.
2. In the RGui screen, change the working directory to C:\GRTS\temp (or an appropriate alternative). Open an existing GRTS script in R. If no GRTS script is available, the example in step 4 below can be copied and saved into the text editor and edited as necessary. Examples are also available from the EPA EMAP website and in the *spsurvey* reference manual.
3. In RGui, load the *spsurvey* package (Packages > Load Package).
4. R code example for drawing a GRTS sample. This sample can be copied and saved directly into the R script text editor, modified as necessary, and executed by highlighting desired sections of code, and keying "ctrl-shift" and then "r" on the computer keyboard.

```
*****
# File: UCBNpenstemon_Rcode_GRTS_stratified_BIHO_20140528.txt
# Purpose: Example area stratified GRTS survey
# designs for BIHO extensive (population inference) penstemon and knapweed
# monitoring plots
# Two strata - allocation unequal, weights must be archived and adjusted if
# necessary before estimating status
# Contact: Tom Rodhouse, UCBN Ecologist, Tom_Rodhouse@nps.gov
# Date: May 28, 2014

# Load the spsurvey library

library(spsurvey)

#Input Files
#BIHO_PENLEM_ExtensiveSampleFrame_Version1.0.dbf

# Read the attribute table from the shapefile

att <- read.dbf("BIHO_PENLEM_ExtensiveSampleFrame_Version1.0")

#Create the stratum names
att$stratum <- as.factor(att$Stratum)
```

```

att$stratum
[1] Howitzer Horse
Levels: Horse Howitzer

head(att)

Id      Area Hectares Stratum area_mdm stratum
1  0  62990.28  6.299028 Howitzer  62990.28 Howitzer
2  0 265701.34 26.570134   Horse 265701.34   Horse

# Stratified GRTS survey design with an oversample
#Total sample size 300, 100 in Howitzer and 200 in Horse Pasture, each with
their own oversample
#Note drops and replacements are rare but adjust oversample higher if needed

# Create the design list
Stratdsgn <- list("Horse"=list(panel=c(Panel=200), seltype="Equal",over=10),
                  "Howitzer"=list(panel=c(Panel=100), seltype="Equal",over=10))

# Create the GRTS survey design
#Note that very few oversamples are required.
set.seed(8675309) #Set random seed so that this same draw can be recovered,
#if necessary

Stratsites <- grts(design=Stratdsgn,
                   DesignID="PENLEM",
                   type.frame="area",
                   src.frame="shapefile",
                   in.shape="BIHO_PENLEM_ExtensiveSampleFrame_Version1.0",
                   att.frame=att,
                   stratum="stratum",
                   prjfilename="BIHO_PENLEM_ExtensiveSampleFrame_Version1.0",
                   out.shape="BIHO_PENLEM_2014_GRTS_ExtensivePlots")

print(dsgnsum(Stratsites)) #Take a look and make sure this is right
*****
#End Script
*****

```

.....

5. In ArcGIS (or ArcView), add the output file (e.g., BIHO_PENLEM_2014_GRTS_ExtensivePlots.shp) to an open, park map project to display the sample locations. View the associated .dbf table to ensure everything worked as expected. Double check weight calculations (sampling location selection probabilities) by dividing sampling frame or stratum area by the number of sample size (excluding oversamples). Note that UTM coordinates are already included in the dbf. Note that these weights will need to be updated at the end of each sampling session once the total number of sampled quadrats has been determined (i.e., after dropping and adding new locations). For this project, few replacements are required, however, and so initial weights may not change.

Note: In order to maintain the desirable properties of the GRTS sample (e.g., spatial balance), sites must be included in the sample in the same order as is presented in the .dbf list. The points are also

given a site ID as a feature of the `grts()` function in R, and the ID order should be followed. For example, if 10 sites are needed for a sample, but the 2nd and 3rd sites are inaccessible, then sites 1, 4-12 should be used (Figure SOP1-1). If additional sites are needed in the future, then site 13 should be the first choice, followed by 14, 15, and so on.

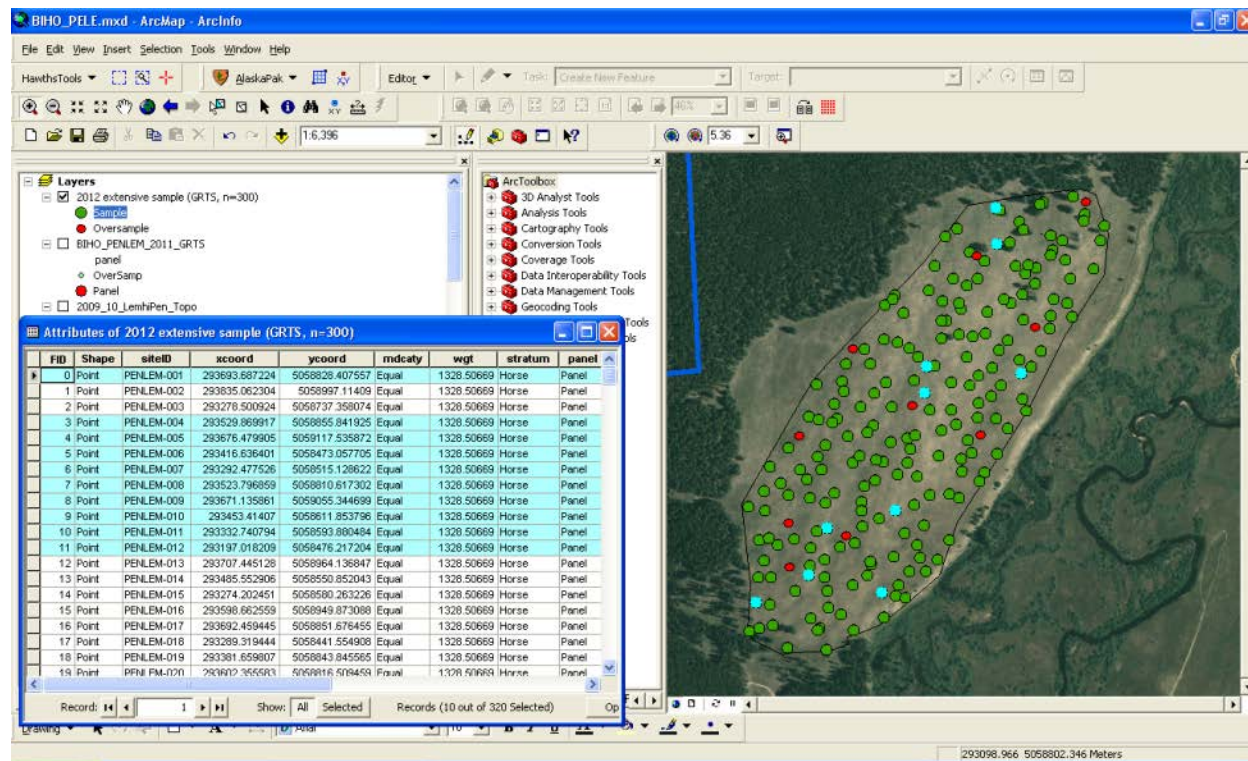


Figure SOP1-1. An ArcGIS screenshot illustrating the BIHO_PENLEM_2012_GRTS shapefile with sites 1 and 4-12 selected in the Horse Pasture stratum.

- 1) Export the output table (e.g., BIHO_PENLEM_2014_GRTS_ExtensivePlots.dbf) and update the Lemhi penstemon monitoring project Access database.
- 2) Import the master sampling location list, as a text file (e.g., BIHO_PENLEM_2014_GRTS_ExtensivePlots.txt), to GPS waypoints following procedures outlined in SOP 3, Finding GPS Waypoints.
- 3) Finally, create maps in ArcGIS (e.g., Figure SOP1-2) illustrating the point locations labeled with the plot ID. Note that this ID is temporary and used only for the duration of the survey event as a convenient reference. A permanent globally-unique identifier is produced for each record uploaded to the project Access database. Zoom in to make strata-specific maps, or in the case of the Horse Pasture, which is too big to view on one map, two maps that each show one half of the strata. This will enable the labels to be legible for easy reference in the field. Print these maps on Rite-in-the-Rain paper.

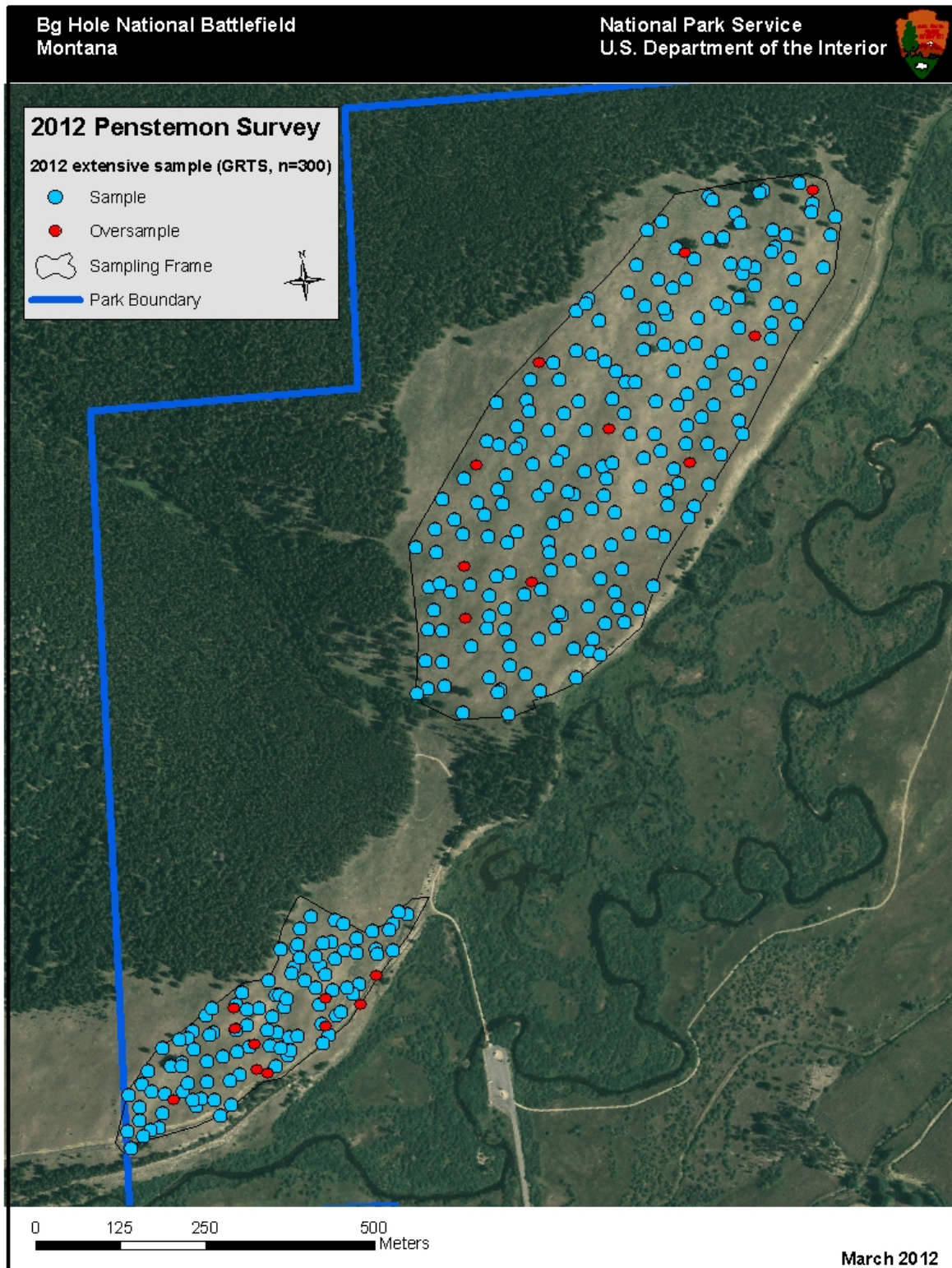


Figure SOP1-2. A map illustrating 2012 extensive plot origin locations, drawn from the GRTS algorithm.

Intensive sample

Review the list of permanent plot locations

Table SOP1-1 contains the UTM X and Y coordinates for the 42 permanent intensive plots that were established in 2012. Figure SOP1-3 illustrates where these plots are located. Prior to each field season, review the list of plots and their locations, and upload a text file of these locations as waypoints to the GPS units. The shapefile of permanent plot coordinates is located in the following penstemon project directory folder:

Penstemon\3_Implement\GIS_Data_Working\Features\Plot_Locations and in Table SOP1-1. Issues such as plot wear-out from trampling or loss of marking rebar for instance should be provided in close-out notes and annual reports and addressed prior to the following sampling year.

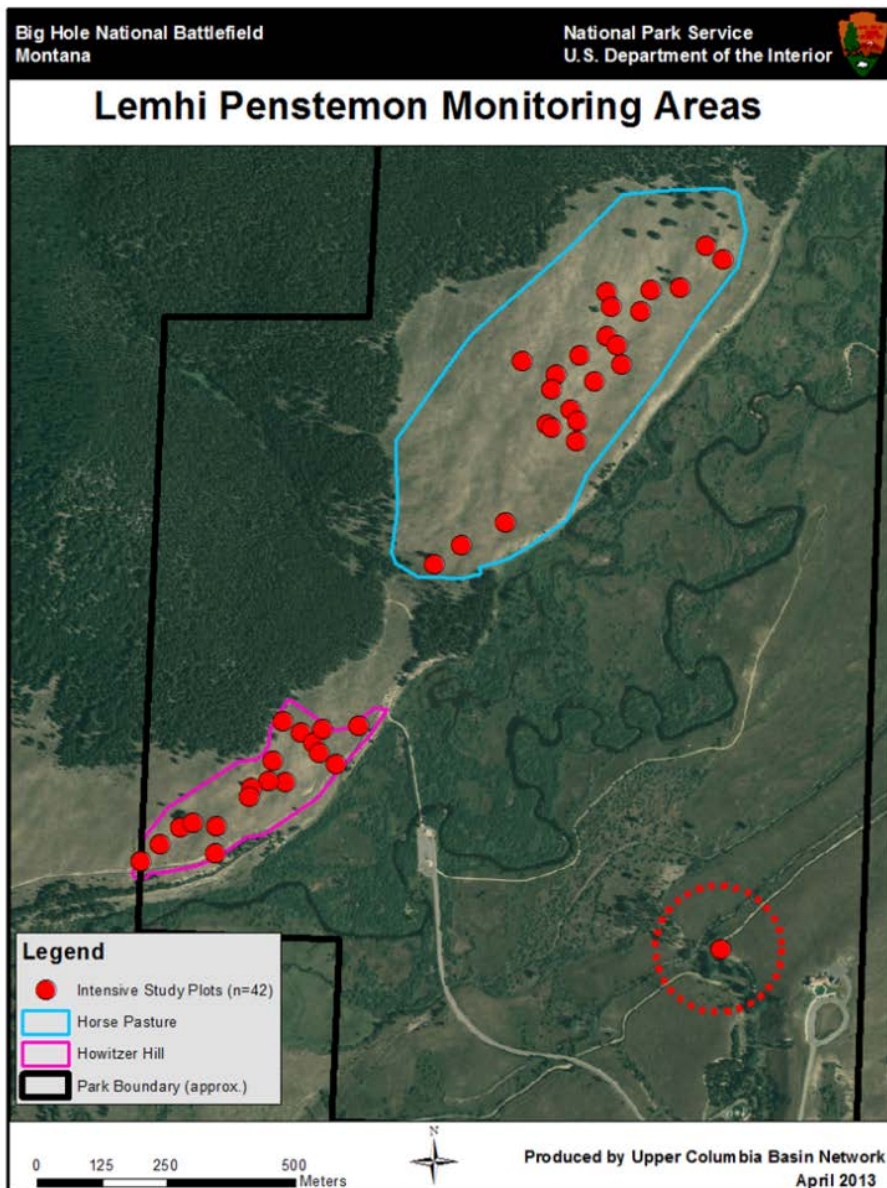


Figure SOP1-3. Location of intensive plots (n=42) in BIHO.

Scheduling and Organizing Fieldwork

Schedule surveys to occur during peak flowering during the last week of June. Annual variations in weather and temperature may result in delayed flowering and should be considered in scheduling. Begin scheduling of fieldwork as early as possible to avoid conflicting sampling periods for observers. The network project lead has the primary responsibility for ensuring that all hiring, schedules, and logistical details are addressed. Close coordination with park resource staff is essential. Hiring tasks are minimal because staffing of the penstemon survey crew usually draws from available UCBN, NEPE, and BIHO staff who are typically working in BIHO during the same week to survey camas lily.

Sampling plans must include a sufficiently flexible window of time to accommodate inclement weather, snowmelt, and other complications such as trail maintenance. Approximately one week should be allocated to complete sampling within the Battlefield. This schedule allows for excess travel time and should adequately account for other workflow challenges such as limited personnel, weather, or road and trail closures.

Equipment Preparation

Each independent field team requires a full set of survey equipment specific to the plot type being surveyed (i.e., spatially extensive or intensive plots). Make an inventory of existing equipment, needed repairs identified, and construction or purchases of additional equipment well in advance of the approaching field season. Note that some safety equipment, including the SPOT or InReach satellite beacons, can be shared among the entire team and typically only one of these units is carried out into the field.

Spatially-Extensive Plot Survey Equipment

- One 50-m reel tape.
- Chaining pins for temporarily anchoring ends of reel tape (2).
- 2-m long PVC pipe sampling guide.
- Compass (declination properly adjusted to 13°) with inclinometer.
- Pin flags (optional).
- Plant ID references (e.g., examples of Lemhi penstemon, look-alikes, invasive species).

Intensive Plot Survey Equipment

- 1 m² PVC pipe sampling quadrat and point intercept frame for intensive plots.
- Metal rod for point intercept measurements.
- Plant tags (aluminum 1.5" pre-numbered 1-999) and steel pins.
- Plant reference sheet with tag numbers, sub-plot quadrant location, and previous year's status (alive/dead, rosette and inflorescence counts).

- Plant ID references (e.g., examples of Lemhi penstemon, look-alikes, invasive species).

Navigation and Recording Equipment

- Weatherized data entry PDA or tablet PC with supporting data entry software (e.g., Microsoft Access, DataPlus, Pendragon).
- GPS, preloaded with sample location waypoints.
- Digital camera.
- Spare batteries for GPS, PDA, and camera.
- Field reference maps identifying sampling locations (weatherized Rite-in-the-Rain paper).
- Clipboard with mechanical pencils and extra lead.

Safety and Communication

- First Aid kit.
- 2-way handheld radio.
- Cell phone (optional).
- Emergency contact information.
- SPOT or InReach Beacon.
- Field-relevant SOPs (SOP 1–5).

Miscellaneous Field Equipment (per observer)

- Daypack or bag.
- Rain gear.
- Sun protection.
- Insect protection.
- Drinking water and food.

Preparation of Navigation and Field Data Management Equipment

- 1) Upload the sampling point locations (for both temporary extensive and permanent intensive plots) to each GPS unit following procedures outlined in SOP 3. Check digital data entry tools (PDAs and Table PCs) and preload with software and files. At least one back-up GPS unit must also be available and also have all necessary files pre-loaded.
- 2) 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. Dead batteries in the field can lead to a major loss of time.

Post-Field Season Actions

After the field season be sure to clean and organize all non-electronic equipment and store in well labeled plastic bins in UCBN headquarters. Quadrat frames and PVC and intercept rods, and plant tags and pins are stored at BIHO. Some of this equipment will be used by other monitoring projects so it is essential that it is well organized, and checked over for damage. Remove batteries from GPS units and any other electronic tools requiring long-term winter storage. All equipment must be checked in with the Network staff person responsible for equipment inventories

Miscellaneous Preparatory Notes

- 1) Analysis and reporting of previous year's data is necessary before starting a new field effort. This is covered in SOP 6, data management, and SOP 7, data summary and analysis. Update SOPs as necessary following instructions in SOP 8.
- 2) In the event that a prescribed burn (or wildfire) event occurs at BIHO, compile information provided by park staff and/or Glacier Fire Management as in Appenddix E.
- 3) After each field season, slope and aspect values can be updated for extensive plots using the LinearExtract tool in SOP 6, providing a plot average that is better than relying on the field estimate made at the plot origin.
- 4) Crews must maintain a low impact when working in BIHO. Be respectful, pack out all trash, and minimize trampling. In particular, avoid trampling of penstemon plants. Slopes are steep and easily damaged by rough travel and sliding or skidding of boots. For this reason and for safety, walk slowly and carefully, following contours and side hill travel as much as possible. **The UCBN insists that their field crew members and partners maintain the NPS "leave no trace" ethic during all park visits.**
- 5) **NOTE: Clean boots, boot laces, gaters, trousers, and other equipment contaminated with cheatgrass and other weed seeds prior to entering the field!** Typically, crew members are coming directly from field work in other UCBN parks with extremely large infestations of weeds.
- 6) Safety is a vital, but easily overlooked consideration. Each year the project Job Hazard Analysis (JHA) must be reviewed and updated if necessary. A "GAR" (green, amber, red) risk analysis has been conducted by the UCBN and park staff involved in the development of the project (SOP 9), following recommendations provided during NPS Operational Leadership Training, and this GAR must also be reviewed annually. All crewmembers must review the JHA and GAR risk analysis prior to beginning fieldwork. The general safety plan (SOP 9) must be reviewed during training, and a tailgate safety meeting must be conducted with all involved field personnel and hosting BIHO staff (usually the superintendent and ranger) where specific park hazards, emergency contact information and park emergency procedures are reviewed. A brief review of the severity, probability, and exposure risks ("SPE" risk analysis) must also be conducted during the tailgate meeting. Park safety protocols must be reviewed and adhered to. Communications between teams will be facilitated with 2-way radios. Cell phones may be used in addition to two-way radios 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. Make sure each team member knows where vehicle keys are to be stored during field operations and emergency contact and operation procedures for the park.

Table SOP1-1. UTM coordinates for the 42 intensive permanent Lemhi penstemon and spotted knapweed monitoring plots.

Subpopulation	Permanent ID	UTMX	UTMY
Hill	1	292694	5057833
Hill	2	292731	5057865
Hill	3	292769	5057898
Hill	4	292794	5057907
Hill	5	292837	5057848
Hill	6	292841	5057900
Hill	7	292903	5057957
Hill	8	292908	5057976
Hill	9	292940	5057988
Hill	10	292950	5058028
Hill	11	292970	5058105
Hill	12	292973	5057985
Hill	13	293003	5058082
Hill	14	293027	5058062
Hill	15	293038	5058043
Hill	16	293045	5058088
Hill	17	293072	5058021
Hill	18	293116	5058095
Horse	19	293262	5058408
Horse	20	293315	5058445
Horse	21	293399	5058489
Horse	22	293432	5058801
Horse	23	293480	5058680
Horse	24	293489	5058747
Horse	25	293489	5058673
Horse	26	293499	5058775
Horse	27	293527	5058708
Horse	28	293538	5058646
Horse	29	293540	5058685
Horse	30	293544	5058814
Horse	31	293574	5058763
Horse	32	293598	5058850
Horse	33	293598	5058935
Horse	34	293606	5058907
Horse	35	293617	5058833
Horse	36	293625	5058795
Horse	37	293663	5058899
Horse	38	293682	5058940
Horse	39	293740	5058945
Horse	40	293789	5059025

Table SOP1-1 (continued). UTM coordinates for the 42 intensive permanent Lemhi penstemon and spotted knapweed monitoring plots.

Subpopulation	Permanent ID	UTMX	UTMY
Horse	41	293823	5058997
VC	42	293819	5057662

Literature Cited and Recommended References

- Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. US Department of Interior, Bureau of Land Management, Denver, Colorado.
- Kincaid, T. 2011. User guide for spsurvey, version 2.2 probability survey design and analysis functions. Version 2.2 May 6, 2011. Available at: http://www.epa.gov/nheerl/arm/documents/design_doc/UserGuide%20for%20spsurvey%202.0.pdf.
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Standard Operating Procedure 2: Training Field Personnel

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

This SOP describes the step-by-step procedures for training field personnel. By design, the technical expertise, knowledge, skills, and abilities required of field crew are relatively minimal for this protocol in order to ensure long-term sustainability. The SOP serves primarily as a reference for the UCBN and park project leads. Training of crew members is typically conducted in “real-time”, with less experienced members paired with more experienced members. However, in the event of rapid turnover in staff, a more formal training can be conducted following the procedures and recommendations in this SOP. Definitions for terms crewmembers are required to know are presented in Table 6. Use of the GPS to locate waypoints and navigate to field sites is discussed in SOP 3 and should also be reviewed and practiced before commencing fieldwork. Procedures for plot set-up and measurements are detailed in SOPs 4 and 5. Procedures for data management are in SOP 6. These SOPs should be used as training manuals and hard copies can be provided to each technician for reference during the survey event. Note that field SOPs are not meant to be stand-alone training manuals replacing the thorough documentation available for GPS and field botany techniques. Training personnel should refer to these SOPs as a guide and seek out additional information in the suggested reading and through hands-on training courses provided by NPS and outside sources. A list of technical references for plant identification, including regional floras, is provided at the end of this SOP. Up-to-date and certified park species lists are available through the NPS Integrated Resources Management Applications (IRMA) portal (<https://irma.nps.gov/App/Portal/Home>).

Roles and Responsibilities

The project lead is typically the lead trainer of the field crews; however the designated field lead will fulfil the role if the project lead is not present. The lead trainer will be well versed in the protocol and SOPs, and have considerable experience both conducting field work as well as training and directing technicians. The lead trainer will provide field technicians with a copy of the narrative and SOPs prior to technicians arriving on site for training. By the start of field training, technicians will be familiar with program objectives, ecological context, and field methods.

Training Location

Training will take place at BIHO so field technicians will become familiarized with the protocol as well as having ample time to be trained in identifying Lemhi penstemon, superficially similar “look-alikes”, and invasive plants, especially spotted knapweed. It is recommended that the group complete data collection as a group training exercise for one or more of the actual plots in that year’s panel to simultaneously deliver hands-on experience and to work through situations that arise while working an actual plot. Field crew members will receive training on all aspects of the field work. The roadcut at the base of the Howitzer Hill and the nearby plots is an excellent location for training. Lemhi penstemon and spotted knapweed are typically abundant along the road.

Training Outline

The following outline has been developed to guide training. This outline will be updated periodically as needed.

Goals

- Review plant identification terminology.
- Review use of available plant identification manuals, keys, and photos.
- Be able to identify Lemhi penstemon and spotted knapweed, even if the plants are not flowering. Identification of these plants in basal rosette stage, and in the case of Lemhi penstemon, identification of seedlings, is crucial.
- Be able to differentiate a seedling from an established Lemhi penstemon plant.
- Be able to determine the number of rosettes present on an individual Lemhi penstemon plant.
- Be able to determine the number of rosettes present with a flowering stem on an individual Lemhi penstemon plant.
- Acquire proficiency in identification of common native and invasive forbs, shrubs, and trees found in BIHO.
- Acquire confidence and consistency in conducting point intercept to estimate total ground cover.
- Acquire proficiency in use of GPS equipment and navigation to sampling points.
- Acquire proficiency in use of PDA and/or Tablet PCs and accompanying data entry software, including troubleshooting and procedures for backing up data.
- Understand, and acquire proficiency with, data entry form and field QA/QC checks
- Demonstrate competence in all field skills, including meticulous data entry, compass reading, and attention to detail in the field environment.
- Understand procedures for plot boundary decisions, sampling frame errors, and dropping and replacing plots, if necessary.
- Understand and demonstrate a sincere appreciation for, and commitment to follow, safety procedures, including regular communication with Park points of contact and Network headquarters. Operational leadership skills should be promoted.
- Understand and demonstrate a sincere appreciation for, and commitment to follow, procedures for the prevention of non-native species spread during field work.
- Demonstrate appreciation of overall program monitoring objectives.

Agenda

Training can begin with introductions and orientation, followed by an introduction to the project and group discussion of the protocol. Safety procedures, field work expectations and risks, and park

emergency protocols and contacts should be reviewed along with park expectations and any cultural concerns related to the Battlefield. The entire group will review, discuss, and sign the Lemhi penstemon monitoring job hazards analysis in SOP 9. Review data entry procedures and make sure that field crew members are comfortable using the PDAs/tablet PCs and other electronics, including use of GPS. Also, data QA/QC should be stressed to all field crew members involved.

Field training will be necessary so that crew members can compare Lemhi penstemon with some of the local look-alikes, particularly the gentian *Frasera albicaulis*. A roadcut site with some easily accessible example specimens can be found by crossing over the foot bridge and turning south, following the old wagon road at the foot of Howitzer Hill. Field crew members should take note of the distinct morphological features exhibited by Lemhi penstemon and other plants in the immediate area. The two other penstemon species, *Penstemon procerus* and *Penstemon attenuatus*, can be found in the vicinity. They are easily distinguished from Lemhi penstemon by size and growth form. Time should be spent differentiating rosettes from individual plants. Field crew members should also be shown an example of spotted knapweed and any other invasive plants of concern to the park if possible. The basal rosettes of scarlet gilia (*Ipomopsis aggregata*) have been initially confused with those of spotted knapweed by some new staff.

As field crew members become familiar with plant identification and data entry, the next step should be to navigate to an actual sample point and, as a group, practice by setting up the plot, performing all field measurements and observations, and finally entering the data. Field crew members, especially those with limited experience to the protocol should work on multiple group practice plots while performing different roles (e.g., data collection, plant identification and counting). When moving together as a large group it is essential to spread out and reduce trampling as much as possible. Finish training by addressing any lingering questions or outstanding issues.

Definitions

Definitions for key field terms are presented in Table SOP2-1 and should be reviewed during training.

Table SOP2-1. Important field definitions for monitoring Lemhi penstemon in BIHO.

Term	Definition
Established plant (Lemhi penstemon)	A plant that has developed one or more basal rosettes of leaves and a thickened caudex; leaves usually longer than 3 cm; most second year plant are considered established though they may remain quite small. See example photographs.
Basal rosette (leaves)	The leaves on the stem growing very close together near the ground and arranged on the stem so they appear to radiate out from a central axis.
Seedling (Lemhi penstemon)	A recently germinated plant consisting of a pair of "seed" leaves and one to two sets of "true" leaves, leaves usually less than 2 cm long; plant not yet developing rosette of leaves or thickened caudex. See example photographs.

Table SOP2-1 (continued). Important field definitions for monitoring Lemhi Penstemon in BIHO.

Term	Definition
Extensive Plot	The defined sampling unit of measurement (2 x 50 m), with boundaries framed temporarily by fixing a 50-m reel tape down the centerline from the origin to the end and using a 2-m long guide while sampling to determine plot edges while simultaneously reading the plot. The plot is anchored by a surveyor's pin at the GRTS sample point UTM coordinates. The plot is oriented parallel to the slope.
Intensive Plot	The defined sampling unit of measurement (1 x 2 m), with the two bottom (downhill side) plot corners permanently marked with rebar and a PVC pipe quadrat used to frame subplots. The plot is oriented from southwest (225°) to northeast (45°).

Miscellaneous Training Topics to be covered

- 1) Adequate time must be given to properly set up plots, and for decision-making associated with plot boundaries and moving plots. Although effort has been made to minimize these decisions (e.g., through office evaluation with GIS), problems will inevitably be encountered. Each technician should understand that in order for the GRTS sample to remain valid, a plot must either be used, or rejected following pre-established criteria and replaced with an oversample location following the order of the GRTS sample draw itself. It is also important for the project lead to understand that if time and crew resources are short such that the full survey is unlikely to be completed, a subset of plots should be targeted for completion following GRTS order so as not to leave “holes” in the coverage and complicate subsequent statistical analysis and scope of inference. Note that recent surveys have been easily completed with the time and staffing recommended in this protocol and no plots have been dropped and replaced.
- 2) Objective positioning of the plot is essential to prevent unintentional bias. Placement of the plot is described in SOP 4, but it still needs to be demonstrated for circumstances that may not be straightforward in training (e.g., routing the reel tape through a large shrub rather than around it).
- 3) Train the technicians on compass use for establishing the azimuth of the plot. Teach the mnemonic “red in the shed” for orienting the compass correctly with magnetic north. Make sure that compass declinations are set correctly. Obtain proper declinations for BIHO prior to the field season. As of March 13, 2012, the azimuth at BIHO is 13° 37' E, changing by 0° 9' W per year. Updated declinations can be found online at:
<http://www.ngdc.noaa.gov/geomagmodels/struts/calcDeclination>.
- 4) Crew members should spend adequate time training on plot measurements and observations to ensure that the information gathered in a consistent manner and will be of high quality. Repeatability is an important goal and needs to be assessed requiring observers to be calibrated before sampling begins. Consistently differentiating between an individual and a basal rosette is imperative to maintain accurate population estimates, for instance.
- 5) Plant identification should be practiced throughout the training and focus on Lemhi penstemon (Figures SOP2-1 and SOP2-2), as well as spotted knapweed and other invasive species. Superficially similar “look-alike” species should be pointed out and their morphological

differences described. Properly documenting invasive species is crucial to allow for increased awareness from park management and to prevent overall habitat degradation of Lemhi penstemon. The gentian *Frasera albicaulis* produces basal rosette leaves that resemble Lemhi penstemon leaves (Figure SOP2-3).



Figure SOP2-1. Lemhi penstemon (*Penstemon lemhiensis*) basal rosettes and inflorescences in BIHO. Basal leaves have a thick, leathery feel resembling culinary sage.



Figure SOP2-2. Lemhi penstemon seedlings are distinguished by a pair of cotyledon leaves and, when developed, a second pair of small first-year's basal leaves. Leaf margins and undersides are reddish in color. Through a hand lens, these leaves resemble in color, texture, and pubescence those of established plants. Small white hairs along the leaf margins are particularly distinctive relative to other seedling forbs in the study areas.



Figure SOP2-3. The gentian species *Frasera albicaulis* is common on the BIHO hillslopes and its leaves resemble those of *Penstemon lemhiensis*. However, with practice, they can be readily distinguished.

- 6) Use of the handheld PDA and/or Tablet PCs and Microsoft Access or Pendragon data entry forms must be practiced and thoroughly understood by all field personnel. Crew members should practice navigating through screens and entering data using the stylus and on-screen keyboard function. Allow time for initial field practice as a group in data entry and in post-field backup procedures. Troubleshooting tips should be reviewed.
- 7) Safety procedures are outlined in SOP 9. These procedures must be reviewed as a group in a focused tailgate session. All UCBN staff will review and sign the Job Hazard Analysis worksheet prior to the field season. Park staff will follow park procedures for ensuring proper risk awareness and management.
- 8) Weed spread prevention is a critical issue in all NPS field activities. Boots and clothing should be thoroughly cleaned of all weedy debris, particularly before arriving in the field, or when moving between one field area to another. Boots laces and pant cuffs seem to readily collect weed seeds and time should be spent brushing off seeds and material, picking seeds out of boot laces, and disposing of these materials properly in a plastic bag or any other way that eliminates the risk of transfer. Vehicles are vectors for spreading invasive plants and care should be given to make sure vehicles are free of weeds before entering the park and after any potential contact with noxious weeds. For the purposes of this protocol, vehicle travel will be restricted to paved surfaces in BIHO so the threat of picking up weedy materials should be low. Park-specific procedures should

be followed when provided, and this topic should be discussed with park staff at the beginning of each park sampling session to address any changing needs.

Suggested Reading and Reference Materials

Taxonomic References

Hitchcock, C. L., and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, Washington.

U.S. Department of Agriculture Natural Resources Conservation Service (USDA, NRCS). 2006. The PLANTS Database. National Plant Data Center, Baton Rouge, Louisiana. Available at: <http://plants.usda.gov> (accessed 25 August 2010).

Plant Identification Software

Flora of the Pacific Northwest. CD-ROM Version 1.0. University of Washington Press, Seattle, Washington.

Flora ID Northwest. Interactive plant keys and color photos for the Pacific Northwest. All known native and naturalized vascular plants. Flora ID Northwest, Pendleton, Oregon. Available at: <http://flora-id.org/> (accessed 25 August 2017).

Aids to Terminology and Structures Important in Plant Identification

Harris, J. G., and M. W. Harris. 2001. Plant identification terminology, an illustrated glossary. 2nd edition. Spring Lake Publishing, Spring Lake, Utah.

Local Noxious Weed References

Pokorny, M. and J. Mangold. 2008. Montana's noxious weeds. Montana State University Extension Service, Bozeman, Montana.

An Excellent Monitoring Reference

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. US Department of Interior, Bureau of Land Management, Denver, Colorado.

Standard Operating Procedure 3: Finding GPS Waypoints

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

The purpose of this SOP is to describe the procedures necessary to navigate to sampling locations using GPS units, particularly the Garmin GPSmap 62st. Information on GPS specifications and settings are also included. This SOP is not intended as a substitute user's guide for GPS units. Please consult the appropriate user's guide for more detailed information on unit functionality.

Suggested Reading

Garmin. 2011. GPSMAP 62 Series Owner's Manual. Garmin International, Olathe, Kansas.

Available online at https://static.garmin.com/pumac/GPSMAP62_OM_EN.pdf

Before the Field

Preparation is essential to successful field work, particularly when that field work relies on GPS data collection or navigation. The baseline GPS constellation consists of 24 satellites that orbit the earth approximately every 12 hours. The position and time signals transmitted by these satellites are used by GPS receivers to triangulate a location on Earth. Although this process is subject to various sources of error, pre-planning can minimize the impacts. For the Lemhi penstemon monitoring protocol, objective placement of the sampling frame is usually more critical than the precision of the location. Sample locations are temporary and permanent, with each type representing a different overall challenge concerning GPS use. Permanent plots will be revisited in the future so points should be averaged in an effort to be as precise and accurate as possible, enabling the plots to be revisited as efficiently as possible. The locations have been established and unless changes are directed by the field crew lead, new permanent locations are not likely to be a task for field crew. Extensive plot locations are temporary and will not be revisited so the GPS unit will be used as a tool for objective plot placement although the precision of the location may vary within the limits of the GPS. However, the precision of the GPS unit should be consistent among all units used for monitoring, and within the limitations of the capabilities of the GPS units based on satellite locations and terrain.

Setting GPS Specifications

Verify Time: Time synchronization of the GPS receiver and GPS satellites is critical for the most accurate data collection and navigation. With the Garmin GPSmap 62st, use the Time Setup Menu to set the time format, zone, and to conform to Daylight Savings Time.

Verify Projection and Datum:

All GPS positioning information is referenced to the World Geodetic System 1984 (WGS84) datum (Figure 14). While the difference between WGS84 and NAD83 is minimal (<1 m), best practice is to navigate and collect data in WGS84. With the Garmin GPSmap 62st, use the Units Setup Menu to select the position format and map datum. BIHO is located within UTM zone 12.

Enable WAAS:

Enabling WAAS (Wide Area Augmentation System) allows for real-time correction of GPS coordinates as long as the WAAS satellites are in view. Due to the fixed position of these satellites

over the equator, signal reception is best in open areas with a clear view of the southern sky. With the Garmin GPSmap 62st, use the System Setup Menu to enable WAAS.

Calibrate the Compass:

The internal compass in the Garmin GPSmap 62st should be calibrated prior to each use for increased accuracy in navigation. Use the Calibration Setup Menu to calibrate the compass. Follow the directions on screen.

Batteries:

Fully charge the batteries and remember to take spares. The Garmin GPSmap 62st units use 2 (AA) batteries and can fail on battery power quickly and without warning. Spare batteries should always be carried into the field to avoid lost work time.

Loading Waypoints:

Sample points are generated using ArcGIS and exported to a shape or dBase file for each park. Uploading these locations to the Garmin GPSmap 62st as waypoints is simplified by using DNRGarmin, a freeware program developed and maintained by the Minnesota Department of Natural Resources. The program can be downloaded from <http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html>. The site has information on the application including installation guidelines and documentation.

To upload waypoints to the Garmin GPSmap 62st, connect the GPS unit to the PC and open DNRGarmin. DNRGarmin should display your GPS unit and say connect. If it does not, go to GPS and open port.

Use the File Menu to set the correct projection (Figure SOP3-1). Next go to 'Load Data' in the File Menu and select your shapefile or dBase file of interest (Figure SOP3-2). You can delete and or edit points, add comments, etc. if necessary. Use the GPS Menu to open the port to the GPS unit. Then, use the Waypoint Menu to upload the points to the GPS unit.

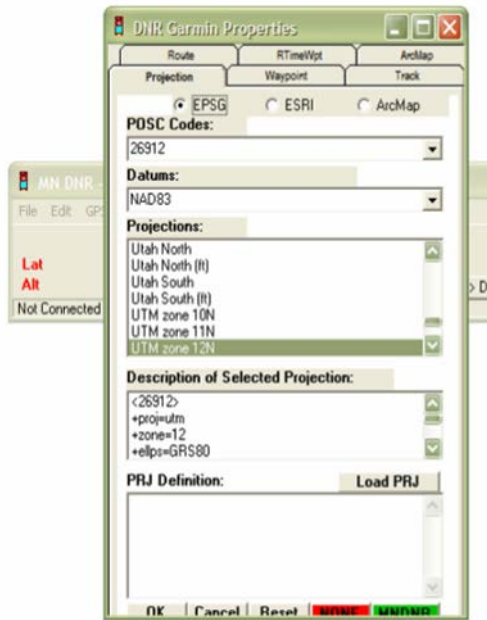


Figure SOP3-1. Screenshot from DNRGarmin used to set the correct map projection.

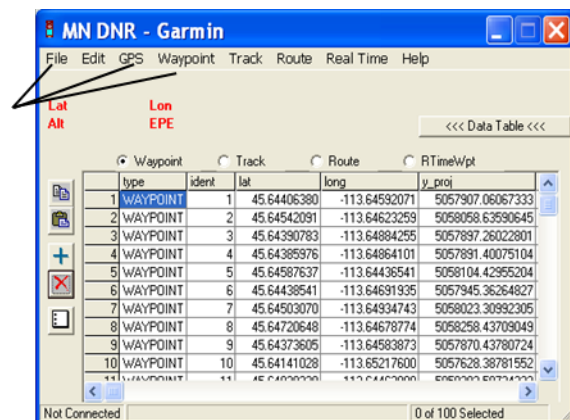


Figure SOP3-2. Screenshot from DNRGarmin used to view and upload selected waypoints.

In the Field

Monitoring Location Error

Ideally, you would be able to set thresholds for the maximum PDOP (Position Dilution of Precision) allowed as well as the minimum number of satellites. While you cannot set these values in the Garmin GPSmap 62st, you can monitor the satellite strength and relative location error by using the Satellite Main Page (Figure SOP3-3).

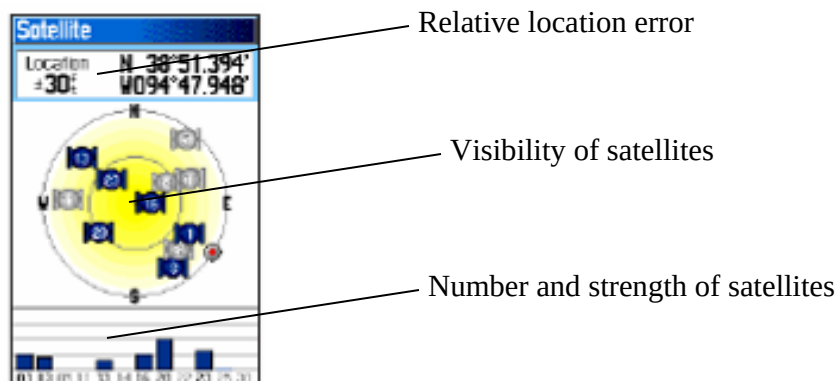


Figure SOP3-3. Screenshot from GPS unit showing satellite information.

Selecting and Navigating to Waypoints

With Garmin GPSmap 62st, use the Find Menu to search for a waypoint of interest. Select 'Find by Name' and scroll to the point ID of interest. Conversely, you can select the waypoints icon and scroll to the Point ID of interest. Note that often the menu is set to 'Find by Nearest' and if the desired point is not near, no points will be displayed (although because sample locations are clustered in a spatially balanced design this may be the most efficient setting for locating sample points). To change this setting, go to the waypoint menu, push the menu button, and select 'Find by Name.'

Once selected, the items information page for the waypoint opens, allowing you to show the item on the map (by selecting Map) or create a route to the point (select GoTo). Select 'GoTo' to navigate to the point. You can use the 'Page' button to switch through various pages, select the Compass page (Figure SOP3-4) and, holding the GPS level, walk in the direction indicated by the compass until the 'Dist to Dest' window reads zero.

When navigating with the GPS unit and approaching the waypoint location, focus on the coordinates and ignore the vegetation. Once the GPS unit registers "zero" (or otherwise shows that the coordinates have been reached exactly), stop immediately. Mark the location with a chaining pin/pin flag between the locator's boots. This pin will fix the origin (start) of the 50 m long plot. Place the plot perpendicular to the slope to minimize trampling and reduce observer bias.



Figure SOP3-4. Screenshot from GPS unit compass page for navigation to a waypoint.

Creating New Waypoints

A location of interest can be marked and recorded by creating a new waypoint. This is useful for recording the

After the Field

Deleting Waypoints

After completion of fieldwork, delete any waypoints on the GPS units. Go to the Find Waypoints page, select Menu – Delete – All waypoints. Remove batteries from units before any long-term winter storage to prevent corrosion and leakage.

Standard Operating Procedure 4: Locating and Establishing Plots

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

The purpose of this SOP is to describe the step-by-step procedures for establishing permanent intensively monitored plots and non-permanent extensive sampling plots for surveys of the Lemhi penstemon and spotted knapweed populations on the hillslopes and below the visitor center. This SOP begins where SOPs 1, 2, and 3 leave off, with field preparations complete, crews trained and ready to hit the field with equipment, GPS units, and field reference maps.

Extensive Plots

Non-permanent plots, referred to as “extensive” plots because of the broad spatial extent of the distribution of these plots across the entire study area, are used to determine population sizes and long-term trends in population estimates for Lemhi penstemon and spotted knapweed, and to determine number of rosettes and flowering stems per penstemon plant. Plots are 100-m² belt transects 50-m long and 2-m wide, modified from an approach described by Lesica (1987).

When the GPS reads 0 m to destination (SOP 3), immediately stop walking and place a chaining pin in the ground between the navigator’s feet. This pin marks the plot origin. It is important to do this action objectively so that no observer bias is introduced. Begin plot setup by attaching one end of the 50-m reel tape to the chaining pin at the origin and then run the tape out 50 m at an azimuth parallel to the contour of the slope. The tape should be set up as straight as possible, eliminating any bends if necessary, going through shrubs rather than over or around them, and fixing the other end of the reel tape with a chaining pin so it remains stationary.

It is very important to avoid criss-crossing adjacent transects. This can be avoided by maintaining parallel azimuths. If it is apparent that a transect will cross a previously surveyed transect, a slight offset to the origin and azimuth to re-direct the tape is permissible. However, this must be done without consideration of whether target plant species will fall within transect boundaries.

Observers hold a 2-m long PVC pipe while walking the length of the plot to visually determine where the edges of the plot are located without the need for additional plot setup. The observer walks along the centerline (reel tape) while holding the pipe, enabling the observer to simultaneously see the plot boundaries while searching for penstemon and spotted knapweed plants (Figure SOP4-1).



Figure SOP4-1. A field observer searching for Lemhi penstemon and spotted knapweed plants within an extensive plot on the Horse Pasture.

Intensive Plots

Permanent plots, known as intensive plots because of the fine scale at which information is derived, were established in 2012 at 42 locations (Figure SOP1-3). Intensive plot dimensions are 1 m × 2 m, with the long axis (2 m) oriented perpendicular to the slope (Figure SOP4-2). Plots are divided into two, 1-m² subplots, a left (L) subplot and a right (R) subplot (see Figure SOP4-2). Intensive plots are monumented with a 5/8" × 10" piece of rebar at each of the two lower/downslope corners and the location of the lower left (southeast) corner is used for UTM coordinates and GPS navigation. Yellow rebar caps are stamped "NPS Monitor". Cover is estimated with point interception in 98 interception points (Figure SOP4-3).

Intensive Plot Design penstemon and knapweed counts

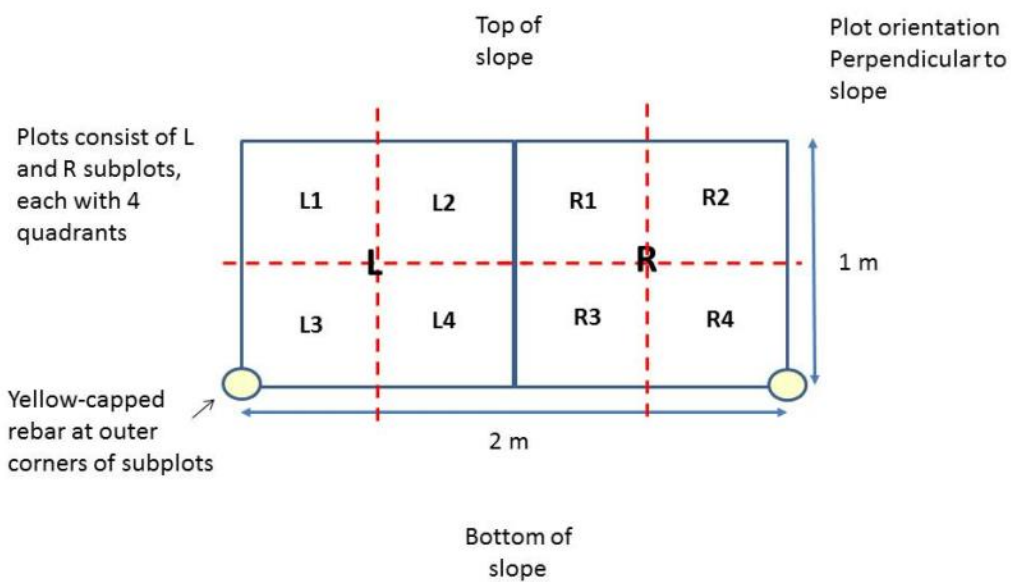


Figure SOP4-2. Plot diagram illustrating 1 m × 2 m “Intensive Plot” for counting Lemhi penstemon and knapweed plants.

Intensive Plot Design

Point-intercept Cover Estimation

Plots consist of L and R subplots, each with 49 intercepts and a total of 98 intercepts

Grid of pvc pipe for point-intercept cover estimation

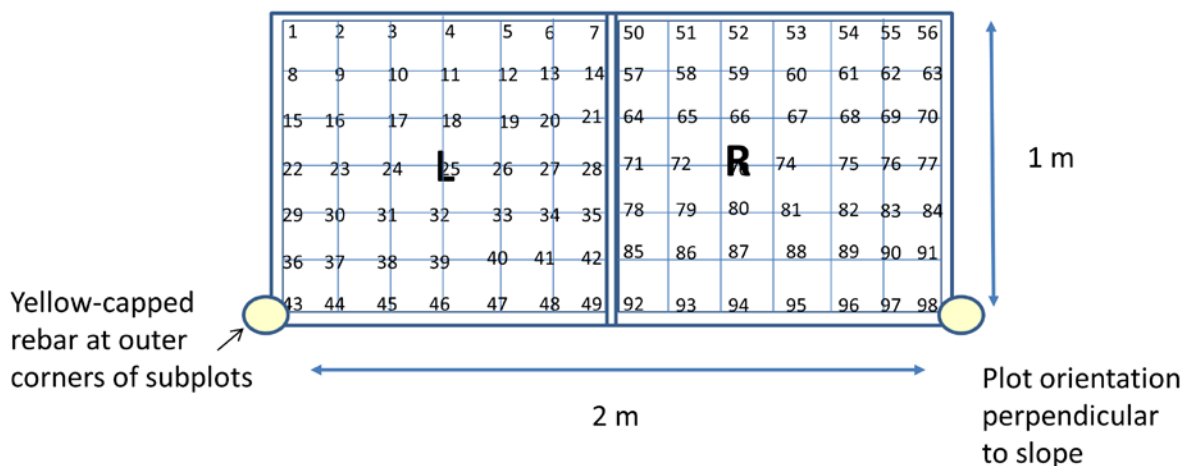


Figure SOP4-3. The diagram for estimating ground cover in intensive study plots with a point-intercept frame.

When revisiting the intensive plot, crew members will navigate to the point using GPS as described in SOP 3. UTM coordinates for the 42 intensive plots are listed in Table SOP1-1. A straight line must be established between the two pieces of rebar on the downhill side of the plot. This line can be accomplished by fixing the “0” end of the reel tape to the ground at the origin with a chaining/surveyor’s pin, then running the tape in a straight line to the other rebar, and pinning that end as well. It may be necessary to run the tape past the 2nd rebar to ensure that the reel tape body does not interfere with the placement of the PVC 1-m² frame. This downhill plot edge is the standard that all other plot measurements are based on.

Each subplot will be surveyed by placing a 1-m² PVC pipe point intercept frame around the perimeter and then taking plot measurements of plants rooted within this square as described in SOP 5 (Figure SOP4-4). The observer will make all plot measurements and observations within the first subplot (L) before moving the frame over to the next subplot (R).



Figure SOP4-4. An observer searching for Lemhi penstemon seedlings in an intensive plot. An established Lemhi penstemon plant is in the foreground.

Suggested Reading

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. US Department of Interior, Bureau of Land Management, Denver, Colorado.

Standard Operating Procedure 5: Measuring Response Variables

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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.
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3. Post new versions on the internet and forward copies to all individuals with a previous version of the SOP.

Purpose

The purpose of this SOP is to describe the step-by-step procedures for measuring response variables within sampling plots for the purposes of long-term monitoring of Lemhi penstemon and spotted knapweed in BIHO. This SOP begins where SOPs 1, 2, 3, and 4 leave off, with field preparations complete, crews trained and deployed with equipment, GPS units, and field reference maps, and with plots (quadrats) located and set-up in the field.

Measuring Response Variables

Extensive Plot

The general workflow is to have observer 1 unroll the 50-m reel tape, guided by the partnering observer 2 at the origin who has a compass and can ensure that the plot is perpendicular to the slope. During tape roll-out, target plant species are sometimes found by observer 1 so be alert! Any plants found during plot set-up and during plot searches should be marked with colored irrigation pin flags to ensure plants aren't counted twice or overlooked. After the 50-m reel tape has been positioned and secured, the observer 1 slowly walks back towards the origin along the plot center line (reel tape), searching for and marking plants with irrigation flags while holding the 2-m PVC sampling guide centered over the plot center line, as shown in Figures SOP4-1 and SOP5-1. Meanwhile, the observer 2 at the origin will enter plot information in to the PDA and then when finished with that task, assist observer 1 in the plant search by walking slowly to the far end of the tape, before returning back to the origin. Observer 2 will also need to carry some irrigation flags to mark plants. Observers will share use the 2-m PVC pipe as a guide to determine edges of the plot while simultaneously searching the plot (See Figures SOP4-1 and SOP5-1). Some plants near the tape centerline are easily determined to be inside the plot; the PVC pipe is most important for making decisions when plants are near the edge. Throughout the search, found plants are marked with irrigation pin flags to ensure that plants are not counted more than once.

For each established Lemhi penstemon plant found, one observer will count and call out the number of basal rosettes and the number of inflorescences (flowering stems) for recording into the PDA by the second observer (these roles can be fluid, depending on ease of work [e.g., which observer has the PDA and is closest to plants needing counting]). Basal rosettes are recognized as a group of leaves arranged around a central axis (whorl). It can be helpful to physically separate the rosettes with your fingers in order to differentiate one rosette from the next. Sometimes it is necessary to gently tug on the woody caudex of the plant to determine if a neighboring rosette is part of the plant (it also moves) or is rooted independently and therefore considered a separate plant. It is possible for one flowering stem to arise from each basal rosette.

Tally the total number of spotted knapweed plants found within plot boundaries. No additional information about spotted knapweed (e.g., rosettes and inflorescences are not counted for spotted knapweed) is recorded.

For both species, only plants rooted within the plot should be recorded. If the roots of a plant are within 1 m of the plot center line then it is considered "in" and will be recorded. Conversely, if a plant is leaning into the edge of the plot but the roots are outside, the plant is considered "out" and is not recorded. This is important to assure that plants are counted consistently from year to year. For

both plants, the position along the transect center tape line, in 1 m increments, and also their position right or left of the center tape line (looking from the origin north), will also be recorded to add locational precision to plants. This is particularly important for relocating spotted knapweed for weed spraying, but may also become useful for some analyses of Lemhi penstemon spatial configuration.

When a spotted knapweed plant is observed outside of the plot, record and appropriately name its location with GPS waypoints, and use the “plot notes” field in the data entry form to record this information. Estimate the number of plants observed at the location. At the end of the survey week, ensure that the batch of knapweed waypoints is downloaded to a park computer for use by BIHO resource management.

After all temporarily marked (with irrigation flags) plants are recorded, observer 1 (typically) returns to the end of the transect to reel up the center line tape, pick up all pin flags, and prepares to move to the next plot location.



Figure SOP5-1. Established Lemhi penstemon plants are temporarily marked with irrigation pin flags during searching. This plot shown here is unusually densely populated with target plant species. Typically, plots have none or few target plant species.

Measuring Response Variables

Intensive Plot

Intensive plots are surveyed by teams of two, as with extensive plots. However, because intensive plots require penstemon seedling identification and more complex decision-making and troubleshooting (e.g., regarding plant tag placement, or when tags are lost) intensive plot teams must be staffed with experienced botanists (typically the project lead).

After the intensive plot is set up, the lead observer 1 will measure response variables within the intensive plot. First identify, count, and record all tagged Lemhi penstemon plants and all spotted knapweed plants rooted within each quadrant. Next, search carefully for new (un-tagged) established Lemhi penstemon plant single-rosette recruits. Third, if new penstemon plant(s) are found, assign and pin into the ground a new tag number as indicated by the database which tracks sequential order of tag numbers already in use. At the time of protocol publication, 201 tags have been used on hillslope plants. Tags up through 999 have been purchased and are stored at the Battlefield office (see SOP 1 equipment list). Demographic rates of Lemhi penstemon are relatively slow (few new recruited established plants per year) and it will be many years before all 999 tags have been used. NOTE: Do not recycle tag numbers from dead plants back into hillslope plots. It is acceptable to recycle tags into visitor center subpopulation plants, however.

Tags are pinned next to but not through plant rosettes, as shown in Figure SOP5-2. Seedlings require very careful searching (SOP 2). It is good practice to search quadrant by quadrant to help narrow the search frame and make the work more systematic and organized. Note that only established penstemon plants and seedlings rooted within the 1- m² PVC subplot frame should be recorded. Likewise, only established knapweed plants with an obvious rosette should be counted (NOTE: knapweed seedlings are cryptic and have not been a source of confusion for this protocol). Give careful attention to boundaries of the quadrants (internal portion of each subplot). View the quadrant boundaries from above (bird's eye view) to best determine which quadrant plants growing on the boundaries should be assigned to. Refer to the previous years' records to ensure consistency. For each established Lemhi penstemon plant found, determine how many basal rosettes grow from the individual, and how many of those basal rosettes have a flowering stem growing from them. Note for each plot whether any Lemhi penstemon flowers were in bloom, specifically if the corollas were open. Record the number of Lemhi penstemon seedlings.



Figure SOP5-2. Established Lemhi penstemon plants are tagged by placing pins down next to but not through plant rosettes and caudexes.

Ground cover will be determined using the point intercept method. The 1-m² subplot frame has a removable cross bar with seven holes drilled through. This cross bar can be placed in seven different positions, creating 49 point-intercept locations (a total of 98 for each plot; Figure SOP4-3). The holes are drilled to enforce a vertical drop of the pin to the ground, accounting for the slope (i.e., the pin is parallel to the legs of the frame). Measure cover at each one of the intercept locations by dropping a thin metal rod straight down through the hole; the rod should be lightly grasped near the top and the bottom should be allowed to hang freely. Let the rod fall down and record what the end of the rod contacts. The most basal object touched by the end of the rod will be counted for cover. The rod may require being guided through plant stems and leaves and shrub branches. For example, if the rod touches a leaf that is suspended over bare ground, the leaf should be disregarded and the bare ground should be counted. Plants will only be counted if the rod contacts the basal region of that plant, for instance the living base of a bunchgrass or a sagebrush branch or root that is lying directly on the ground. Care must be taken to avoid “placing” the rod and thereby biasing the sample. Repeat this procedure for each of the 49 intercept locations in both subplots of each intensive plot. Note that the purpose of recording only the most basal object is to capture information about cover that is likely to

interfere with Lemhi penstemon germination. Seedlings frequently become established in bare soil that is underneath plant canopies. Refer to Table SOP5-1 for the cover category definitions.

Table SOP5-1. A list of cover classes and descriptions of each follows:

Term	Definition
Bare Ground	Mineral soil not directly covered by any other cover class.
Crust (soil)	Mosses or lichens forming a continuous layer on or within the top layer of soil.
Forb	Herbaceous, non-woody, flowering vascular plant, excluding graminoids. An example includes Arrow leaf balsamroot (<i>Balsamorhiza sagittata</i>).
Graminoid	Grass and grass-like plants including sedges and rushes. Examples include Idaho fescue (<i>Festuca idahoensis</i>) and bluebunch wheatgrass (<i>Pseudoroegneria spicata</i>).
Lemhi penstemon	Lemhi penstemon plant.
Litter	Dead, non-woody plant material no longer attached to a living plant. May also be animal in origin (fur, scat, etc.).
Rock	Rock larger than 5 mm in diameter.
Shrub	Perennial plant that develops woody roots and/or branches and tends to have a compact or sometimes sprawling growth form. An example includes Big sagebrush (<i>Artemisia tridentata</i>).
Tree	Living part of a tree; likely roots or bole of tree.
Wood	Portion of woody branch, stem, root or log which is no longer living and larger than 5 mm.

Measuring Ancillary Information

The aspect of the long axis of each extensive plot is recorded during plot establishment and set-up. To do this, aim the compass housing in the direction of the tape (the long axis perpendicular to the slope) and spin the housing until “red is in the shed” and read the number, in degrees, that is aligned with the compass direction (typically with a white pointer). The slope, in degrees, is also measured at extensive plots. Compasses have inclinometers and provide a coarse estimate of the deviation of the slope from 0° (flat ground). Slope degrees typically vary from approximately 20° to 35°.

Standard Operating Procedure 6: Data Management

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Note: This SOP provides documentation for the Lemhi penstemon and spotted knapweed protocol and provides instructions for the development, maintenance, archiving, and distribution of the database or datasets.

Introduction

This SOP describes data management procedures. The database model is described in detail, including definitions of all input and computed data fields. Procedures for documenting data entry, certification, data archiving, QA/QC, and handling of sensitive information are also provided. Additional details can be found in the Lemhi penstemon and spotted knapweed monitoring data quality standards report (Lonneker and Rodhouse 2017).

Database Model

The UCBN Lemhi penstemon database was developed within Microsoft Access and conforms to the standards of version 3.2 of the Natural Resource Database Template (NRDT).

The database consists of a user interface front-end (holding user forms for data entry, review, and export) that is linked to a back-end database file (holding the core protocol data tables, various lookup tables and PDA data transfer tables). The general data management strategy employs a “working copy” of the database (used to enter the current season’s data, conduct error-checking, and perform validation) and a “master version” of the database, which stores all validated data and facilitates multi-year analyses by providing specific data summaries and export formats. A physical data model for the UCBN Lemhi penstemon database shows the relationships among the core data tables, lookup tables, and cross reference tables (Figure SOP6-1).

The core data tables in the UCBN Lemhi penstemon database are tbl_Sites, tbl_Locations, and tbl_Events. There are additional tables for intensive (permanent) and extensive (temporary) plot data (tbl_EvObs_Int_Quads, tbl_EvObs_Int_SubQuads, tbl_EvCover_Normalized, tbl_InQuadsPenSeedlingKnapweed, tbl_EvObs_Ext_Transect, tbl_EvObs_Ext_SubTransect and tbl_EvObs_Ext_Transect_Knapweed). The tbl_Sites table stores descriptive data on the Lemhi penstemon population sample frame sites. The tbl_Locations table stores the unique physical location information for each intensive and extensive sampling plot. The tbl_Events table, storing information about sampling visits to a given Lemhi penstemon sampling plot, links to all of the sampling data (i.e., tbl_EvObs_Int_Quads, tbl_EvObs_Ext_Transect and tbl_EvObs_Ext_Transect_Knapweed) and to a series of cross reference tables (tbl_xref_Events_Contacts and tlu_Contacts) that stores data about the contacts associated with each sampling visit. The PDA data transfer tables (PDA_tbl_Ext_Transect, PDA_tbl_Ext_subTransect and PDA_tbl_Ext_subTransect_Knapweed) store the templates for managing transfer of plot data from the PDAs to the Lemhi penstemon monitoring database. The visitor center population is considered a complete census of that particular area and the data are stored in a separate table called tbl_VisitorCenter_Census. The intensive plot ground cover data tables are supported by the tlu_CoverCats lookup table. The protocol version in use at the time of data collection is linked to tbl_Events through use of a tlu_Protocol_Ver lookup table, and revisions to the Lemhi penstemon monitoring database will be captured in two metadata tables, tbl_Db_Meta and tbl_Db_Revisions.

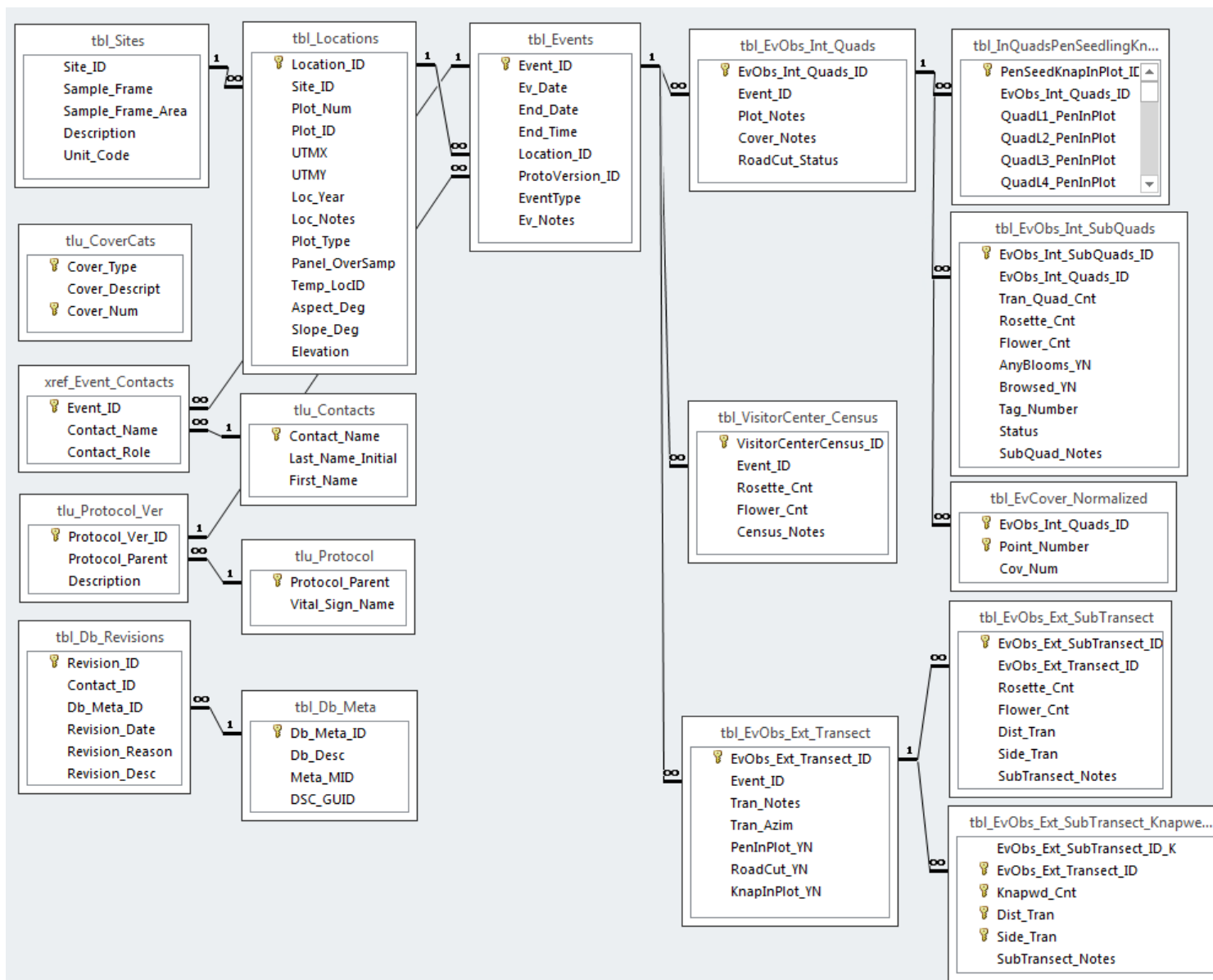


Figure SOP6-1. The Lemhi penstemon monitoring protocol database model.

Database Dictionary

The following data dictionary provides a description for every table contained in the database back-end file, and for each table, lists the field names and their associated field type, format and description. Tables that form the data dictionary are shown below [Table SOP6-1. (a)-(r)].

Table SOP6-1. Tables and data fields from Lemhi penstemon database.

(a) Table name: *tbl_Sites*: A site is a population sampling frame/site.

Field Name	Type	Format	Description
Site_ID	Text	Up to 10 characters	Primary key, uniquely identifying each <i>tbl_Sites</i> record
Sample_Frame	Text	Up to 50 characters	Full name of sampling site location
Sample_Frame_Area	Double	Numeric	Sample frame area in square meters
Description	Text	Up to 255 characters	Description of sampling site location
Unit_Code	Text	Up to 4 characters	Park unit code

(b) Table name: *tbl_Locations*: A Location is either an intensive (permanent) or extensive (temporary) plot to be sampled.

Field Name	Type	Format	Field Description
Location_ID	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each <i>tbl_Locations</i> record
Site_ID	Text	Up to 10 characters	Link to <i>tbl_Sites</i> (Foreign Key)
Plot_Num	Number	Numeric	Location (PlotID) number
Plot_ID	Text	Up to 20 characters	Sampling site and location number (i.e., VC_042)
UTMX	Double	Numeric	X (Easting) UTM coordinate
UTMY	Double	Numeric	Y (Northing) UTM coordinate
Loc_Year	Text	Up to 4 characters	Year plot location was defined
Loc_Notes	Text	Up to 255 characters	Notes relevant to plot location
Plot_Type	Text	Up to 10 characters	Intensive (permanent) or extensive (temporary GRTS) plots
Panel_OverSamp	Text	Up to 20 characters	Panel or oversample plot
Aspect_Deg	Integer	Numeric	Aspect (degrees) of plot or transect
Slope_Deg	Integer	Numeric	Slope (degrees) of plot or transect
Elevation	Integer	Numeric	Elevation (meters) of plot or transect

(c) Table name: *tbl_Events*: An event is a field sampling event at a plot.

Field Name	Type	Format	Description
Event_ID	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each tbl_Events record
Ev_Date	Date/Time	mm/dd/yyyy	Date of field data collection
End_Date	Date/Time	mm/dd/yyyy	End date of field data collection
End_Time	Data/Time	hh:mm	End time (Hours:Minutes) of field data collection
Location_ID	GUID ReplicationID	Alphanumeric	Link to tbl_Locations (foreign key)
ProtoVersion_ID	Text	Up to 20 characters	The name or code of the protocol governing the event
EventType	Text	Up to 50 characters	Sample event type
Ev_Notes	Text	Up to 255 characters	Notes on the field sampling event

(d) Table name: *tbl_EvObs_Int_Quads*: This table holds quad scale site characterization data collected at intensive (permanent) plots.

Field Name	Type	Format	Description
EvObs_Int_Quads_ID	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each EvObs_Int_Quads_ID record
Event_ID_fk	GUID ReplicationID	Alphanumeric	Link to tbl_Events (foreign key)
Plot_Notes	Text	Up to 255 characters	Sampling plot notes
Cover_Notes	Text	Up to 255 characters	Cover type notes
RoadCut_Status	Integer	Numeric	Is the plot still on a road cut?

(e) Table name: *tbl_InQuadsPenSeedlingKnapweed*: This table holds quad scale vegetation data collected at intensive (permanent) plots:

Field Name	Type	Format	Description
PenSeedKnapInPlot_ID	GUID ReplicationID	Alphanumeric	Primary key for vegetation data in the quadrant
EvObs_Int_Quads_ID	GUID ReplicationID	Alphanumeric	Link to tbl_EvObs_Int_Quads for each EvObs_Int_Quads_ID record (foreign key)
QuadR1_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R1
QuadR1_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R1
QuadR1_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R1
QuadL4_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad L4
QuadR1_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R1
QuadR2_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R2
QuadR3_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R3
QuadR4_PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in Plot Quad R4
QuadL1_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad L1
QuadL2_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad L2
QuadL3_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad L3
QuadL4_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad L4
QuadR1_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad R1
QuadR2_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad R2
QuadR3_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad R3
QuadR4_SeedlingCnt	Integer	Numeric	Seedling Count in Plot Quad R4
QuadL1_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad L1
QuadL2_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad L2
QuadL3_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad L3
QuadL4_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad L4
QuadR1_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad R1
QuadR2_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad R2
QuadR3_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad R3

QuadR4_KnapwdCnt	Integer	Numeric	Knapweed Count in Plot Quad R4
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(e) Table name: *tbl_EvObs_Int_SubQuad*: This table holds sub quad scale data collected at intensive (permanent) plots, with one record per Lemhi Penstemon.

Field Name	Type	Format	Description
EvObs_Int_SubQuads_ID	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each EvObs_Int_SubQuads_ID record
EvObs_Int_Quads_ID	GUID ReplicationID	Alphanumeric	Link to tbl_EvObs_Int_Quads (Foreign Key)
Tran_Quad_Cnt	Text	Up to 50 characters	Unique Key with Site, Plot_ID, Quad, flower and rosette count
Rosette_Cnt	Integer	Numeric	Count of Rosettes (for individual plant)
Flower_Cnt	Integer	Numeric	Count of Flowers (for individual plant)
AnyBlooms_YN	Yes/No	True/False	Any flower blooms on plant?
Browsed_YN	Yes/No	True/False	Any sign of browsing on plant?
Tag_Number	Integer	Numeric	Field tag number for Lemhi penstemon plant
Status	Text	Up to 10 characters	Lemhi penstemon stage status (alive, withered or dead)
SubQuad_Notes	Text	Up to 255 characters	Notes

(f) Table name: *tbl_EvCover_Normalized*: This table holds point intercept ground cover data collected at intensive (permanent) plots.

Field Name	Type	Format	Description
EvObs_Int_Quads_ID	GUID ReplicationID	Alphanumeric	Link to EvObs_Int_Quads unique ID (foreign key)
Point_Number	Integer	Numeric	Point intercept number (1 - 98)
Cov_Num	Integer	Numeric	Cover class number attained from tlu_CoverCats

(g) Table name: *tbl_EvObs_Ext_Transect*: This table holds data collected at sampled extensive (temporary) plots.

Field Name	Type	Format	Description
EvObs_Ext_Transect_ID	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each EvObs_Ext_Transect_ID record
Event_ID	GUID ReplicationID	Alphanumeric	Link to tbl_Event (Foreign Key)
Tran_Notes	Text	Up to 255 characters	Sampling plot notes
Tran_Azim	Integer	Numeric	Azimuth of transect (degrees)
PenInPlot_YN	Yes/No	True/False	Lemhi Penstemon in plot?
RoadCut_YN	Yes/No	True/False	Is plot on a road cut?
KnapInPlot_YN	Yes/No	True/False	Is there knapweed in the plot?

(h) Table name: *tbl_EvObs_Ext_SubTransect*: This table holds sub-transect scale data collected at extensive (temporary) plots, with one record per Lemhi Penstemon.

Field Name	Type	Format	Description
EvObs_Ext_SubTransect_ID_L	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each EvObs_Ext_SubTransect_ID record
EvObs_Ext_Transect_ID	GUID ReplicationID	Alphanumeric	Link to EvObs_Ext_SubTransect (Foreign Key)
Rosette_Cnt	Integer	Numeric	Count of Rosettes (for individual plants)
Flower_Cnt	Integer	Numeric	Count of Flowers (for individual Plants)
Dist_Tran	Double	Numeric	Distance (meters) along transect where Lemhi penstemon is located
Side_Tran	Text	Up to 10 characters	Side of transect (left or right) where Lemhi penstemon is located
SubTransect_Notes	Text	Up to 255 characters	Notes

- (i) Table name: *tbl_EvObs_Ext_SubTransect_Knapweed*: This table holds sub-transect scale data collected at extensive (temporary) plots, with one record per knapweed.

Field Name	Type	Format	Description
EvObs_Ext_SubTransect_ID_K	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each EvObs_Ext_SubTransect_ID record
EvObs_Ext_Transect_ID	GUID ReplicationID	Alphanumeric	Link to EvObs_Ext_SubTransect (Foreign Key)
Knapwd_Cnt	Integer	Numeric	Knapweed count at location along transect
Dist_Tran	Double	Numeric	Distance (meters) along transect where knapweed is located
Side_Tran	Text	Up to 10 characters	Side of transect (left or right) where Lemhi penstemon is located
SubTransect_Notes	Text	Up to 255 characters	Notes

- (j) Table name: *tlu_CoverCats*: Lookup table of categories for plot cover.

Field Name	Type	Format	Description
Cover_Type	Text	Up to 255 characters	Cover type
Cover_Descript	Text	Up to 255 characters	Cover type description
Cover_Num	Integer	Byte	Cover type number

- (k) Table name: *tlu_Contacts*: Lookup table of contacts associated with protocol data collection and entry.

Field Name	Type	Format	Description
Contact_Name	Text	Up to 50 characters	Primary key, Contact identifier, first name and last initial only
First_Name	Text	Up to 50 characters	First name
Last_Name_Initial	Text	Only 1 character	Last name, initial only

- (l) Table name: *xref_Events_Contacts*: Cross-reference table between *tbl_Events* and *tlu_UCBN_Contacts*. Facilitating one or more contacts to be associated with a sampling event.

Field Name	Type	Format	Description
Event_ID	GUID ReplicationID	Alphanumeric	Link to <i>tbl_Events</i> (Foreign Key)
Contact_Name	Text	Up to 50 characters	Link to <i>tlu_UCBN_Contacts</i> (Foreign Key)
Contact_Role	Text	Up to 50 characters	The contact's role in field data collection

- (m) Table name: *tlu_Protocol*: Lookup table of vital sign protocol..

Field Name	Type	Format	Description
Protocol_Parent	Text	Up to 20 characters	Code to identify each vital sign protocol (i.e., PENLEM)
Vital_Sign_Name	Text	Up to 50 characters	Full name of associated vital sign

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- (n) Table name: *tlu_Protocol_Ver*: Lookup table of protocol versions, linked to *tbl_Events* associating a protocol version per individual sampling event.

Field Name	Type	Format	Description
Protocol_Ver_ID	Text	Up to 50 characters	Protocol_Version ID. Protocol Parent code plus version
Protocol_Parent_fk	Text	Up to 50 characters	Protocol_Parent (Foreign key)
Description	Memo	Up to 65,535 characters	Description of this Protocol

(o) Table name: *PDA_tbl_Ext_Transect*: PDA table data collected at sampled extensive (temporary) plots.

Field Name	Type	Format	Description
TranID	Text	Up to 50 characters	PlotID (Zn-Quad_X-Y_UtmZn) from lookup
TranID2	Text	Up to 50 characters	Duplicate PlotID for records imported from PDAs (non-editable backup to PlotID)
Unit_ID	Text	Up to 150 characters	PDA field
FieldDateStamp	Date/Time	mm/dd/yyyy	Sampling Date
User_ID	Text	Up to 50 characters	PDA field
TranNum	Integer	Numeric	Plot Number, manually entered by User as an accuracy check
Observer	Text	Up to 50 characters	from lookup
Tran_Notes	Text	Up to 255 characters	Notes regarding transect (Event_Notes)
Tran_Azim	Integer	Numeric	Azimuth of transect (degrees)
KnapInPlot_YN	Yes/No	True/False	Are there knapweed plants within the plot?
PenInPlot_YN	Yes/No	True/False	Are there penstemon plants within the plot?
RoadCut_YN	Yes/No	True/False	Is the plot on a road cut?
TranDhold	Integer	Numeric	Tran_DateStamp identifier (for link with PenLem_Sub records)
Location_ID	GUID ReplicationID	Alphanumeric	Location_ID will be populated during data merging with master dB
Event_ID	GUID ReplicationID	Alphanumeric	Event_ID will be populated during data merging with master dB

(p) Table name: *PDA_tbl_Ext_subTransect*: PDA table sub-transect scale data collected at extensive (temporary) plots, one record per Lemhi Penstemon.

Field Name	Type	Format	Description
Tran_Cnt	Text	Up to 80 characters	TranNum and RosFlwCnt (from handheld)
TranID2	Text	Up to 50 characters	Duplicate PlotID for records imported from PDAs (non-editable backup to PlotID)
RecID	Autonumber	Numeric	Automatically generated unique identifier
Rosette_Cnt	Integer	Numeric	Count of Rosettes
Flower_Cnt	Integer	Numeric	Count of Flowers
Dist_Tran	Integer	Numeric	Distance (meters) along transect where penstemon is located
Side_Tran	Text	Up to 10 characters	Side of transect where penstemon is located
Notes	Text	Up to 150 characters	Notes about penstemon observation
TranDhold	Text	Up to 150 characters	Tran_DateStamp identifier (for link to Tran record)
EvObs_Ext_transect_ID	Integer	Number	Will be populated during data merging with master dB

(q) Table name: *PDA_tlb_Ext_subTransect_Knapweed*: PDA table data collected at sampled extensive (temporary) plots (continued), one record per spotted knapweed observation.

Field Name	Type	Format	Description
Tran_Cnt	Text	Up to 30 characters	Tran Number, Distance along transect, side of transect and knapweed count
TranID2	Text	Up to 30 characters	Duplicate PlotID for records imported from PDAs (non-editable backup of PlotID)
RecID	GUID ReplicationID	Alphanumeric	Automatically generated unique identifier
Knapwd_Cnt	Integer	Number	Number of spotted knapweed plants present
Dist_Tran	Integer	Number	Distance (meters) along transect where spotted knapweed is located
Side_Tran	Text	Up to 10 chracters	Side of transect where spotted knapweed is located
Notes	Text	Up to 150 characters	Notes about spotted knapweed observation
TranDhold	Text	Up to 150 characters	Tran_DateStamp identifier (for link to Tran record)
EvObs_Ext_Transect_ID	Integer	Number	EvObs_Ext_Transect_ID will be populated during data merging with the master dB

(r) Table name *tbl_VisitorCenter_Census*: This table holds data specific to observations of the visitor center sub-population.

Field Name	Type	Format	Description
VisitorCenterCensus_ID	GUID ReplicationID	Alphanumeric	Primary key, uniquely identifying each penstemon census record
Event_ID	Integer	Number	Event_ID foreign key to "tbl_Events"
Rosette_Cnt	Integer	Number	Count of rosettes (for individual plant)
Flower_Cnt	Integer	Number	Count of flowers (for indifical plant)
Census_Notes	Text	Up to 255 characters	Notes about visitor center census

Extensive Plot Data Entry

This protocol is set up for paperless field-data entry using personal assistant (PDA) handheld computers with Pendragon software. Custom data entry forms were created with Pendragon and loaded into the PDAs. The Pendragon data entry form has built in quality assurance components such as pick lists, form controls, and warnings to prevent missing data or illogical entries. Because this protocol is set up for paperless field data entry, extra care should be taken to review all plot data while the observers are in the field so that any inconsistencies or questions can be resolved without resorting to long-term memories.

The UCBN will provide database administration and maintenance, and maintain a copy of the annually-updated master database. Shortly, after completion of field work the Database Manager (or Data Technician) will transfer field data from the PDAs into a working copy of the project database. The project leads will then review all plot data using this working copy and address inconsistencies and errors before certifying the data.

Data Processing

Data processing is required prior to and after completion of the field season. The Data Manager (or Data Technician) will follow these steps provided below.

Software Install

- 1) Install and/or update Pendragon Forms 5.1 on PC and PDAs to be used for current field season. For instructions on the use of the software or software downloads go to <http://www.pendragonsoftware.com/forms3/>. The UCBN Data Manager will have all information on current licensing.

Uploading to PDAs (prior to field season)

All Lemhi penstemon Pendragon field forms are completed and are stored within the Pendragon Forms Manager. No editing to the design of field forms is necessary. However, if changes are needed or if more comprehensive instructions are needed to assist in the following steps, all Pendragon user manuals are located online at <http://www.pendragonsoftware.com/support/documentation/>.

- 1) In Pendragon Forms Manager administration update 'Users' to include the list of current PDA names (i.e., Juno_DM1) and 'Groups' to include all forms and tables (i.e., PenLem_PlotFixed) to be uploaded to PDAs.
- 2) Connect the Pendragon Forms Manager software, which contains the Lemhi penstemon monitoring field forms to the back-end MS Access database that contains the necessary look up tables (i.e., permanent and temporary plots, cover categories, observers and schools). Keep both the Pendragon Forms Manager and the MS Access database open for next several steps.
- 3) Connect PDA to PC. Windows Mobile Device Center will open new window. Select 'Connect without setting up device'.

- 4) In Pendragon Forms Manager 'Users', under user list select the user name of the PDA that is currently connected and in 'Groups' select the user group which contains the list of forms and tables to be uploaded.
- 5) In PDA connected to PC, select 'Forms 5.1' from windows drop down list. Select 'Sync' and then 'Sync Now'. Messages should list sync successful. If not, select 'Log' for information on why it might not have worked. If successful, turn off and disconnect PDA device.
- 6) Repeat steps 3-5 for all PDA devices to be used for field season.

Downloading to PC (after daily field collection)

The team leader or data manager must download and back up PDA field data daily.

- 1) Connect the Pendragon Forms Manager software, which contains the Lemhi penstemon monitoring field forms, to the back-end MS Access database that contains the blank table templates that field data will be downloaded into. Within these tables are set fields that must match the 'Field Mappings' in the form properties within Pendragon Forms Manager (refer to Pendragon Forms Manager manual for directions on Field Mappings). Keep both the Pendragon Forms Manager and the MS Access database open for next several steps.
- 2) Connect PDA to PC. Windows Mobile Device Center will open new window. Select 'Connect without setting up device'.
- 3) In Pendragon Forms Manager 'Users', under user list select the user name of the PDA that is currently connected.
- 4) In PDA connected to PC, select 'Forms 5.1' from windows drop down list. Select 'Sync' and then 'Sync Now'. Messages should list sync successful. If not, select 'Log' for information on why it might not have worked. If successful there should no longer be any plots listed under the 'Review' button within 'Forms 5.1' on PDA.
- 5) Repeat steps 2-4 for all PDA device with field data to download.
- 6) The back-end MS Access database connected to the Pendragon Forms Manager will now contain all downloaded field data from the PDA. These tables and data can now be transferred to the Lemhi Penstemon working database using the pre-built PDA- labeled tables within.

Intensive Plot Data Entry

The preferred method for data collection involves using the UCBN Lemhi penstemon 'front-end' Access database on a ruggedized table PC with Microsoft Windows operating system which allows data entry directly into the Access database 'back-end'. The data entry forms were designed to be self-guiding and allow real-time quality control. Accurate data recording is viewed as an essential step in the overall QA/QC process and care should be taken to review all plot data while the

observers are in the field so that any inconsistencies or questions can be resolved without having to rely on distant or hazy memories. Data entry should be a group effort, with a designated data entry crew member working the tablet PC. A ‘call and repeat’ method should be implemented where the observer calls out a value which is then repeated back by the crew member entering data.

Data Entry Form

Select Plot Location Being Entered - Not Designed for Location Info Editing

Plot ID: Hill_001

Plot Number Manual:

Event Type:

Date: 6/26/2013 Start (24Hr:Min): 13:29

UTM XY:

Contact: Role:

Quad Data | Sub Quads (Lemhi Rosette and Flower Entry) | Cover Points

Protocol Ver: PENLEM_1_0 Quad ID: 9B3F-464B-8472-E252EF87A4D0

Aspect (Deg): 184 Plot Notes:

Slope (Deg): 24 Cover Notes:

Plot on road cut?: NoRoadCut

Quadrant Left 1 (QuadL1 - Upper Left)

Penstemon in Quad (L1): No

Seedling Count (L1): 1

Knapweed Count (L1): 0

Quadrant Left 2 (QuadL2 - Upper Right)

Penstemon in Quad (L2): No

Seedling Count (L2): 2

Knapweed Count (L2): 0

Quadrant Left 3 (QuadL3 - Lower Left)

Penstemon in Quad (L3): Yes

Seedling Count (L3): 3

Knapweed Count (L3): 1

Quadrant Left 4 (QuadL4 - Lower Right)

Penstemon in Quad (L4): Yes

Seedling Count (L4): 1

Knapweed Count (L4): 0

Quadrant Right 1 (QuadR1 - Upper Left)

Penstemon in Quad (R1): No

Seedling Count (R1): 0

Knapweed Count (R1): 0

Quadrant Right 2 (QuadR2 - Upper Right)

Penstemon in Quad (R2): No

Seedling Count (R2): 0

Knapweed Count (R2): 0

Quadrant Right 3 (QuadR3 - Lower Left)

Quadrant Right 4 (QuadR4 - Lower Right)

Plot Scale Buttons:

Cover Data Buttons:

Cover Class Abbreviations

Bare Grd (BG) | Rock (Ro)

Forb (F) | Shrub (Sh)

Grass (Gr) | Soil Crust (SC)

Lemhi (LP) | Tree (Tr)

Litter (Li) | Wood (Wo)

Figure SOP6-2. Screen captures of UCBN Lemhi penstemon intensive plot digital data entry forms.

(a) Intensive plot data entry form landing page where data are collected at the quad level.

Data Entry Form - New Record - Select plot location being collected - New Data Entry for: Hill_001

Select Plot Location Being Entered - Not Designed for Location Info Editing

Plot ID: Add New record

Plot Number Manual:

Event Type: Change PlotID

Date: Start (24Hr:Min):

UTM XY: X: Y:

Quad Data: Cover Points

Add a person

Contact	Role
Jeff Lonneker	Note taker

Lemhi Rosette and Flower Entry for Plot: **Quadrant:**

Previous Year: First Year: Tag Number: New Tag/Lemhi:

Rosette Count: Flower Count: Rosette Count: Flower Count:

Browsed: Flower Blooms: Browsed: Flower Blooms:

Status: Status: Tag Num Control:

Plot Notes:

Plot SiteID, Rosette Cnt, Flower Cnt:

Summary of Lemhi Counts for Plot: **Last** **Edit Lemhi Record**

Subplot L1: L2: R1: R2: **Next**

Subplot L3: L4: R3: R4: **Previous** **Delete Lemhi Record**

Total Lemhi in Plot:

Plot Scale Buttons:

Finish record w Checks

Close Record w/No Checks

Delete Entire Plot Record

SubQuad Scale Buttons

Finish SubQuad / Add New Plant

Cover Data Buttons:

Add Cover Data

Finish Cover Data

Cover Class Abbreviations

Bare Grd (BG) | Rock (Ro)
 Forb (F) | Shrub (Sh)
 Grass (Gr) | Soil Crust (SC)
 Lemhi (LP) | Tree (Tr)
 Litter (Li) | Wood (Wo)

(b) Intensive plot data collection form which collects data at a sub quad level. Data specific to individual plants including tag number, rosette count and number of flowers are entered here.

Data Entry Form - New Record - Select plot location being collected - New Data Entry for: Hill_001

Select Plot Location Being Entered - Not Designed for Location Info Editing

Plot ID: Add New record

Plot Number Manual:

Event Type: Change PlotID

Date: Start (24Hr:Min):

UTM XY: X: Y:

Contact: Role:

Quad Data: Sub Quads (Lemhi Rosette and Flower Entry): Cover Points: Add a person

Point Number: Cover Type: Submit Cover Data

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

Plot Scale Buttons:

Finish record w Checks

Close Record w/No Checks

Delete Entire Plot Record

Cover Data Buttons:

Add Cover Data

Finish Cover Data

Cover Class Abbreviations

Bare Grd (BG)	Rock (Ro)
Forb (F)	Shrub (Sh)
Grass (Gr)	Soil Crust (SC)
Lemhi (LP)	Tree (Tr)
Litter (Li)	Wood (Wo)

(c) Intensive plot data collection form for capturing point intercept ground cover observations.

If multiple devices are used for field data collection the databases from those devices should be compiled into one 'intermediate' version. The tables listed below are updated with each plot surveyed and should have their new data carried over to the 'intermediate' version.

Table SOP6-2. Tables to be merged between field data collectors used at intermediate plots.

Table Name	Description
tbl_Events	Table stores data about each survey event
tbl_EvObs_Int_Quads	Quad scale data collection information
tbl_EvObs_Int_SubQuads	Sub quad level data, one record per Lemhi penstemon observation
tbl_EvCover_Normalized	Vegetative cover class values at each plot
tbl_inQuadsPenSeedlingKnapweed	Lemhi penstemon and spotted knapweed seedling count per quadrant
tbl_xref_Events_Contacts	Name of crew member entering data
tblu_Contacts	List of field crew members on hand for current field season

Attributing database fields using UCBN LinearExtract tools

UCBN has written Python code that will take input points (plot origins), convert them to lines along a specified azimuth (plot transect), convert the lines to a series of points (at defined intervals) and then extract summary statistics from any given raster based on those points. After each field season this code will be used to update the aspect and slope fields for the extensive plots. This code can also be used by data analysts to generate summary statistics for other datasets such as normalized burn ratios. This tool is important to generate representative average values of entire 100 m² belt transects.

To attribute slope and aspect, the general workflow is as follows:

1. Export extensive plot information from Access back-end being sure to include plotID, x/y location, azimuth and year of survey.
2. Import tabular data into ArcGIS, and convert data to shapefile.
3. Add a new field called “distance” that will hold the distance of the transect. For extensive plots, this field should be set to 50 to represent 50 meters.
4. Update the Python code with the appropriate paths to files and field names in the ‘User Parameters’ section.
5. Run the code.
6. The output will include a table which can be imported into Access and used in an update query to attribute the slope and aspect fields by using the unique plot ID field.

```
# -----
# LinearExtract.py
# Created on: 2015-03-17
# Description:
#
# Output: From defined point locations (i.e. transect starting points)
# applies a transect a defined distance and azimuth. Per transects raster
# values
# are extracted by converting the linear transect to points at a defined
# sampling distance. By transect summary values of
# "COUNT", "MAX", "RANGE", "MEAN", "MIN", "STD", "SUM", "FIRST", "LAST"
# are calculated per extracted raster.
# Output products are a linear transect feature class and a geodatabase table
# with summary values per transect and extracted raster.

#####
# User Parameters (Start)
#####

#Input File Paths and Field Names
inPts =
r'C:\Kirk\working\Lemhi\LinearExtract\Lemhi_DB_Spatial_20150313.gdb\Utm12N\Pl
ots_Extensive_All_w_Azimuth_gt2010' ## Point file with the transect starting
points
```

```

fId = "Plot_ID_Year"  ##Field in inPts dataset representing the unique ID for
the transect/plot for which summary statistics will be derived
fX = "UTMX"  ##Field in inPts dataset defining the x field
fY = "UTMY"  ##Field in inPts dataset defining the y field
fAzimuth = "Tran_Azim"  ##Field in inPts dataset defining the starting point
azimuth direction for the transect
fDistance = "Distance"  ##Field in inPts dataset defining the transect
distance

# Input sample distance
vertexDist = 1  ## Distance (i.e. meters) at which vertices will be created
during transect densification prior to converting derived transects to
points. This is sampling distance per transect at which raster value
extraction will occur.

# Input paths to rasters from which values will be extracted, be sure to
include the name that will be concatenated with the summary statistic type
(ie, "slope" will become "MEAN_slope", "RANGE_slope")
inRasList =
[[r'M:\VitalSign_Protocols\LemhiPenstemon\3_Implement\Data_Management\GIS_Dat
a_Working\NDVI\Output\NDVI_UTM_SampleFrame_IDWInfillShadow.tif',
'DNDVI_Fall2013'],[r'C:\Kirk\working\Lemhi\LinearExtract\biho_dem',
'Dem'],[r'C:\Kirk\working\Lemhi\LinearExtract\dem10_slop',
'Slope'],[r'C:\Kirk\working\Lemhi\LinearExtract\biho_aspect','Aspect']]

#Output and Workspace Parameters, these must be geodatabases
outName = "Lemhi_Transect_Summary"  ##Output name for the Transect Summary
Table
outGdb = r'C:\Kirk\working\Lemhi\LinearExtract\workspace\Test_Output.gdb'
##Output geodatabase
workspace = r'C:\Kirk\working\Lemhi\LinearExtract\workspace'  ## Workspace for
Processing
workGdb = r'C:\Kirk\working\Lemhi\LinearExtract\workspace\workGDB.gdb'  ##
Workspace Gdb
logFileName = workspace + "\\ExtractTransects_logFile.txt"  ##Logfile Name

#####
# User Parameters (End)
#####

#####
## Below are paths which are hard coded
#####
# Import system modules
import sys, string, os, arcgisscripting, math, arcpy, glob, traceback
from arcpy import env
from arcpy.sa import *

# Set Geoprocessing environments

```

```

arcpy.env.scratchWorkspace = workGdb
arcpy.geoprocessing.env.workspace = workGdb
arcpy.env.extent = inPts
arcpy.env.nodata = "PROMOTION"
#arcpy.env.snapRaster = energy

# Check out any necessary licenses
arcpy.CheckOutExtension("Spatial")
# Set overwrite files to True
arcpy.geoprocessing.env.overwriteOutput = True

#####
# Checking for working directories
#####

if os.path.exists(workspace):
    pass
else:
    os.makedirs(workspace)

#Check if Output Gdb exists
if os.path.exists(logFileName):
    pass
else:
    logFile = open(logFileName, "w")    #Creating log file if it doesn't
    exist
    logFile.close()

def timeFun():          #Function to Grab Time
    from datetime import datetime
    b=datetime.now()
    messageTime = b.isoformat()
    return messageTime
#####
##

def main():
    try:

        outTrans = outGdb + "\\Trasects_" + outName
        #Hit bearing tool to create linear transects for the defined azimuth
        BearingTool(outTrans)

        #Set spatial extent to transect extent
        arcpy.env.extent = outTrans

        #Density at a distance of 1 meter
        arcpy.Densify_edit(outTrans, "DISTANCE", vertexDist)

```

```

        messageTime = timeFun()
        print ("Successfully Densified Transect - " + outTrans + " - " +
messageTime)
        arcpy.AddMessage("Successfully Densified Transect - " + outTrans + "
- " + messageTime)

        outPoints = workGdb + "\\TransectPts_" + outName
        #Convert Vertices to Points and summarize
        arcpy.FeatureVerticesToPoints_management(outTrans, outPoints, "ALL")
        messageTime = timeFun()
        print ("Successfully converted transects to points - " + outPoints +
" - " + messageTime)
        arcpy.AddMessage("Successfully Converted Transects to Points - " +
outPoints + " - " + messageTime)

        #Extract the Raster in One Pass
        ExtractMultiValuesToPoints(outPoints, inRasList, "BILINEAR")
        messageTime = timeFun()
        print ("Successfully Extracted Raster Values to Points - " +
outPoints + " - " + messageTime)
        arcpy.AddMessage ("Successfully Extracted Raster Values to Points - "
+ outPoints + " - " + messageTime)

        #Summary Function to derive the Max, Min, Std, Averager, Median, etc.
        outDisList = DissolveFields(inRasList)

        #Perform Dissolve
        outDissolve = workGdb + "\\SummaryDisPts_" + outName
        arcpy.Dissolve_management(outPoints, outDissolve, fId, outDisList)
        messageTime = timeFun()
        print ("Successfully Calculated Summary Statistics via Dissolve tool
- " + outDissolve + " - " + messageTime)
        arcpy.AddMessage ("Successfully Calculated Summary Statistics via
Dissolve tool - " + outDissolve + " - " + messageTime)

        summaryTable = "SummaryTable_" + outName
        summaryTableFull = outGdb + "\\\" + summaryTable
        #Export Dissolve To Table
        arcpy.TableToTable_conversion(outDissolve, outGdb, summaryTable)
        messageTime = timeFun()
        print ("Exported Dissolve to stand alone summary table - " +
summaryTableFull + " - " + messageTime)
        arcpy.AddMessage ("Exported Dissolve to stand alone summary table - "
+ summaryTableFull + " - " + messageTime)

        #####
        #Clean up routine
        #####

```

```

arcpy.env.workspace = workGdb
datasetList = arcpy.ListTables("?", "")
for file in datasetList:
    try:
        arcpy.Delete_management(file)
    except:
        print "Failed to Delete " + str(file)
        print arcpy.GetMessages()
        traceback.print_exc(file=sys.stdout)

arcpy.env.workspace = workGdb
datasetList = arcpy.ListFeatureClasses("?", "")
for file in datasetList:
    try:
        arcpy.Delete_management(file)
    except:
        print "Failed to Delete " + str(file)
        print arcpy.GetMessages()
        traceback.print_exc(file=sys.stdout)

messageTime = timeFun()
print ("ExtractTransects.py Completed - " + summaryTableFull + " - "
+ messageTime)
arcpy.AddMessage("ExtractTransects.py Completed - " +
summaryTableFull + " - " + messageTime)
scriptMsg = "ExtractTransects.py Completed - " + summaryTableFull + "
- " + messageTime
logFile = open(logFileName, "a")
logFile.write(scriptMsg + "\n")
logFile.close()

except:
    messageTime = timeFun()
    scriptMsg = "Error ExtractTransects.py - " + messageTime
    print "Error ExtractTransects.py\nSee log file " + logFileName + "
for more details - " + messageTime
    logFile = open(logFileName, "a")
    logFile.write(scriptMsg + "\n")
    print arcpy.GetMessages()
    traceback.print_exc(file=sys.stdout)
    logFile.close()

#Function derives the Transects
def BearingTool(outTrans):

    try:

```

```

        arcpy.BearingDistanceToLine_management(inPts, outTrans, fX, fY,
fDistance, "METERS", fAzimuth, "DEGREES", "GEODESIC", fId)
        return outTrans
        messageTime = timeFun()
        arcpy.AddMessage("Successfully created - " + outTrans)
        print ("Successfully created - " + outTrans)

    except:
        messageTime = timeFun()
        print "Error on BearTool Function using input file - " + inPts
        print arcpy.GetMessages()
        traceback.print_exc(file=sys.stdout)
        sys.exit()

def DissolveFields(inRasList):
    try:

        sumList =
["COUNT", "MAX", "RANGE", "MEAN", "MIN", "STD", "SUM", "FIRST", "LAST"]

        outDisList = []
        #Loop thru the extracted rasters
        for ras in inRasList:
            field = ras[1]

            #Loop thru the desired summary statistics
            for stat in sumList:

                inFieldSum = []
                inFieldSum.append(field)
                inFieldSum.append(stat)
                #Append to Master Dissolve Summary Statistics Field List
                outDisList.append(inFieldSum)

        messageTime = timeFun()
        print ("Successfully Defined Dissolved Fields List " + messageTime)
        arcpy.AddMessage ("Successfully Defined Dissolved Fields List " +
messageTime)

        return outDisList
    except:
        messageTime = timeFun()
        print "Error DissolveFields function -" + messageTime
        print arcpy.GetMessages()
        traceback.print_exc(file=sys.stdout)
        sys.exit()

if __name__ == '__main__':

```

```

# Write parameters to log file -----
---
#####
# Checking for working directories
#####

if os.path.exists(workspace):
    pass
else:
    os.makedirs(workspace)

#Check for logfile

if os.path.exists(logFileName):
    pass
else:
    logFile = open(logFileName, "w") #Creating index file
    logFile.close()

# Analyses routine -----
main()

```

Quality Review

After the data have been entered and processed, they need to be reviewed by the project lead for quality, completeness, and logical consistency. The working database application will facilitate this process by using pre-built queries that check for data integrity, data outliers, missing values, and illogical values. The user will fix these problems and document the fixes. Not all errors and inconsistencies can be fixed, in which case the resulting errors are documented and included in the metadata and certification report.

Once data has been certified by the Project Lead and merged into the master database by the Data Manager (or Data Technician), analysis and annual reporting may proceed. The UCBN will manage and archive the master database.

Metadata Procedures

Data documentation is a critical step in ensuring that data sets remain useable for their intended purposes well into the future. This documentation involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog data sets within intranet and internet systems, making data available to a broad range of potential users. Metadata for the Lemhi penstemon monitoring data will conform to Federal Geographic Data Committee (FGDC) standards and NPS guidelines when applicable and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. The metadata requirements and standards described here also apply to other forms of data and information associated with the project including incidental photographs or videos, analyses, and reports. 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 require updating to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and describing any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the UCBN Data Management Plan. In general, the Project Lead and the Data Manager (or Data Technician) work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The Project Lead should update the metadata content as changes to the protocol are made, and each year as additional data are acquired. Edits within the document should be tracked so that any changes are obvious to those who will use it to update the XML metadata file. At the conclusion of the field season, the Project Lead will be responsible for providing complete, up-to-date metadata to the Data Manager (or, at a minimum, a completed metadata questionnaire that captures all of the required metadata information). The Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to national clearinghouses as described below.

Sensitive Information

Metadata development includes determining if the data contain sensitive information such as specific locations of rare, threatened, or endangered species, or cultural resources. In some cases, it may be necessary to restrict access to data containing sensitive information, except where a written confidentiality agreement is in place. The Project Lead and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager. Lemhi penstemon data are not sensitive and should not be treated as such. If cultural resources are encountered during the survey, work should be stopped immediately and park staff notified. No information about any cultural resource discoveries should be entered into the database. No personally identifiable information (PII) will be collected or stored in the database. Only the first name and last initial of the crew member entering information will be collected.

Data Certification and Delivery

Data certification is a benchmark in the project information management process that confirms 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies, which may not have been detected during quality assurance reviews.

To ensure that only data of the highest possible quality are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The project lead is responsible for completing certification. The completed certification form, certified data, and updated metadata should be delivered to the Data Manager as outlined in the following steps.

Data certification steps

To package the certification materials for delivery, the project lead will follow these steps:

- 1) After quality review of data in working database has been completed, open the back-end working database file and compact it (in Microsoft Access, Tools > Database Utilities > Compact and Repair Database), to make the file size much smaller.
- 2) 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.
- 3) Add the completed metadata and certification summary (e.g., summation of database records for which errors were corrected, for which errors cannot be corrected, etc.) to the compressed file.
- 4) Add any geospatial data files created for the current year's data.
- 5) All file names – except for image files and geospatial data files – should include the project code and the year or span of years for the data being certified. For example: PENLEM_2017_certified_backend.mdb, PENLEM_2017_cert_report.doc
- 6) The compressed file may then be submitted to the UCBN Data Manager.

Upon receiving the certification materials, the Data Manager will check them in, store them in the UCBN Digital Library, upload the certified data to the UCBN master project database, and update the project GIS data sets with any geospatial data that are submitted. Upon notification that the year's data have been uploaded and processed successfully, the Project Leader may then proceed with data summarization, analysis and reporting.

Data Archiving

Paper data-sheets, if used, will be archived indefinitely according to NPS policy and network Data Management Plans. In general, original paper data sheets will be archived and photocopied or scanned versions will be stored on the network digital file server(s).

Digital datasets are stored indefinitely, with local copies stored on UCBN file server and master datasets posted to the national Integrated Resource Management Application (IRMA) system. Upon certification, data and reports will be archived on the UCBN server, and all non-sensitive information posted to UCBN website. Each year, after all certified records have been merged into the master database, the project master database excluding sensitive information will be archived and posted to the national web-accessible IRMA system, thereby making it readily available to all networks and parks.

A review of archive and expendable data products will be undertaken by the Project Lead and Data Manager during season close-out each year. An example of an expendable data product is an intermediate draft of an annual report that was saved during report preparation.

Directory Structure

The project directory structure for organizing documents and data associated with this protocol will follow guidelines and policies established by the UCBN. These directives can be found in the network's Data Management Plan. The project directory structure should provide a foundation and a minimum standard of organization and consistency. The goal is to organize all project materials in an efficient hierarchical structure that reflects the life cycle and workflow of the project. Additional subfolders may be added as needed, but a strong emphasis must be placed on keeping the structure as simple and logical as possible.

Schedule of Data Management Tasks

Table SOP6-3. Yearly Lemhi Penstemon and Spotted Knapweed monitoring data management task list. The list includes task by project stage, who is responsible for the task and establishes timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Preparation	Notify Data Manager of needs (field maps, GPS support, training, changes to database or digital data collection forms)	Project Lead	ASAP, before Feb 1
	Perform GRTS draw for extensive plots	Project Lead or Data Manager	By May 1
	Prepare and print field maps for extensive plots	Data Manager	By May 31
	Load GRTS points onto GPS units and PDA devices	Data Manager	By May 31
	Load front-end/back-end databases onto field computers to be used for intensive plots	Data Manager	By May 31
Data Acquisition	Collect field observations	Technicians, volunteers, park staff, UCBN staff	June - July
	Review field data collection for completeness	Field lead, Project Lead, Data Manager	Daily, during field season
	Backup field data	Field lead, Project Lead, Data Manager	Daily, during field season
Data entry and processing	Review database entries for completeness and accuracy	Field Lead	After each tour
	Compile extensive and intensive field datasets into one, intermediate, dataset for the current field season	Field lead, Project Lead, Data Manager	After each tour
	Upload intermediate field dataset to master database copy	Data Manager	August
Interim product delivery	Report weed locations to park staff	Data Manager	As soon as possible after tour

Table SOP6-3 (continued). Yearly Lemhi Penstemon and Spotted Knapweed monitoring data management task list. The list includes task by project stage, who is responsible for the task and establishes timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Quality Review	Quality review and data validation using database tools	Project Lead and Data Manager	July – August
	Prepare coordinate summaries and/or GIS layers and datasets as needed for spatial data review and reporting	Project Lead and/or Data Manager	September 30
Metadata	Identify any sensitive information in the dataset	Project Lead, Data Manager, Park Resource Manager	August 31
	Update project metadata records (non-spatial and spatial datasets)	Project Lead	October 31
Data Certification	Certify current years data	Project Lead	September 30
Data Delivery	Deliver certified data, updated metadata and certification documents to Data Manager	Project Lead	September 30
	Upload certified data into master project database in both UCBN digital library and Data Store	Data Manager	November 30
	Notify Project Lead that data are uploaded and ready for analysis and reporting	Data Manager	November 30
Data Analysis	Sample site selection (GRTS draw) for upcoming field season	Project Lead or Data Manager	October 31
	Status and trend analysis	Project Lead and/or Data Analyst	October 31
Product Development	Export automated summary queries and reports from database	Project Lead and/or Data Analyst	September 1
	Generate report quality map output for reports	Data Manager and/or Data Analyst	September 30
	Acquire the proper report template from the NPS website, create draft resource brief	Project Lead and/or Data Analyst	November 15
	Screen all reports and data products for sensitive information	Project Lead and Park Resource Manager	November 30

Table SOP6-3 (continued). Yearly Lemhi Penstemon and Spotted Knapweed monitoring data management task list. The list includes task by project stage, who is responsible for the task and establishes timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Product Delivery	Submit draft resource brief to Network Coordinator for review	Project Lead	November 15
	Review brief for formatting and completeness, notify Project Lead of approval or need for changes	Network Coordinator	November 30
	Send completed resource brief to UCBN Data Manager	Project Lead	December 15
	Deliver other products according to delivery schedule and instructions	Project Lead	Upon completion
	Product check-in	Data Manager	Upon receipt
Posting and Distribution	Post certified field data for current year to IRMA	Data Manager	October 15
	Post reviewed and approved resource brief to UCBN website	Data Manager	December 15
	Send approved resource brief to park staff	Project Lead	December 15
Archival and Records Management	Store finished products in UCBN digital library	Data Manager	Upon receipt
	Review, clean up and store and/or dispose of files according to NPS Director's Order #19	Project Lead	December 30
	Update protocol information in Protocol Tracker	Data Manager	December 30
Season Close-out	Meet to discuss the recent field season and document any needed changes to the sampling protocol or working database	Project Lead, Park Resource Manager and Data Manager	July – August
	Discuss and document changes to analysis and reporting procedures	Project Lead, Park Resource Manager and Data Manager	October 30

Suggested Reading

- Dicus, G. H. and L. K. Garrett. 2007. Upper Columbia Basin Network Data Management Plan. National Park Service Upper Columbia Basin Network Inventory and Monitoring Program. Moscow, Idaho.
- Garrett, L. K., T. J. Rodhouse, G. H. Dicus, C. C. Caudill, and M. R. Shardlow. 2007. Upper Columbia Basin Network vital signs monitoring plan. Natural Resource Report NPS/UCBN/NRR—2007/002. National Park Service, Fort Collins, Colorado.
- Lonneker, J., and T. J. Rodhouse. 2017. Data Quality Standards for Population Monitoring Protocol for Lemhi Penstemon (*Penstemon lemhiensis*) and Spotted Knapweed (*Centaurea stoebe*) in Big Hole National Battlefield. Natural Resource Report NPS/UCBN/NRR—2017/XXX. National Park Service, Fort Collins, Colorado.
- National Park Service. 2006. Natural Resource Database Template Version 3.1 documentation. Natural Resource Program Center, Office of Inventory, Monitoring, and Evaluation, Fort Collins, Colorado.

Standard Operating Procedure 7: Data Analysis and Reporting

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

This SOP provides details of the recommended analytical and reporting guidelines for the UCBN Lemhi penstemon and spotted knapweed population monitoring program in Big Hole National Battlefield. Code written for the R statistical software and language environment is included. R is an open source version of S-Plus and is a powerful system for statistical computations and graphics which runs on Windows, Unix, and Mac computers. It can be downloaded for free from <http://www.r-project.org/>. The R Wiki provides an online forum <http://wiki.rproject.org/rwiki/doku.php> and documentation. R is one of the analytical environments of choice for the UCBN. Direct references to R commands in the text are distinguished by **Courier New Font** rather than Times New Roman, with arguments for the commands noted by closed parentheses (). Note that there are many other possible strategies for statistical analysis than those presented here. Over time the most useful and efficient strategies will be identified and incorporated into an updated version of this SOP.

The Negative Binomial – A Canonical Model for Overdispersed Counts of Lemhi Penstemon and Spotted Knapweed

We begin by developing a basic modeling framework for analyzing spatiotemporal changes in Lemhi penstemon and spotted knapweed populations. For both species, we envision underlying (latent) biotic and abiotic processes that generate counts of plants, seedlings, established plant rosettes and inflorescences, and of established plant mortality rates (counts of annual transitions from live to dead) within quadrats. We can model directly, or indirectly by proxy, some of these processes, for example by including slope, aspect, vegetation cover, and a prescribed fire treatment/control designation as explanatory variables into models, in addition to a variable for year (trend). Unmodeled processes contribute to overdispersion in counts. Inspecting the distribution of observed established plant counts (Figure 11 of the narrative), it is apparent that the negative binomial distribution provides a good model – there is too much overdispersion to make use of the Poisson distribution in which the variance is equal to the mean (Hilbe 2011). Following the parameterization recommended by Hilbe (2011) for negative binomial regression, we define the (vector of) counts of plants as $Y_i \sim \text{Negative-binomial}(\mu, \alpha)$, with mean $\mu = e^{X'\beta}$ and variance $\mu + \alpha\mu^2$, for which α is the overdispersion parameter. Note that the Poisson distribution can be considered a special case of the Negative Binomial distribution as overdispersion approaches 0 and the variance reduces to μ . The regression predictors $X'\beta$ (e.g., year and slope) are linearly related to the mean on the log scale via the negative binomial link function such that exponentiated regression coefficients are interpreted in terms of a multiplicative change in the population growth rate, λ , for each unit change in a given predictor (holding all other predictors included in the model constant). This modeling strategy provides a natural connection to the monitoring and sampling hypotheses and objectives. It provides flexibility for addressing questions about the influence of prescribed fire, and environmental factors such as slope because they also can be included as regression predictors. Model 1 describes such an approach for extensive plot data:

$$\log(\mu) = \beta_0 + \beta_1 * \text{HorsePasture} + \beta_2 * \text{Slope} + \beta_3 * \text{RxFire} + \beta_4 * \text{Year}, \quad [1]$$

where HorsePasture and RxFire represent indicator variables that provide additional parameters so that different means (intercepts) between counts in the Howitzer Hill and Horse Pasture and between burned and unburned plots can be estimated. This is analogous to the analysis of covariance (ANCOVA) strategy. Temporal trend is modeled as a deterministic linear fixed effect. The `glm.nb` function in the *MASS* library (Venables and Ripley 2002) in R is one way to construct and fit such a model. Note that this modeling strategy does not account for the sampling design inclusion probabilities (GRTS weights), in this case acceptable because of the equal probability design used within hillslope frames, and the inclusion of an indicator variable and parameter adjustment (a de facto weighting) for hillslope strata membership.

A similar approach will be used to model change in the seedling rate (γ) from seedling counts and in other measures obtained from intensive plots including mortality rate of established plants ($1-\Phi$) modeled with counts of annual live-to-dead transitions. However, these plots are permanent, creating a repeated-measures scenario in which counts from plots are highly correlated, much more so than any among-plot correlation. This necessitates the construction of a mixed-effects or hierarchical model (Gelman and Hill 2007) in which counts are grouped within plots, as described by Model 2:

$$y_{j[i]} \sim \text{Negative-Binomial}(\mu_{j[i]}, \alpha), \quad [2]$$

$$\log(\mu_{j[i]}) = \beta_{0j} + \beta_1 * \text{Slope} + \beta_2 * \text{RxFire} + \beta_{3j} * \text{Year}_{j[i]},$$

$$\beta_j \sim N(\mu_\beta, \sigma_\beta^2),$$

where $y_{j[i]}$ is the observed i th count, from $1, \dots, n$, $n = \text{years} \times \#$ of permanent intensive plots, nested within j plots from $1, \dots, 42$. This is a random-intercept, random-slope type of hierarchical regression model (Gelman and Hill 2007). The count-generating process has a characteristic mean, $\mu_{j[i]}$, for each count, that is modeled on the log scale as a linear combination of the intercept β_{0j} and Year β_{3j} that vary among plots (the random effects), after accounting for fundamental differences in slope and prescribed fire treatment (β_1 and β_2 fixed effects). The intercept and year parameter vary among plots according to a normal distribution each with mean, μ_β , and variance, σ^2 . Note that the two μ_β parameters provide overall estimates of the mean count and the mean year effect for the entire population, whereas β_{0j} and β_{3j} provide means and year effect estimates for each of the 42 permanent plots. This parameterization accounts for the correlation of within-plot counts over time. It does not appear necessary to also describe random effects for Slope and RxFire although this can easily be done if a motivating hypothesis is proposed. This model describes a plausible ecological scenario of annual count-generating processes for each permanent intensive plot, drawn from a common population-level mean and variance. The selection of intensive plots from the 2011 GRTS sample supports population-level inferences and further motivates the use of the random effects model for intensive plots. Note that Negative Binomial random effects models cannot be fitted in the *MASS* package. The *glmmADMB* library in R (Fournier et al. 2012, Skaug et al. 2014) provides this capability.

Statistical Power to Detect Changes Over Time

We considered simple sample size equations that rely on large-sample asymptotic normal approximations provided by Elzinga et al. (1998:346-354). Based on annual estimates of variance (s^2) from pilot surveys, the precision (% of mean, 90% confidence interval half-width) for estimating the mean number of established plants per 100-m² extensive plot with a sample size of 300 was 37%, or approximately 0.37 plants. For estimating the population total, using an estimate of s^2 obtained from the more efficient “local” GRTS estimator (Stevens and Olsen 2003), the estimated precision was 2%. The estimated minimum detectable change in the difference between two years of population total estimates using the 300 extensive (temporary) plots was 5%, or 140 plants. The estimated minimum detectable change in the difference between two years in mean established penstemon plant counts for the 42 paired 2-m² intensive plots was 20%, or approximately 0.61 plants.

We also simulated data from the negative binomial distribution and estimated power to detect declines with $\alpha = 0.1$ (Type I error) using parameter values and error estimates from trend models fitted to existing pilot data. Although we did not exhaustively explore different scenarios, we found ample evidence that our sample sizes are sufficient to detect declines of 10% per year or greater over 10 years with both extensive and intensive plot data. For example, using a generalized linear mixed model with random intercept and slope effects for each of the 42 permanent intensive plots (repeated measures induced serial correlation) with negative binomial error, power was estimated at 92% (Type I false change error $\alpha = 0.1$, Type II missed change error $\beta = 0.20$). R code to duplicate this procedure is provided here:

```
#####
#UCBN R Script - Lemhi penstemon and spotted knapweed population trend
#monitoring - power analysis
#For Big Hole National Battlefield
#Updated August 16, 2014
#####

#Purpose: Estimate simulated power to detect declines under fixed sample
#sizes with estimates or
#error from pilot data, under assumed negative binomial model.

#####
#Load packages
library(MASS)
library(glmmADMB) #for fitting GLMMs
library(coefplot) #for plotting results
library(bbmle)    #for comparing models
#####
#Intensive plot data
#####
#Step 1: Import dataset. Example based on 2009-2014 certified data

data<-read.table("UCBN_Penstemon_IntensivePlots_2012-
2014_Certified.txt",header=T)

#Works best to rename data
Slope<-as.vector(scale(data$Slope))
Year<-as.factor(data$Year)
```

```

Penlem<-data$Plants
PlotID<-as.factor(data$PlotID)

#Step 2: Fit basic trend model to pilot data

m1<-glmmadmb(Penlem~Year+(1|PlotID),zeroInflation=FALSE,family="nbinom")
sumary(m1)

Call:
glmmadmb(formula = Penlem ~ Year + (1 | PlotID), family = "nbinom",
  zeroInflation = FALSE)

AIC: 524.1

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)   0.8468      0.1550    5.46 4.6e-08 ***
Year2013       0.0229      0.1555    0.15  0.88
Year2014       0.0194      0.1556    0.12  0.90
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Number of observations: total=126, PlotID=42
Random effect variance(s):
Group=PlotID
              Variance StdDev
(Intercept)   0.4429 0.6655

Negative binomial dispersion parameter: 8.8913 (std. err.: 4.0512)

Log-likelihood: -257.052

#Use 0.84 (0.15) as mean and sd for drawing intercept coefficients
#Use 8 or smaller values for theta (note used 1 below, increased dispersion)

#####
#Step 3:
#####
#Power simulation

#Establish number of plots and years
n.plots<-42
n.years<-10
n<-n.plots*n.years
pop<-gl(n=n.plots,k=n.years)

#Scale year
original.year<-rep(1:n.years,n.plots)
year<-(original.year-1)/9

#Create the design matrix
Xmat<-model.matrix(~pop*year-1-year)
Xmat<-model.matrix(~pop*year)
print(Xmat[1:50],dig=2)

```

```

#Parameterize the slope and intercept, and random effects for plots
#("subjects" upon which repeated measures are taken)
intercept.mean<-.85
intercept.sd<-.15
slope.mean<-.1
slope.sd<-.05
intercept.effects<-rnorm(n=n.plots,mean=intercept.mean,sd=intercept.sd)
slope.effects<-rnorm(n=n.plots,mean=slope.mean,sd=slope.sd)
all.effects<-c(intercept.effects,slope.effects)

#Generate data and plot
lin.pred<-Xmat[, ]%*%all.effects
C<-rnbino(m=n,n.size=8,mu=exp(lin.pred))
hist(C,col="gray",main="20 years of simulated pentstemon counts",xlab="# of
Plants", ylab="# of Plots",
cex.axis=1.2,cex.main=1.2,cex.lab=1.5)

its<-100
sims<-matrix(0,ncol=2,nrow=its)

for (i in 1:its){

  intercept.effects<-rnorm(n=n.plots,mean=intercept.mean,sd=intercept.sd)
  slope.effects<-rnorm(n=n.plots,mean=slope.mean,sd=slope.sd)
  all.effects<-c(intercept.effects,slope.effects)

  lin.pred<-Xmat[, ]%*%all.effects
  C<-rnbino(m=n,n.size=8,mu=exp(lin.pred))

  m1<-glmmadmb(C~year+(1+year|pop),zeroInflation=FALSE,family="nbinom")

  sims[i,1]<-fixef(m1)[2]

  vc <- vcov(m1, useScale = FALSE)
  b <- fixef(m1)
  se <- sqrt(diag(vc))
  z <- b / sqrt(diag(vc))
  P <- 2 * (1 - pnorm(abs(z)))

  sims[i,2]<-P[2]

}

power=sum(sims[,2]<0.1)/its
power
#0.92 for decline of -0.10 per year over 10 years
#####
#End Script
#####

```

Annual Status Analysis

Status results will be summarized and reported in an NPS Natural Resource Technical Report or Data Series report (<http://www.nature.nps.gov/publications/nrpn/>) each October following field work. Four annual reports (Stucki and Rodhouse 2009, Rodhouse 2016, Rodhouse and Stucki 2013a,

2013b) from pilot surveys are available templates for future reports. Point estimates and 95% confidence intervals for Lemhi penstemon and spotted knapweed population totals (N) from extensive plot survey data are obtained using the Horvitz-Thompson estimator and the modified Horvitz-Thompson “local” variance estimator developed for GRTS surveys (Stevens and Olsen 2003, 2004). The *spsurvey* library (Kincaid and Olsen 2012) in the R statistical software environment (R Development Core Team 2013) makes these calculations quick and accessible. A summary table of survey and population attributes similar to those provided by Rodhouse (2016) or published in Stucki et al. (2013), that include the total number of plots surveyed, number of penstemon and knapweed plants counted, and frequencies and averages per plot, will also be routinely reported. Summaries of intensive plot data will be reported similarly. These simple summaries can be used in State of the Parks reporting, resource briefs, and other interpretive media. Figure 10 of the narrative shows the annual status estimates for Lemhi penstemon and spotted knapweed population sizes generated with *spsurvey* from extensive-plot data from 2009-2017. R code to produce population estimates using an example for data from 2009-2014 and a graph similar to Figure 10 is included here. Summaries of annual visitor center subpopulation censuses can be included with these summaries, although note that because these counts are generated from a census rather than a sample, no estimate of uncertainty is possible (i.e., no error bars), as illustrated in Figure SOP7-1 with a summary bar graph of census counts through 2017.

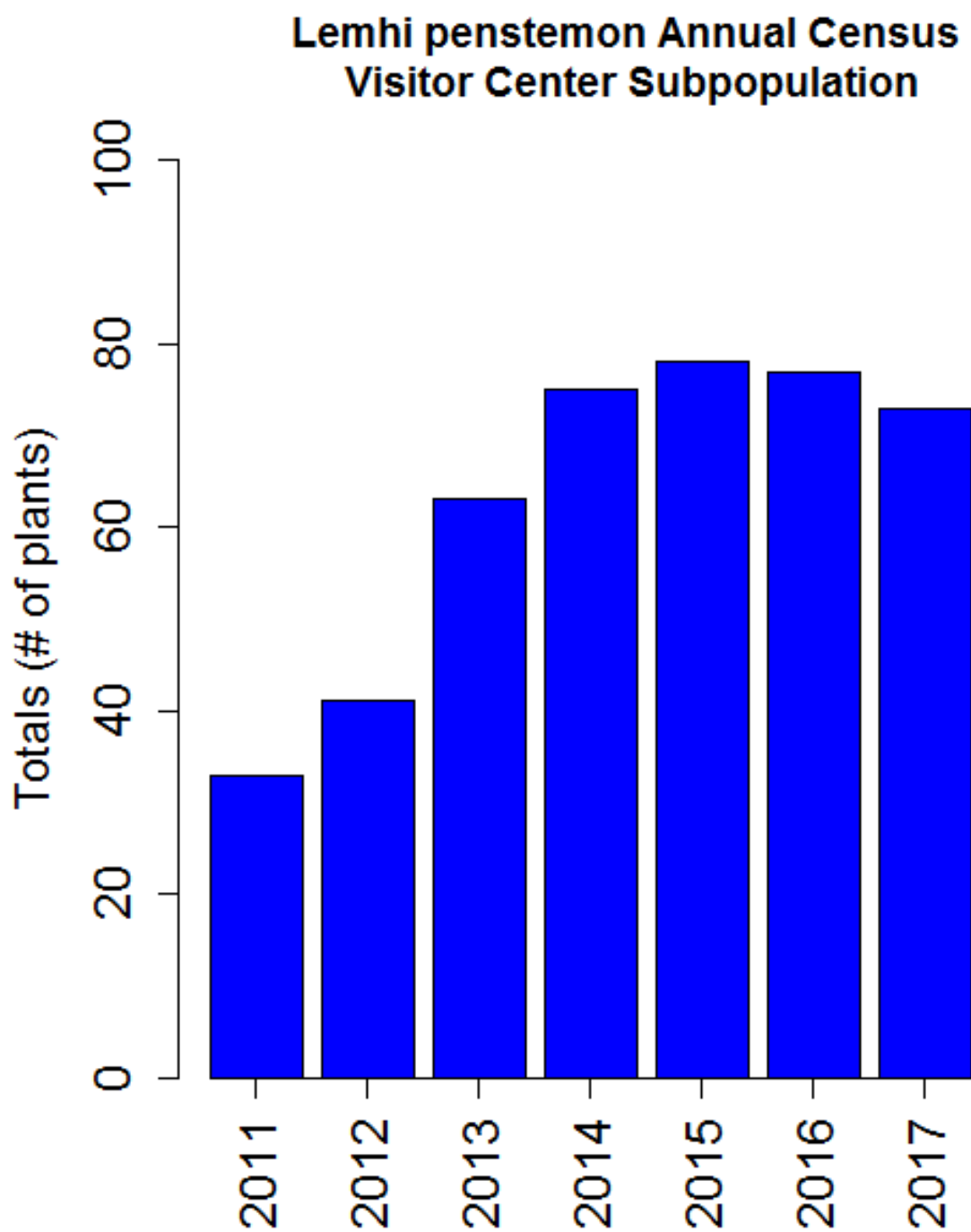


Figure SOP7-1. Bar graph of visitor center Lemhi penstemon subpopulation summaries.

```
#####
#UCBN R Script - Lemhi penstemon and spotted knapweed population monitoring
#For Big Hole National Battlefield
#Updated August 16, 2014
```

```
#####
```

```
#Purpose: Estimate population means and totals from extensive plot data  
#NOTE: Using spsurvey library to estimate "local" GRTS variance estimator
```

```
#Step 1: Import dataset. Example based on 2009-2014 certified data
```

```
data<-read.table("BIHO_PENLEM_2009-  
2014_ExtensivePlots_Certified.txt",header=T)
```

```
names(data)  
#[1] "Plot"           "PlotNum"           "SAMPLE_YR"         "X"  
#[5] "Y"             "Roadcut"           "Stratum"           "wgt"  
#[9] "Aspect"        "Slope"             "KnapCount"         "Plants"  
#[13] "Rosettes"      "Rosettes_Plants"  "Flowers"           "Flowers_Plants"
```

```
#X and Y are UTM coordinates for extensive plot (belt transect) origin  
#Roadcut is an indicator variable for plots that fall within or cross the  
#Howitzer Hill roadcut  
#Stratum is an indicator for hillslope (Howitzer Hill or Horse Pasture)  
#wgt is GRTS design weight. The realized (post-hoc) weight is frame  
#area/sample size  
#Note that frame area is scaled to 100 m^2 area of each plot.  
#With target sample sizes of n_Horse=200 and n_Howitzer=100, weights are  
#13.28 and 6.3.  
#Note that since 2011 frame areas (in plot units) have been stable at 2657  
#(Horse) and 630 (Howitzer)  
#Note in 2010 we explored adaptive sampling and incorporated the non-adapted  
#plots drawn from SRS with  
#a GRTS draw for comparison. Hence the set of 4 weights instead of two.
```

```
#Use table(data$wgt,data$SAMPLE_YR) to see all weights and sample sizes by  
#year.
```

```
#Step 2: run estimation with spsurvey
```

```
library(spsurvey) #Load the library
```

```
data.saved<-data #create a temporary dataset  
data<-data.saved[data$SAMPLE_YR=='2014',] #create a slice for each year
```

```
#Estimate spotted knapweed means and totals:
```

```
total.est(data$KnapCount,wgt=data$wgt,stratum=as.factor(data$Stratum),  
popsize=c("Horse"=2657,"Hill"=630),x=data$X,y=data$Y,vartype="Local",  
support=rep(1,times=length(data[,1])),pcfsize=c("Horse"=2657,"Hill"=630),  
popcorrect=T)
```

```
#Results output
```

	Statistic	NResp	Estimate	StdError	LCB95Pct	UCB95Pct
1	Total	300	2266.3400000	612.4134561	1066.0316824	3466.648318
2	Mean	300	0.6896653	0.1863800	0.3243673	1.054963
3	Variance	300	14.2303150	6.6429295	1.2104124	27.250218
4	Std. Deviation	300	3.7576507	0.8492826	2.0930874	5.422214

```
#Repeat for each year and for data$PenLem (penstemon counts)
```

```
#####
#To create bar chart used in annual reports

#Penstemon estimates and CIs (from previous step)

Yr09<-c(690,1362.5612070,2034)
Yr10<-c(974.7690492,1618.7487900,2262.728531)
Yr11<-c(1816,2973.9047164,4131)
Yr12<-c(1838.1328995,2424.1519145,3010.170930)
Yr13<-c(2098.0889422,2688.4500000,3278.8110578)
Yr14<-c(2872,3642,4412)

#knapweed estimates

Yr09<-c(0,243.56250300,622)
Yr10<-c(285.15572202,784.6330300,1284.1103380)
Yr11<-c(945,2784.0209930,4622)
Yr12<-c(13568.825138,17395.358997,21221.892856)
Yr13<-c(1250.7044864,1889.4000000,2528.0955136)
Yr14<-c(1066,2266,3466)

pen.total<-c(1362,1618,2973,2424,2688,3642)
pen.lower<-c(690,974,1816,1838,2098,2872)
pen.upper<-c(2034,2262,4131,3010,3278,4412)

knap.total<-c(243,784,2784,17395,1889,2266)
knap.lower<-c(0,285,945,13568,1250,1066)
knap.upper<-c(622,1284,4622,21221,2528,3466)

library(Hmisc) #need this library for barplot

totals<-numeric(12)
lowers<-numeric(12)
uppers<-numeric(12)
totals[(1:12%%2)==0]<-pen.total
totals[(1:12%%2)==1]<-knap.total
lowers[(1:12%%2)==0]<-pen.lower
lowers[(1:12%%2)==1]<-knap.lower
uppers[(1:12%%2)==0]<-pen.upper
uppers[(1:12%%2)==1]<-knap.upper

names=c("", "2009", "", "2010", "", "2011", "2012", "2013", "2014")
par(mar=c(5, 5, 4, 2) + 0.1)
barplot(totals,col=rep(c("red","blue"),12),names="",xlab="Year",
ylab="Totals (# of plants) and 95% Confidence
Intervals",axes=TRUE,axisnames=TRUE,
ylim=c(0,25000),cex.lab=1.4,cex.axis=1.5)

axis(1,c(1.3,3.7,6.1,8.5,10.9,13.3),labels=c("2009","2010","2011","2012","2013",
"2014"),
cex.axis=1.5)
abline(h=0,lwd=1)

errbar(c(0.7,1.9,3.1,4.3,5.55,6.75,7.9,9.1,10.4,11.5,12.7,13.9),totals,uppers,
lowers,
add=T,pch=18,lwd=2)
```

```
legend(0,25000,c("spotted knapweed","Lemhi  
penstemon"),fill=c("red","blue"),cex=1.5,bg="gray")
```

```
#####  
#End of Script  
#####
```

Trend Analysis

Modeling Counts of Abundance, Germination, and Mortality

Trend analyses will be conducted on a periodic basis as data become available. We demonstrate analyses using the 2009-2014 extensive plot data and the 2012-2014 intensive plot data here. Rodhouse (2016) provides a more thorough example for the 2009-2014 period of study. We estimate population change over time using generalized linear mixed models with a negative binomial link function appropriate for the overdispersed counts of plants in plots. The mixed-modeling strategy allows us to estimate random effects for repeated observations made within the intensive permanent plots over time and account for the serial correlation that is induced from repeated measures. In the following R script we demonstrate trend analyses with the `glm.nb` function in the *MASS* library (Venables and Ripley 2002) and with the *glmmADMB* library (Fournier et al. 2012, Skaug et al. 2016):

The following R script demonstrates a trend model for extensive plots over 2009-2014. Note that θ is the estimated dispersion parameter. The results from the models of extensive plot data indicate that mean established Lemhi penstemon counts are lower in the Horse Pasture than in the Howitzer Hill, and increase with increasing slope steepness and have also increased consistently over time, at an approximate average annual rate of $\exp(0.29) = 1.33$, or 33%. However, spotted knapweed counts also increased substantially from the start of the study in 2009 (although note that in recent years a marked decline since the worrisome peak in 2012). Note that spotted knapweed appears to decline along the hillslope steepness gradient (Figure SOP7-2), a pattern opposite of that observed for Lemhi penstemon. Spotted knapweed increased dramatically in the Horse Pasture over the study period, but the negative quadratic term indicates the apparent abatement in the infestation following 2012 (Figure 10).

Results from the intensive plot models indicate that counts of plants, rosettes, and seedlings all increase along the slope steepness gradient but over the 3-yr period considered here (2012-2014) only rosette counts appear to have trended upward. Note that modeling was not demonstrated for spotted knapweed in intensive plots due to being too rarely encountered. Figure SOP7-2 illustrates the use of the *coefplot* library (Lander 2013) for quick plotting of fixed effects estimates from a negative binomial regression model for spotted knapweed trend over time and along the hillslope steepness gradient with a quadratic term included to account for the apparent steep increase and then decrease in spotted knapweed after BIHO park managers redoubled efforts to control the infestation with herbicides (Figure 10). An interaction term is also included to illustrate how the increase in knapweed over the study period was particularly pronounced in the Horse Pasture. Note that in the following R script demonstrating trend analysis for intensive plots, an indicator variable for the first 10 plots anticipated to be burned in fall of 2014 was included. Exploratory data analysis with boxplots comparing means, medians, and quartiles between these treatment plots ($Rx_Burn = 1$) and control plots ($Rx_Burn = 0$) did not differ. We therefore do not include this variable in example trend models but note that this is how analysis of covariance will be accomplished. It is reassuring to see evidence of no difference in treatment means prior to treatment, suggesting the sampling design has provided for representative samples in both experimental groups.

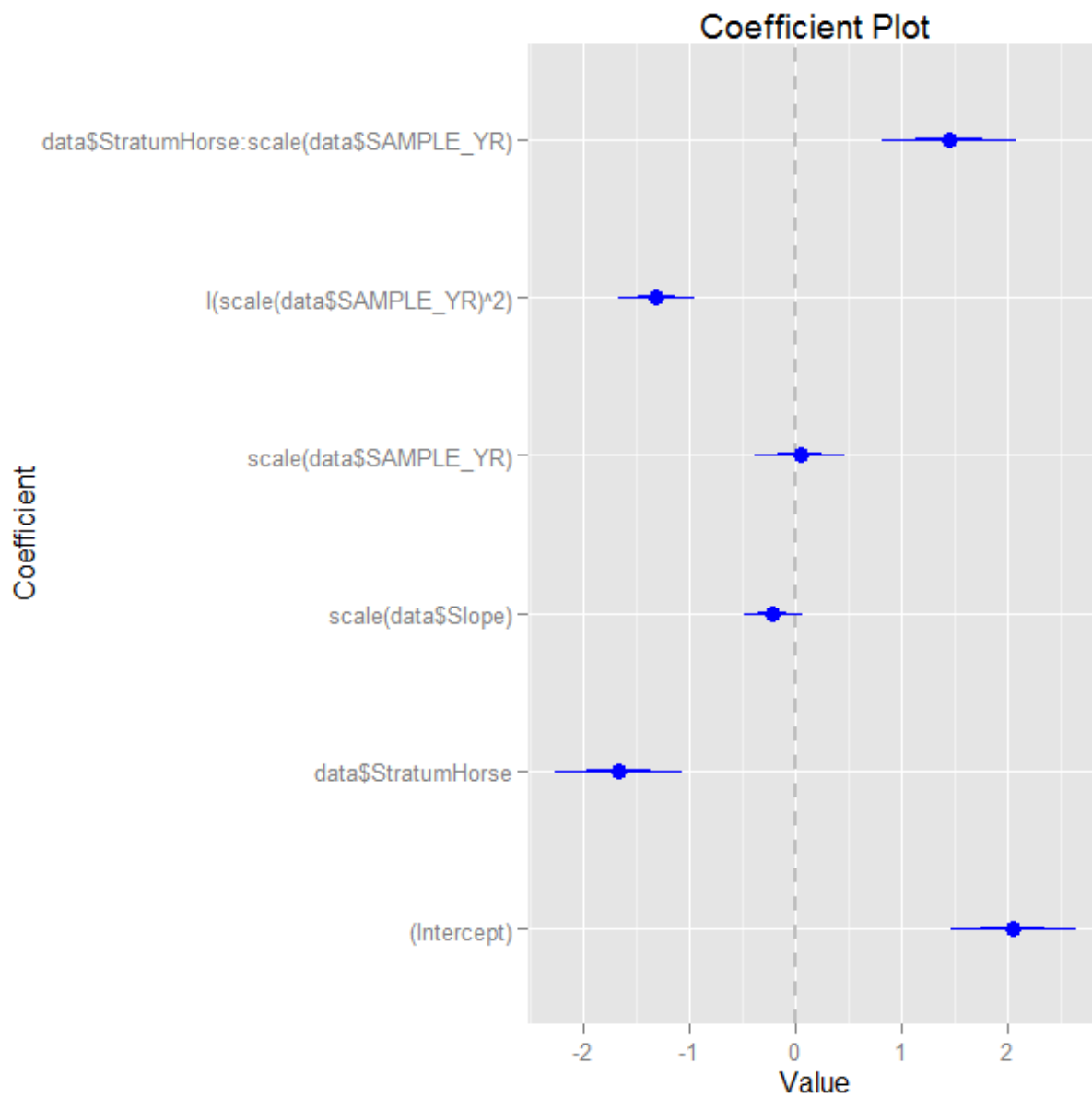


Figure SOP7-2. Estimated fixed effects estimates from a regression model for spotted knapweed from extensive plot data, including a quadratic term for curvilinear trend over time, and an interaction term between hillslope and temporal trend.

```
#####
#UCBN R Script - Lemhi penstemon and spotted knapweed population trend
#monitoring
#For Big Hole National Battlefield
#Updated August 16, 2014
#####

#Purpose: Estimate population trend over time from extensive and intensive
#plot data

#Load packages
library(MASS)
library(glmmADMB) #for fitting GLMMs
library(coefplot) #for plotting results
library(bbmle)    #for comparing models

#Step 1: Import dataset. Example based on 2009-2014 certified data

data<-read.table("BIHO_PENLEM_2009-
2014_ExtensivePlots_Certified.txt",header=T)

names(data)
#[1] "Plot"           "PlotNum"         "SAMPLE_YR"       "X"
#[5] "Y"             "Roadcut"         "Stratum"         "wgt"
#[9] "Aspect"        "Slope"           "KnapCount"       "Plants"
#[13] "Rosettes"      "Rosettes_Plants" "Flowers"         "Flowers_Plants"

m1<-glm.nb(data$Plants~data$Stratum+scale(data$Slope)+scale(data$SAMPLE_YR))
summary(m1)
#####
#Pasted results:

Call:
glm.nb(formula = data$Plants ~ data$Stratum + scale(data$Slope) +
scale(data$SAMPLE_YR), init.theta = 0.1703339502, link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.1611  -0.7726  -0.7003  -0.5188   3.7841

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)    0.20426    0.10891   1.876   0.0607 .
data$StratumHorse -0.78090    0.13971  -5.589 2.28e-08 ***
scale(data$Slope)  0.30211    0.06586   4.587 4.49e-06 ***
scale(data$SAMPLE_YR) 0.29047    0.06794   4.276 1.91e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.1703) family taken to be 1)

Null deviance: 1007.03 on 1654 degrees of freedom
Residual deviance: 949.87 on 1651 degrees of freedom
AIC: 3442

Number of Fisher Scoring iterations: 1
```

```

          Theta:  0.1703
        Std. Err.: 0.0122

2 x log-likelihood:  -3432.0190

#####
#Compare with reduced model with no year trend

m2<-glm.nb(data$Plants~data$Stratum+scale(data$Slope))
summary(m2)

#Likelihood ratio test of m1 and m2:
anova(m1,m2)
#####
Response: data$Plants

                                Model      theta Resid.
df
1                                data$Stratum + scale(data$Slope) 0.1644685
1652
2 data$Stratum + scale(data$Slope) + scale(data$SAMPLE_YR) 0.1703340
1651
      2 x log-lik.   Test    df LR stat.      Pr(Chi)
1      -3450.546
2      -3432.019 1 vs 2      1 18.52693 1.675209e-05

#Note ample evidence for positive trend over 5-yr study period in established
plants

#####
#Spotted knapweed trend
#####

m1<-
glm.nb(data$KnapCount~data$Stratum+scale(data$Slope)+scale(data$SAMPLE_YR)+da
ta$Stratum:scale(data$SAMPLE_YR) )
summary(m1)

Call:
glm.nb(formula = data$KnapCount ~ data$Stratum + scale(data$Slope) +
      scale(data$SAMPLE_YR), init.theta = 0.03157588079, link = log)

Deviance Residuals:
      Min       1Q   Median       3Q      Max
-0.6036  -0.5108  -0.4755  -0.4415   2.4508

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)      0.5316    0.2378   2.235 0.025415 *
data$StratumHorse -0.3815    0.2974  -1.283 0.199589
scale(data$Slope) -0.3117    0.1462  -2.132 0.032969 *
scale(data$SAMPLE_YR) 0.5539    0.1428   3.879 0.000105 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.0316) family taken to be 1)

```

Null deviance: 433.06 on 1654 degrees of freedom
 Residual deviance: 424.84 on 1651 degrees of freedom
 AIC: 2387

Number of Fisher Scoring iterations: 1

Theta: 0.03158
 Std. Err.: 0.00272

2 x log-likelihood: -2377.01000

#Look at quadratic year trend based on inspection of Figure 7 annual status estimate bar chart.

```
m2<-
glm.nb(data$KnapCount~data$Stratum+scale(data$Slope)+scale(data$SAMPLE_YR)+I(
scale(data$SAMPLE_YR)^2))
summary(m2)
```

Call:
 glm.nb(formula = data\$KnapCount ~ data\$Stratum + scale(data\$Slope) +
 scale(data\$SAMPLE_YR) + I(scale(data\$SAMPLE_YR)^2), init.theta =
 0.03582706573,
 link = log)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-0.6245	-0.5168	-0.4917	-0.4031	3.7603

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	1.6707	0.2842	5.879	4.12e-09	***
data\$StratumHorse	-1.1609	0.2871	-4.043	5.28e-05	***
scale(data\$Slope)	-0.1448	0.1389	-1.043	0.297169	
scale(data\$SAMPLE_YR)	0.5136	0.1415	3.630	0.000284	***
I(scale(data\$SAMPLE_YR)^2)	-0.9750	0.1566	-6.228	4.72e-10	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.0358) family taken to be 1)

Null deviance: 478.23 on 1654 degrees of freedom
 Residual deviance: 431.25 on 1650 degrees of freedom
 AIC: 2353.5

Number of Fisher Scoring iterations: 1

Theta: 0.03583
 Std. Err.: 0.00314

Warning while fitting theta: alternation limit reached

2 x log-likelihood: -2341.49800

#Look at interaction between knapweed trend and hillslope (having noted the substantial increase in

```

#the Horse Pasture during surveys)

m3<-
glm.nb(data$KnapCount~data$Stratum+scale(data$Slope)+scale(data$SAMPLE_YR)+
I(scale(data$SAMPLE_YR)^2)+data$Stratum:scale(data$SAMPLE_YR) )
summary(m3)

Call:
glm.nb(formula = data$KnapCount ~ data$Stratum + scale(data$Slope) +
scale(data$SAMPLE_YR) + I(scale(data$SAMPLE_YR)^2) +
data$Stratum:scale(data$SAMPLE_YR),
init.theta = 0.03726106309, link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.6612  -0.5447  -0.4793  -0.3464   3.4849

Coefficients:
                                Estimate Std. Error z value Pr(>|z|)
(Intercept)                   2.0538     0.2957   6.946 3.76e-12
data$StratumHorse              -1.6659     0.2986  -5.580 2.41e-08
scale(data$Slope)              -0.2098     0.1381  -1.519   0.129
scale(data$SAMPLE_YR)          0.0499     0.2122   0.235   0.814
I(scale(data$SAMPLE_YR)^2)     -1.3041     0.1801  -7.242 4.43e-13
data$StratumHorse:scale(data$SAMPLE_YR)  1.4592     0.3171   4.602 4.19e-06

(Intercept)                    ***
data$StratumHorse              ***
scale(data$Slope)
scale(data$SAMPLE_YR)
I(scale(data$SAMPLE_YR)^2)      ***
data$StratumHorse:scale(data$SAMPLE_YR) ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.0373) family taken to be 1)

Null deviance: 493.12  on 1654  degrees of freedom
Residual deviance: 428.25  on 1649  degrees of freedom
AIC: 2339.6

Number of Fisher Scoring iterations: 1

Theta: 0.03726
Std. Err.: 0.00325
Warning while fitting theta: alternation limit reached

2 x log-likelihood: -2325.56000

AICtab(m1,m2,m3) #Note m3 has lowest AIC (also note convergence issues -
these are complex models,
#take results with many salt grains and respect George Box's famous quote
about models!)

coefplot(m3) #note strong quadratic effect - increase mostly seen in Horse
Pasture (as noted in the field).

```

```
#####
#Intensive plots
#####
#Random effects model for permanent plot data

#Bring in permanent plot data - only 3 years (2012-2014).
#Use ANCOVA structure for year as indicator with random effect
#Use this approach for seedling counts, rosettes, and new plants

#Load data frame
data<-read.table("UCBN_Penstemon_IntensivePlots_2012-
2014_Certified.txt",header=T)

names(data) #note the Rx_Burn is anticipated 10 plots in eastern half of
Howitzer Hill
#[1] "PlotID"      "PlotNum"      "Year"          "Penlem"        "Rosettes"      "Seedlings"
#[7] "Slope"        "Rx_Burn"

#####
#Visualize data
boxplot(data$Penlem~data$PlotNum) #Considerable variation among plots -
suggesting random intercept
boxplot(data$Penlem~data$Year,col=c("white","gray","dark gray")) #No trend
boxplot(data$Penlem~data$Rx_Burn) #No variation between treatment means pre-
burn
boxplot(data$Rosettes~data$PlotNum) #Random intercept!
boxplot(data$Rosettes~data$Year,col=c("white","gray","dark gray")) #Evidence
of increasing trend over time
boxplot(data$Rosettes~data$Rx_Burn)#No variation between treatment means pre-
burn
boxplot(data$Seedlings~data$PlotNum) #Random intercept!
boxplot(data$Seedlings~data$Year,col=c("white","gray","dark gray")) #No trend
#####
#Fit a suite of models - example for penstemon data
#Works best to rename data
Slope<-as.vector(scale(data$Slope))
Year<-as.factor(data$Year)
Penlem<-data$Plants
PlotID<-as.factor(data$PlotID)
#####
#Models for established plants, results not pasted
#####
#m1 is no random effects
m1<-glmmadmb(Penlem~Slope+Year,zeroInflation=FALSE,family="nbinom")
#m2 is random intercept
m2<-
glmmadmb(Penlem~Slope+Year+(1|PlotID),zeroInflation=FALSE,family="nbinom")
#m3 is random intercept and random year slope
m3<-
glmmadmb(Penlem~Slope+Year+(1+Year|PlotID),zeroInflation=FALSE,family="nbinom
")

AICtab(m1,m2,m3) #Note m2 has lowest AIC

coefplot(m2) #Plot fixed effects; note no apparent difference among years,
positive relationship with
```

```

#slope as seen with extensive plots

ranef<-as.data.frame(ranef(m2)) #Rename random effects estimates from m5

#Plot random intercept along Slope gradient - note overall mean is red line

plot(sort(data$Slope),exp(fixef(m2)[1]+fixef(m2)[2]*sort(Slope)),type="l",
ylim=c(0,5),xlim=c(min(data$Slope),max(data$Slope)),lwd=3,bty="l",col="red",x
lab="Slope (degrees)",ylab="Estimated Mean # of P. lemhiensis",
cex.lab=1.2,cex.axis=1.2,main="Trend in Lemhi Penstemon Counts")

for (i in 1:42){

lines(sort(data$Slope),exp(ranef[i,1]+fixef(m2)[2]*sort(Slope)),lty=1)
}
#####
#Try this with rosettes

Penlem<-data$Rosettes

m1<-glmmadmb(Penlem~Slope+Year,zeroInflation=FALSE,family="nbinom")

m2 <-
glmmadmb(Penlem~Slope+Year+(1|PlotID),zeroInflation=FALSE,family="nbinom")

m3 <-
glmmadmb(Penlem~Slope+Year+(1+Year|PlotID),zeroInflation=FALSE,family="nbinom
")

AICtab(m1,m2,m3) #Note m2 has lowest AIC

coefplot(m2) #Plot fixed effects - evidence of temporal trend and stronger
influence of slope steepness

#####
#Try this with Seedlings

Penlem<-data$Seedlings

m1<-glmmadmb(Penlem~Slope+Year,zeroInflation=FALSE,family="nbinom")

m2 <-
glmmadmb(Penlem~Slope+Year+(1|PlotID),zeroInflation=FALSE,family="nbinom")

m3 <-
glmmadmb(Penlem~Slope+Year+(1+Year|PlotID),zeroInflation=FALSE,family="nbinom
")

AICtab(m1,m2,m3) #Note m2 has lowest AIC

coefplot(m2) #Plot fixed effects - seedlings also increase w slope, but no
temporal trend

#####
#End Script
#####

```

Modeling Survival

An alternative approach to using generalized linear mixed models (GLMM) to estimate mortality from annual counts of live-dead transitions is to directly model time-to-death (time-to-event) with Cox proportional hazards models (Cox 1972). The concept is very similar to GLMMs and this approach has been widely used in medicine, social sciences, and ecology (e.g., plant pathology, Scherm and Ojiambo 2004) to study survival of studied subjects (e.g., people, or plants in our case) in relation to risk factors (hazards). Poulos et al. (2014) provide an example application to the study of *Penstemon palmeri* survival under different experimental competitive understory conditions. Proportional hazards models are uniquely able to accommodate right-censored data which arise when times-to-event are known for only some plants, but others are still alive at the time of analysis (end of study) and therefore become right-censored.

Proportional hazards models are conceptually well-aligned to test hypotheses about differential rates of Lemhi penstemon survival (Φ) of established plants among groups of burned and unburned (tagged) plants, or among plants in different microsites. To account for the repeated-measures clustering of plants within intensive plots, a mixed-effects proportional hazards (sometimes referred to as a “frailty” model) model is available (McGilchrist and Aisbett 1991). Specifically, this model links survival at time t to a baseline hazard function (proportional to a survival curve), $\Phi(t)$, adjusted by fixed effects and random effects with a multiplicative link as $e^{X'\beta + Zb}$, where β is the vector of fixed-effect coefficients and b is the vector of random effects coefficients. The random effects component is modeled as a Gaussian (normal) random process with mean zero and variance matrix Σ dependent on a vector of parameters θ , $b \sim G(0, \Sigma(\theta))$. This allows for the vector of random effects for plots to be interpreted directly as the multiplicative (percentage) increase or decrease in survival of plants within each plot. We demonstrate this with 2012-2017 intensive plots data in the following R script and figures, using the `coxme` function in the `coxme` library in R (Therneau 2015). Figure SOP7-3 illustrates survival curves for plants in burned and unburned blocks. Note that tagged plants in the visitor center subpopulation may also be included in these kinds of analyses in the future.

```
#####
#UCBN R Script - Lemhi penstemon survival analysis
#For Big Hole National Battlefield
#Updated August 1, 2017
#####

#Purpose: To estimate survival probabilities of marked plants over time
#among groups of plants nested within plots and different management or
#microsite
#conditions

#Load Packages
library(survival)
library(coxme)
library(survminer)

data<-read.table("Survival_2012-2017.txt",header=T)
names(data)
# "Plot"    "Plant"    "Time"    "Status" "Burn"    "Slope"    "Severity" "Bare"
```

```

#Fit standard Cox model
fit0 <- coxph(Surv(Time, Status) ~ Burn,data=data)
summary(fit0)
#Compare with random effects model
fit1 <- coxme(Surv(Time, Status) ~ Burn + (1| Plot),data=data)
summary(fit1)

anova(fit0,fit1)
AIC(fit0); AIC(fit1)# 982-969=delta of 13

#Inspect random effects for each plot
fit1$frail #same as ranef interpreted at exp(ranef)is % of mean survival prob
per plot

#Plot curves
ggsurvplot(survfit(res.cox), color = "#2E9FDF",
            ggtheme = theme_minimal())

#Create new data
burn_df <- with(data,
                data.frame(Burn = c(0, 1),
                           Time = rep(mean(Time, na.rm = TRUE), 1),
                           Burn = c(1, 1)
                )
)
burn_df

# Plot Survival curves among treatment groups
fit <- survfit(res.cox, newdata = burn_df)
ggsurvplot(fit, conf.int = TRUE, legend.labs=c("Unburned=0", "Burned=2"),
            ggtheme = theme_minimal())

#Can try random intercepts and slope models

fit2 <- coxme(Surv(Time, Status) ~ Burn + (1+Burn| Plot),data=data)
summary(fit2)

anova(fit1,fit2)
AIC(fit1); AIC(fit2)# no improvement in this case

#Can try with plot-level slope values (or bare ground)

fit3 <- coxme(Surv(Time, Status) ~ Burn+Slope+(1|Plot),data=data)

#####
#End Script
#####

```

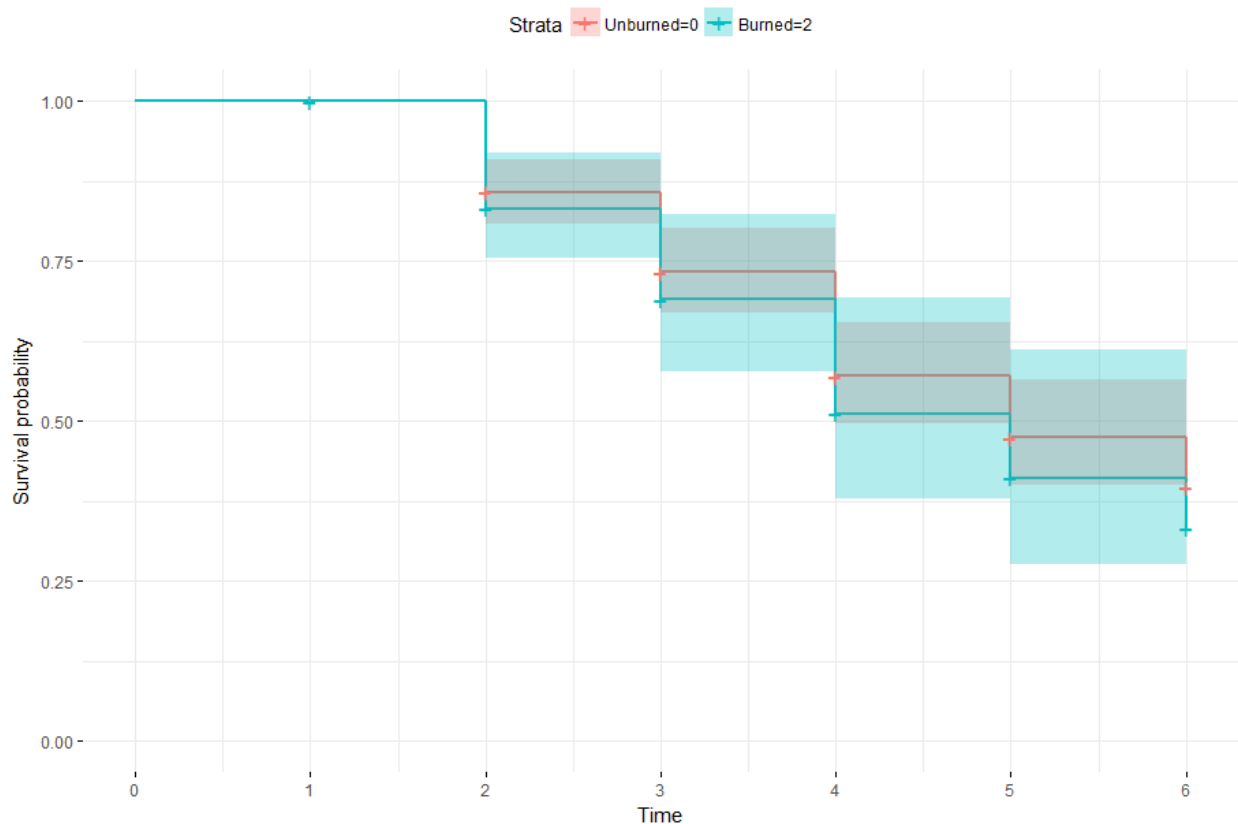


Figure SOP7-3. Survival “curve” (over time this will begin to look more like an actual curve) of probabilities at each observed time step among groups of plants in burned and unburned portions of the two studied hillslopes. Unburned plants have a higher probability of survival, but this is not statistically significantly higher than burned plants. These probabilities were estimated from a model that accounted for the clustering of plants within plots in a random effects structure.

Management Effects Hypothesis Testing

The mixed-effects models described in the two preceding sections provide an intuitive conceptual and statistical linkage to directly estimate fire and weed management effects. We will use these models as in a fixed-effects analysis of covariance (ANCOVA) context in which counts of plants and seedlings, or rates of individual plant survival, are related to discrete and continuous fixed effects, including burn and weed treatments, via models. Random effects will be used to account for the repeated measures on permanent intensive plots. Models will be developed separately for the extensive plots and the intensive plots, providing separate lines of evidence. Rodhouse (2016) provides a thorough example of this approach for the years 2009-2014, and explores pre-treatment differences between burn block 1 and other blocks in an ANCOVA setting.

Auxiliary Information Used to Characterize Microsites and Influential Climatic and Management Events

Integrating auxiliary information that represents management actions and microsite conditions is a critical component of this protocol. Fire and weed management activities will be retrieved from Battlefield (or proxy, e.g., Glacier Fire Management officers) on an annual, or in the case of infrequent fire, after each event (e.g., Appendix E). Weed management actions undertaken by

Battlefield and Exotic Plant Management Teams are reported annually to NISIMS, and NISIMS reports, available to NPS users via the Information Resources Management Applications (IRMA) portal (e.g., Figure SOP7-4), will be used at the time of data analysis to construct binary indicator variables representing sprayed/not sprayed indicator variables in regression models. Appendix E provides all necessary information for constructing burned/unburned binary indicator variables and also quantitative burn severity covariates from the September 2014 Rx burn of block 1. Similar information will be provided by Battlefield staff or Glacier Fire Management staff if future blocks are burned. Climate and weather information will be extracted from the Climate Analyzer web portal (<http://www.climateanalyzer.org/>) at the time of analysis. The Wisdom, Montana co-op weather station (station # 249067) is closest to the Battlefield and has good historic data. The Calvert Creek Snotel station (station # 381) downstream from the Battlefield has also has useful information. Both of these stations are included in ClimateAnalyzer and summary information is easily obtained. Microsite characteristics will be constructed from slope, aspect, and ground cover measurements (SOP 6). Extensive plot analysis will benefit from spatially-extensive measures of ground cover, for example normalized difference vegetation indices (NDVI) developed from high-resolution (1-m) near-infrared aerial photography produced and archived by the National Agricultural Imagery Project (<https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/>). Rodhouse (2016) provides a thorough example of how slope, aspect, ground cover, and NDVI can be used as covariates in GLMMs for penstemon and knapweed trend. All four covariates were found to be informative in that analysis (Rodhouse 2016).

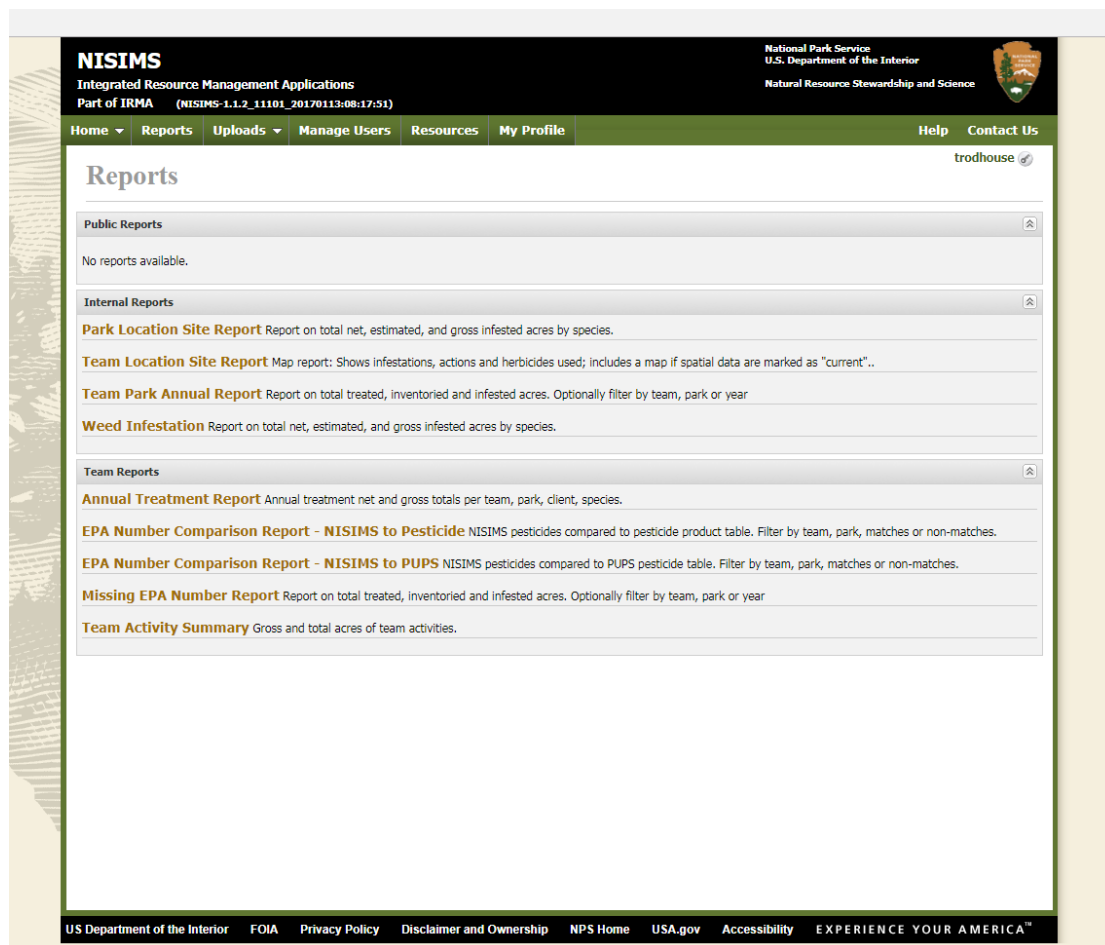


Figure SOP7-4. Screenshot of the NISIMS reporting page on the IRMA web portal. Annual summaries of herbicide application on the hillslopes targeting spotted knapweed can be generated from NISIMS and used as fixed-effect treated/untreated covariates in trend models (see Rodhouse 2016 for an example).

Reporting

An annual summary report will be produced after each year of data collection, with a more detailed report produced approximately every five years. The annual report will:

- Provide a summary of results.
- Provide summary status statistics and interpretation of the results relative to management and monitoring hypotheses and objectives. A summary of management actions will be described based on the management actions query conducted each year prior to close-out and reporting.
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretation.
- Evaluate and identify suggested or required changes to the protocol.

Annual reports have been produced following the 2009, 2012, 2013, and 2014 surveys and can be used as templates to guide future reports (Stucki and Rodhouse 2009, Rodhouse 2016, Rodhouse and

Stucki 2013a, 2013b). A one-page resource brief will also be prepared from this annual report that will be provided to superintendents, park interpretive staff, and resource managers. Resource briefs have also been produced for each year from 2009-2017 and are available on the UCBN website (<http://science.nature.nps.gov/im/units/ucbn/>). Information from the annual summary report will also be provided to parks in time for park reporting and for informing and evaluating park resource stewardship strategies and State of the Parks reports.

A more in-depth trend report will be produced approximately every five years (e.g., Rodhouse 2016). This report will provide greater analytical and interpretive detail, and will evaluate the relevance of findings to long-term management goals. In particular, these trend reports will evaluate findings from both intensive and extensive plot surveys in the context of management and monitoring hypotheses and objectives, including fire effects, if prescribed fire plans are carried out. The report will also evaluate operational aspects of the monitoring program and recommend necessary protocol updates.

Annual reports and trend reports will use the NPS Natural Resource Publications templates, pre-formatted Microsoft Word template documents based on current NPS formatting standards. Template guidelines and documentation of the NPS publication standards are available at the following address: <http://www.nature.nps.gov/publications/NRPM/index.cfm>. Additionally, publication of particularly interesting findings relevant to the broader scientific community-at-large will also be occasionally pursued, in a manner similar to Stucki et al. (2013).

Current versions of the protocol, resource briefs, reports, and journal publications will be made available on the UCBN website (<http://science.nature.nps.gov/im/units/UCBN/index.cfm>), from the national Natural Resources Publications Management (NRPM) website (<http://www.nature.nps.gov/publications/NRPM/index.cfm>), and on the NPS Integrated Resource Management Applications (IRMA) portal (<http://irma.nps.gov>).

Data Archival Procedures

Upon certification, data and reports will be archived on the UCBN Network Attached Storage (NAS) unit and the NEPE and BIHO servers, posted to the UCBN website, and posted to the national web-accessible secure database hosted by the NPS Washington Areas Support Office or National I&M program and accessible through the NPS IRMA portal (<https://irma.nps.gov>).

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Suggested Reading

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Standard Operating Procedure 8: Protocol Revision History Log

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

This SOP describes the recommended practices for revision of the narrative and SOPs and provides a history of the protocol development process.

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 UCBN Project Lead, with support and consultation from the UCBN I&M team and BIHO and NEPE natural resources program staff. The narrative as well as each SOP has a change 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.

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 park resource management staff prior to making modifications. It is important that the UCBN I&M team, particularly the UCBN Ecologist and Data Manager, will work closely with BIHO and NEPE staff to review and implement proposed changes and revisions to the protocol.
2. After all relevant parties agree to a particular set of changes, make the agreed-upon changes in the appropriate protocol document. Note that a change in one area of the 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 Change History Log embedded in the protocol narrative and each SOP. Log changes only in the portion of document being edited (i.e., if there is a change to

an SOP, log those changes only in that section of the 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, the change and the paragraph(s) and page(s) where changes are made, and briefly the 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 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). Record the previous version number, date of revision, and author of revision; identify paragraphs and pages where changes are made, rationale for revisions, and the new version number.

4. Circulate the changed document for internal review among the Battlefield and Network staff.
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 BIHO, NEPE, and UCBN I&M offices. 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 UCBN Data Manager will place a copy of the revised protocol in the proper folder on the Network server.
9. The UCBN Data Manager will post the revised version and update the associated records in the proper I&M databases, including the NPS Data Store, UCBN website, and the Protocol database.

Development History

Table SOP8-1 summarizes the development process and major events leading to the initial approval of the Lemhi penstemon/spotted knapweed monitoring protocol (version 1.0) for implementation.

Table SOP8-1. Protocol development history.

Date	Development Step	Documentation
2007	Initial inventory and exploration of monitoring techniques.	See annual reports and 2013 journal publication (literature cited section of narrative)
2009	First year of pilot monitoring begins	—
2010	Exploration of adaptive sampling design, comparison with GRTS and presentation of results at George Wright Society biennial meeting	—
April 2014	Complete draft of protocol narrative and SOPs circulated to park and network staff for review.	—
August 2014	Version 1.0 protocol submitted for peer review to PWR I&M Program Manager (Latham) and PWR Protocol Review Coordinator (Agee).	—
September 2015	Protocol review decision (accept pending revision) and reviewer comments and requests provided to UCBN for revision.	—
November 2017	Revised final draft of protocol submitted to PWR I&M Program Manager (Garrett) and PWR Protocol Review Coordinator (Bakker) for review and approval.	—

Standard Operating Procedure 9: Safety

Version 1.0

Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

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 UCBN Project Lead and Data Manager of any changes to the SOP 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 SOP.

Purpose

Safety of field personnel is always the first priority in conducting a monitoring program. Advanced planning can reduce or eliminate many safety hazards and better prepare staff for dealing with these issues. This SOP provides safety information, checklists, and forms for Network and contract personnel or cooperators who are involved with field activities. Roles and responsibilities of each party in implementing a safety program are discussed. General safety preparation is reviewed and job hazards and mitigations measures are summarized for driving, wilderness travel, and monitoring fieldwork. An emergency contact form is provided to obtain emergency information for each employee and park-specific contacts are provided for field-related emergencies. Field communications for backcountry travel are outlined. This SOP summarizes basic safety information and procedures but does not comprehensively cover every safety issue. This SOP is intended to engage all personnel and to provide a foundation for an on-going open and dynamic process for addressing field safety. Park safety officer must be consulted to ensure that crews comply with all park-specific safety policies.

Fieldwork requires an awareness of potential hazards and knowledge of basic safety procedures. Risks include working in small teams on steep and rugged hillslopes, hiking over rough terrain, potential contact with dangerous insects, exposure to extreme weather, and long driving trips between BIHO and other park or Network offices. Further details are contained in appendixes to this SOP, including the Lemhi penstemon monitoring Job Hazard Analysis (JHA), which must be reviewed and updated each year by all field staff (a fundamental step in building operational leadership capacity).

Roles and Responsibilities

The following roles and responsibilities are adapted from the NPSafe program. In addition, we have incorporated principles from Operational Leadership to empower all employees to take responsibility for safety and wellness. All Program Managers and Project Leads will participate in Operational Leadership (OL) training and apply OL principles in assessing risk and managing field crew safety. According to these principles, program managers and team leaders are responsible for setting the standards, articulating the standards to employees, and following and enforcing the standards. All staff are responsible for knowing, understanding, following, and encouraging others to follow the standards. Standards include the SOPs specific to this protocol as well as overall safety standards for the monitoring program (i.e. those that are common across protocols such as communication and vehicle safety).

Prior to the start of each field season, certain safety documents must be reviewed, signed, and returned to the park contact and the network coordinator. These documents include fieldwork itinerary forms that outline when and where field operations will take place, readiness reviews that detail necessary safety items that have been prepared for the field season, and JHAs that highlight individual risks associated with fieldwork and ways to mitigate those risks.

Network Program Manager

- Establish a culture of safety and communicate vision clearly and continually.

- Monitor employee/unit performance, recognize successes, and take corrective actions when needed.
- Incorporate safety as a critical result in supervisors' and employees' performance plans.
- Incorporate safety into all decision-making processes.
- Ensure requests are submitted for adequate funding of safety programs and training.
- Integrate audit findings into existing performance management and training processes.
- Ensure all employees are aware of their job hazards.
- Incorporate principles from operational leadership to help all employees take responsibility for safety, understand human error and accident causation, manage stress, evaluate risk, maximize situational awareness, make appropriate decisions, communicate effectively, and be assertive regarding safety in the workplace.
- Ensure all employees understand their roles and responsibilities in implementing a safety program.

Project Managers/Field Supervisors

- Monitor employee/unit performance, recognize successes, and take corrective actions when needed.
- Incorporate safety into all decision-making processes.
- Incorporate safety as a critical result in all employees' performance plans.
- Develop and use employee safety and health orientation checklist identifying job specific hazards and safety concerns.
- Develop and continuously improve Job Hazard Analyses or Guidelines for all tasks.
- Integrate audit findings into existing performance management and training processes.
- Incorporate principles from operational leadership to empower all employees to take responsibility for safety, understand human error and accident causation, manage stress, evaluate risk, maximize situational awareness, make appropriate decisions, communicate effectively, and be assertive regarding safety in the workplace.
- Ensure all employees understand their roles and responsibilities in implementing a safety program.
- Ensure all employees are aware of and control their job hazards.

- Investigate all accidents and near misses, and implement corrective actions for identified hazards.
- Model and participate in periodic to frequent de-briefings or after action reviews with field crews throughout the season to ensure safety remains a central focus for each employee.

Employees

- Collaborate with supervisor to develop Job Hazard Analyses or Guidelines, and review, implement, and use employee safety and health orientation checklists.
- Integrate audit findings into existing performance management and training processes.
- Incorporate safety into all decision-making processes and job tasks.
- Understand their roles and responsibilities in implementing a safety program.
- Be aware of and control their job hazards.
- Identify and report hazards to immediate supervisor, program manager, or park management.
- Apply principles from operational leadership to understand human error and accident causation, manage stress, evaluate risk, maximize situational awareness, make appropriate decisions, communicate effectively and be assertive regarding safety in the workplace.
- Participate in periodic to frequent de-briefings or after action reviews to identify risks, near misses, weak signals, and any other concerns that may compromise field safety.

Knowledge of Standard Operating Procedures

Reading and understanding the protocol and in particular, the SOPs, are crucial prior to initiating fieldwork. This basic understanding of the protocol and the ability to recognize bad data in the field can improve safety by enabling teams to address errors before leaving the plot, eliminating unnecessary sampling trips, and reducing unnecessary exposure to risk. Recognition of data errors on site allows for immediate adjustment in the field. The protocol lead will allow adequate time for all field crewmembers to become familiar with SOPs and check their work in the field. Field-related SOPs will also be covered as part of the hands-on training.

Weather and Field Gear

Fieldwork in BIHO can involve challenging weather extremes. Weather can be variable and change quite rapidly during the sampling period in late June and field crews may encounter cold rainy weather and thunderstorms, unseasonably hot weather, or anything in between. It is essential to the success of the program that all field staff and associates are well prepared for weather extremes. Good rain gear, clothes for a range of temperatures, sunhats, sunscreen, and protection from mosquitoes and biting insects are essential.

First Aid and CPR

Training in basic first aid and CPR is required for all field crew leaders, is strongly recommended for all crewmembers, and will be paid for by the Network. Certification is valid for two years. Protocol leads should make arrangements for those needing training far in advance to the start of the field season.

Driver Safety

Travel between park offices and BIHO often requires long road trips under varied weather and road conditions. Field staff must drive responsibly and obey all traffic laws. Employees must monitor fatigue while driving and pull over to rest when necessary. Roads in BIHO are paved and driving access within the park is limited, though this doesn't mitigate all driving risks. The NPS permits employees on official travel up to 10 hours driving in one day (vehicles with multiple drivers may drive up to a combined total of 12 hours per day though no individual must exceed 10) with an off duty period of eight hours minimum before driving again. Furthermore a 12 hour combined work/travel period must not be exceeded. The NPS driving policy can be found here:

https://www.nps.gov/policy/PolMemos/PM_13-01.pdf Note that even these restrictions are insufficient to truly mitigate driving fatigue – 10 hours of driving makes for a long day! We recommend teams to drive together and share driving among team members. A traveler's driving checklist (Appendix D) must be reviewed prior to undertaking the long drives from Network and park offices to BIHO.

Field Safety for Lemhi Penstemon Monitoring

Safety of field personnel is always the first concern when sampling field sites. No sample or sampling site is worth the risk of injury or death. If employees perceive a risk at any time, they should stop the task immediately and mitigate the risk. This policy applies to all aspects of the work including preparation for fieldwork, travel to and from sites, and actual field sampling.

Sampling frames and plots within BIHO require off-trail hiking to access. Sampling areas may be steep, slippery with loose materials, and have tall vegetation that requires appropriate footwear and technique to traverse. Crews will be trained in orienteering using GPS and map/compass techniques. Maps will be provided to crews showing the location of sampling plots. Crews will be responsible to navigate safely to the sampling plot.

Fieldwork requires an awareness of potential hazards and knowledge of basic safety procedures. Advanced planning can reduce or eliminate many safety hazards. An integral part of informed awareness and successful mitigation of potential hazards is a process that helps to reveal hazards. This protocol uses a Job Hazard Analyses (JHAs) to critically examine tasks, identify specific hazards, and reduce or eliminate these risks. A set of these documents is created for each protocol, is reviewed prior to field implementation, and evolves with the input of subsequent employees to remain a current and effective safety tool. All employees are expected to know, understand, and contribute to these documents.

Working in Small Teams

Field staff will primarily operate in teams of two or more when traveling to and from plots and when sampling vegetation in the field. Field staff will work alone only when necessary and when safe monitoring practices allow for it. When working in such small teams, particular attention must be given to safety and communication. Team members must make an extra effort to work within sight and earshot of one another. See the Field Communications section for further guidelines on establishing travel plans and check-in/check-out procedures.

Varied Weather Conditions

BIHO is in an area that can experience extreme weather conditions, with conditions varying considerably on a daily, or even hourly, basis. Snow, heavy rain, thunderstorms with lightening, high winds, or hot and sunny conditions can occur during field operations with little warning. Field crews should watch the skyline for cumulonimbus cloud development and avoid being on the exposed hillslopes if thunderstorms and lightening are threatening. As a result, fieldwork requires preparation for this range of conditions. Hypothermia and heat-related injuries are possible. Extreme weather can also contribute to fatigue and increase the risk of injury from falls. Field crew leaders should check the National Weather Service website for an up-to-date forecast before initiating fieldwork in BIHO.

An appropriate weather sites for BIHO and surrounding areas:

National Weather Service-Missoula, MT

<http://www.wrh.noaa.gov/mso/>

Incidents, Accidents, and Emergency Contact Information

In the event of an accident or incident, get immediate medical attention if required. To report an accident or incident, local park policy should be followed. At a minimum, the employee will report any injury to their immediate supervisor as soon as possible and fill out a SMIS report. The supervisor needs to report the incident/accident to appropriate personnel, and complete any park specific reporting forms. Supervisors and employees are required to complete a Department of Labor Form CA-1 (Federal Employee's Notice of Traumatic Injury and Claim for Continuation of Pay/Compensation) or CA-2 (Notice of Occupational Disease and Claim for Compensation) when work related injuries or diseases require medical treatment. The Safety Management Information System (SMIS) is the automated system for reporting Form CA-1 or CA-2 for the Department of the Interior (<https://www.smis.doi.gov>). Employees complete a CA-1/2 electronically at <https://www.smis.doi.gov> before the end of the next work shift after an accident. After the employee completes the CA-1/2, the supervisor logs onto SMIS and completes the supervisor portion of the electronic CA-1/2. The supervisor takes any corrective action necessary to prevent similar incidents.

Field Communications

Established lines of communication and a Check-in/Check-out procedure are essential to employee safety and in ensuring timely assistance in case of a mishap or delay. Upon arrival and check-in at the park, establish a clear procedure of communication between field teams and park staff. Cell phone coverage in BIHO is intermittent and should not be relied upon in case of an emergency. Crews will

carry two-way radios to communicate with other field crews. Park radios will be provided for field crews to carry so that communication with BIHO staff at the visitor center or facilities office can be maintained. Radios may also be carried by park staff members assisting with the Lemhi penstemon monitoring effort. Park radios can be used to maintain contact with the Visitor Center in BIHO and to report an emergency. Telephone access is available in the Visitor Center. Check with park contacts for radio availability and use procedures. Crews should be trained on the use of two-way radios and park radios prior to fieldwork. At least one UCBN crew member will carry a SPOT or InReach satellite beacon that can be used to initiate emergency response and search and rescue when other forms of communication fail.

Other Forms and Checklists

Checklists are helpful for ensuring that personnel have the appropriate safety equipment available during fieldwork. The following appendices contain an emergency contact form (for the Network and Park Dispatch, as needed) and equipment checklists for field. Field crewmembers should consider their specific needs and should customize the checklists as necessary. The field crew and project manager will discuss the checklists and determine which items are necessary. Field staff should confirm all contact information annually and ensure that medical information is up-to-date.

Appendix A. Example of Readiness Review document

Protocol/Field Work Readiness Review-Assessment Components Supplement to Protocol Readiness Review Certification

Monitoring Protocol: Lemhi Penstemon Monitoring

Park and Network: Big Hole National Battlefield (BIHO); Upper Columbia Basin Network (UCBN)

Date: 6/24/20xx-6/28/20xx

Readiness Review Component Details

Describe how the protocol and implementation address the following:

- ***Operations planning and field logistics***

A detailed field itinerary form will be submitted to the UCBN Program Manager and Park Contact at least one week prior to planned trip. The itinerary will include: a brief description of field work, dates of field work, transportation arrangements, primary and secondary park contact information, list of participants, detailed daily description of field work, location of field work, risk assessment, and items to be completed prior to field work. Signed field itinerary forms are posted on the UCBN server.

Check-in procedures with park staff are outlined in the field itinerary form. Standard UCBN procedure calls for check in with the park upon arrival and daily check in upon completion of fieldwork each day (timing identified in the field itinerary form). Deviations from this procedure should be clarified and agreed to by the UCBN field crew leader and the BIHO park contact/field work supervisor (e.g., vegetation ecologist or NR chief) at the start of the fieldwork.

Lemhi penstemon monitoring protocol SOP #9 "Safety" describes the procedures for safety preparation prior to fieldwork. Prior to the start of each field season, certain safety documents must be reviewed, signed, and returned to the park contact and the network coordinator. These documents include fieldwork itinerary forms that outline when and where field operations will take place, a travel safety checklist, job hazard analyses (JHAs) that highlight some of the individual risks associated with fieldwork and ways to mitigate those risks, and this readiness review. Signatures for JHAs will be acquired as part of a field crew safety discussion at the start of the field project, and returned by fax, scan, or mail to the UCBN Moscow office for archiving. All documents are completed prior to the start of fieldwork, distributed to all park and safety contacts, and posted to the UCBN server.

Safety Steps include:

1. Completion and review of fieldwork itinerary form
2. Completion and review of Job Hazard Analysis (JHA)

3. Completion and review of Readiness Review materials
4. Completion and review of travel safety checklist
5. Review and update of safety SOP #9
6. Review and update emergency contact information
7. Completion of Medical Information for Office Personnel form
8. Completion of CPR / First Aid for crew leader and, as available, field crew members
9. Completion of Operational Leadership Training for all crew members
10. Check weather and fire hazard conditions

- ***Training requirements***

The approved UCBN Lemhi penstemon monitoring protocol SOPs will serve as the training manual for camas monitoring. See SOP #2 "Training Observers" and SOP #9 "Safety". Minimum requirements for field crew leader include basic first aid/CPR and NPS Operational Leadership. **Current training possessed by the UCBN field crew lead includes 80 hour Wilderness First Responder and Operational Leadership. A second crewmember was a certified (expired) Emergency Medical Technician (EMT) and has also completed Operational Leadership training. Jimmer Stevenson (BIHO maintenance) is a certified EMT.**

In addition, daily tailgate safety meetings are held to address changing conditions.

During initial check in with parks safety concerns and special conditions are discussed with park staff.

- ***Risk management***

Job Hazard Analysis forms and fieldwork itinerary forms are completed and sent to the parks prior to fieldwork. These are also posted on the UCBN server. Daily tailgate safety meetings are held to address changing conditions. During initial check in with parks safety concerns and special conditions are discussed with park staff. **Exact plot location coordinates and maps are provided to the park point of contact. Changes and updates to daily itinerary will be communicated to park staff at morning check-in.**

All participants are to understand that safety is our first priority.

Risks and risk mitigation are also discussed in SOP#9 field safety.

Daily tailgate safety briefings will take place involving an "SPE" exercise (from NPS Operational Leadership) to evaluate the severity, probability, and exposure to risks associated with daily tasks.

- ***Awareness of and consistency with park safety protocols and emergency procedures***

The parks are involved in the review of the UCBN field itinerary forms. Special safety protocols and emergency procedures are discussed at this time and during the initial check in with park staff.

- ***Supervisory oversight***

Lemhi penstemon monitoring standard operating procedures have been peer reviewed and accepted for implementation. In addition, the UCBN program manager and park supervisory staff review all proposed field itineraries for activities to be completed in fulfillment of this protocol. The UCBN supervisory chain of command is UCBN Program Manager>UCBN Ecologist>UCBN field crew lead. Staff from BIHO will participate as crewmembers to assist the UCBN in completing surveys.

- ***Communications***

Check in and out procedures are defined on the field itinerary form and are provided to park staff prior to fieldwork. Personal cell phones are carried by field personnel. Park radios may be available during fieldwork. Two-way radios will be carried by field crews for communicating with other crews. A SPOT emergency beacon issued by the UCBN will be carried during fieldwork. Additional details, including phone numbers, are provided in the itinerary.

Appendix B. Field itinerary form

UCBN FIELD ITINERARY FORM (EXAMPLE)

To be submitted to Program Manager and Park Contact at least one week prior to planned trip.

<i>This form may contain confidential information and must be kept secure</i>	
Field Crew Supervisor	Thomas Rodhouse
Field Crew Leader	Devin Stucki
Monitoring Project etc	Lemhi penstemon monitoring
Field work description	Observers will navigate to plots using GPS. Plot will be searched for camas or penstemon plants.
Dates of field work	6/24/2013 to 6/29/2013
Transportation arrangements	Devin Stucki and Dan Esposito will drive from CRMO to BIHO in the UCBN's GSA vehicle. Tom Rodhouse will fly to Missoula and drive to BIHO. NEPE and BIHO staff will drive from various locations. Access to plot locations will be via foot from the trailhead parking lot. Trails will be used when possible to access sample locations.
What will be the contact arrangement with the Park contact?	Contact person: Jimmer Stevenson Phone number: 406 689-3155, after hours: Superintendent Steve Black or Mandi Wick who live on site at the park. Frequency of contacts: Pre-trip, and regularly throughout the week – Jimmer will assist with fieldwork. NEPE staff will also be serving as points of contact and assist fieldwork.
What shall UCBN staff do if no contact is made?	Contact person: Steve Black Phone number: 406-689-3155, after hours: physically at the park housing. Instructions: If Steve cannot be reached, check in/out should occur with other park staff in the visitor center.

DETAILS OF PARTICIPANTS

NAME	STATUS UCBN staff, Uidaho employee, student, volunteer	JOB HAZARD ANALYSIS ATTACHED? (Mandatory)
Devin Stucki	UCBN staff	Yes
Tom Rodhouse	UCBN staff	Yes

Dan Esposito	UCBN staff	Yes
NEPE staff	NEPE staff	Yes No
BIHO staff	BIHO staff	Yes No
		Yes No
		Yes No

ITINERARY DETAILS

DATE/TIMES	LOCATION	ACCOMMODATION	CONTACT DETAILS
Monday June 24 0800-1130 1200-1730	Travel to BIHO Training for Penstemon monitoring	BIHO residences	Field crew lead can be contacted by cell phone: xxx-xxx-xxxx. Project lead can be reached by cell xxx-xxx-xxxx .
Tuesday June 25 0800-1630	Continued training if necessary. Penstemon field work on upper slopes	BIHO residences	Daily check ins with the park contact may be arranged.
Wednesday June 26 0800-1630	Penstemon field work on upper slopes	BIHO residences	Daily check ins with the park contact may be arranged.
Thursday June 27 0800-1630	Penstemon field work on upper slopes	BIHO residences	Daily check ins with the park contact may be arranged.
Friday June 28 0800-1130 1230-1630	Penstemon field work on upper slopes Return to CRMO	BIHO residences	Daily check ins with the park contact may be arranged.
Saturday June 29 (if necessary) 0800-1130 1230-1630	Penstemon field work on upper slopes Return to CRMO	BIHO residences	Daily check ins with the park contact may be arranged.

RISK ASSESSMENT

FIELD WORK ACTIVITY	POTENTIAL HAZARD What might harm you?	RISK RATING (Extreme, High, Medium, Low)	CONTROLS What are you going to do to make this activity as safe as possible?	PERSON WHO WILL ENSURE THIS HAPPENS
Lemhi penstemon monitoring	See Lemhi penstemon monitoring JHA	Low	Communication with park contact, proper preparation of safety gear and equipment prior to fieldwork. Changes to field itinerary will be communicated with park contact.	Project Lead
See attached JHA for additional activities and hazards				

ITEMS THAT WILL BE COMPLETED PRIOR TO THE FIELD WORK

	Tick as appropriate
Participants briefed on details of proposed field work; relevant safety policies, procedures and expected conduct while in the field	X
Job Hazard Analysis signed by all participants	X
All equipment, vehicles and tools will be checked for safety compliance prior to field work commencing	X
I have made the necessary provisions for emergency situations such as the appropriate level of first aid, emergency contact telephone numbers; e.g., helicopter rescue, police, fire, etc	X
I have checked with participants whether they have any medical conditions that should be disclosed	X
I have checked that appropriate licenses, permits and agreements with have been obtained and are up to date for the use of specialized equipment such as boats.	X

PEOPLE RESPONSIBLE FOR SUBMISSION AND APPROVAL

NAME	SIGNATURE	DATE
Field Work Supervisor		
Field Crew Leader		
Program Manager Based upon the information in the above Field Itinerary Plan: ☐ Approve XX ☐ Do not approve ☐ Grant conditional approval		
Conditions if relevant		
NOTE:- • A copy of this Field Itinerary Plan and associated Job Hazard Analysis forms are filed in the UCBN Moscow office. • Copies of all volunteer forms are filed in the UCBN Moscow office.		

Appendix C. Lemhi penstemon monitoring job hazard analysis

Job Hazard Analysis Lemhi penstemon Monitoring (BIHO)			
U.S. Department of Interior National Park Service	WORK PROJECT/ACTIVITY Lemhi penstemon monitoring	LOCATION Big Hole National Battlefield	UNIT BIHO
JOB HAZARD ANALYSIS (JHA)	DEVELOPED BY Devin Stucki	JOB TITLE Biological Technician	DATE PREPARED 18 April 2012
APPROVED BY:			DATE:
Required Equipment for Each Team: First Aid Kit Park Radio Compass/GPS unit Maps Emergency contact information			
Required Personal Protective Equipment: Sturdy hiking boots/shoes Long pants Sun protection (long sleeves, wide-brimmed hat, sunglasses, and/or sunscreen) Insect protection (long sleeves, head net, and/or insect repellent)			
Recommended Personal Protective Equipment and Other Gear: Backpack/daypack Warm clothing/hat Rain gear Personal water bottles Food			
Tasks/Procedures	Hazards	Abatement Actions	
All Tasks and Procedures	Unfamiliarity	All people (permanent, seasonal, VIPs) involved in any project should receive a general orientation and tailgate safety session specific to the task prior to beginning of work.	
1. Driving to and from remote field sites	1a. Narrow roads with bumpy or "washboard" surfaces	WEAR SEATBELTS AT ALL TIMES WHEN VEHICLE IS MOVING 1a. Maintain a safe speed (this is often below the legal speed limit) for the road conditions; stay clear to the right, especially on curves, drive with headlights on at all times; when turning around on mountain roads always "face the danger"(versus backing toward the cliff edge, e.g.); the passenger should get out and spot for driver when backing up.	

	1b. Driving with limited visibility	1b. Maintain windshield cleaner fluid level and clean both sides of windows regularly (remember back window); slow down; if blinded by sun or dust, proceed slowly or pullover and wait for hazard to pass; keep to the right hand side of the road and drive with your lights on.
	1c. Steep grades	1c. Slow down on steep grades; drive slower and use a lower gear to avoid riding the brakes; use caution while towing and only use vehicles rated for towing.
	1d. Large animals crossing or standing in roads	1d. Slow down where animals might be present to allow for reaction time; do not swerve abruptly to avoid hitting an animal, if necessary it's better to ride out the impact.
	1e. Fatigue at night or after a long shift in the field	1e. Be aware of signs of fatigue- pull over and rest. Take a short nap, eat a snack or have a partner drive; do not take chances by continuing to drive; communicate with your field partner.
	1f. Storm conditions – wind, lightning, muddy/slippy roads	1f. Keep informed on the current weather- check www.weather.com or www.wrh.noaa.gov ; if winds exceed 15 mph, or the excessive wind category on Beaufort scale (tree tops swaying, twigs and leaves falling, etc.), do not travel into the field; avoid going to the field if lightning is present and avoid using radios; drive slowly when roads are muddy and slippery or snow covered.
	1g. Others motorists on the road	1g. Be aware that tourists driving on park roads are often distracted; drive slow and keep right; notify the supervisor or park ranger if you encounter an unusual situation - avoid confrontational situations with visitors- let the proper authorities handle it.
	1h. Wildfire ignition from vehicle undercarriage/catalytic converter	1h. Track fire hazard warnings from Park and other agencies; obey road closures, such as occur in late summer when fire hazards are extreme; avoid driving over vegetated two-track roads whenever possible; constantly monitor accumulated vegetation underneath, and watch behind for smoldering debris and/or smoke; ALL VEHICLES MUST HAVE BASIC FIRE PREVENTION AND EXTINGUISHING EQUIPMENT AT ALL TIMES!
2. Communication	2a. Loss of contact with field partner(s)/team member(s)	2a. Team members should remain in contact with each other at all times; if someone needs to leave for any reason, a plan should be made communicating where and how long the team member will be gone; teams should check in with project leaders using handheld radios throughout the day; make sure radios are charged and on the correct channel.

	2b. Unable to reach radio repeater or other team members	2b. Make sure radio is charged- try to contact someone on the radio to inform him/her of your predicament; if you are unable to reach out with your radio, try to move upslope or onto an elevated area and try again; try at regular intervals, meandering around may help in hitting the repeater.
3. Hiking	3a. Steep, rugged, and slippery terrain	3a. Assess terrain conditions to find safe route and modify sampling plans to avoid unsafe areas; proper footwear is VERY important- wear boots with slip-resistant soles with tops well above the ankle, broken in before the field season, plus extra socks, no tennis shoes or open toed sandals; maintain an erect posture when contouring steep slopes; avoid walking below another person due to the potential for rocks to dislodge from above. Use hiking poles for improved balance.
	3b. Undergrowth	3b. Wear safety glasses (or other glasses) when hiking and working in brushy areas to protect eyes from protruding objects.
	3c. Crossing fences	3c. It is possible that fences will be crossed during the course of work; when possible use gates (leave them open or closed depending on how you find them); if no gate is available cross under or over fence with caution.
4. Encountering noxious plants, animals, disease, and people	4a. Bees/Wasps/Hornets	4a. Determine if any field crew are known to be allergic to bee stings. Notify other crew members and the supervisor if you know you are allergic to bee stings; ensure that individual carries prescribed medication to prevent anaphylactic shock; carry a bee sting kit or Benadryl or other antihistamine; be aware of the ground where you step- some hornets build nests in the ground at the base of trees or shrubs, or in rotten logs- watch for bees buzzing in and out of holes or around ground level; if possible, flag a nest so other surveyors won't run into it.
	4b. Ticks	4b. If bitten by a tick, remove it (grasp tick with tweezers at head and pull straight out); save tick in labeled container so that tick can be identified incase sickness ensues; watch for symptoms of Rocky Mountain Spotted Fever, Colorado Tick Fever, and Tularemia.
	4c. Mosquitoes	4c. Cover up using hat, headnet, gloves, and long sleeve shirt to prevent bites; use chemical repellant if necessary; be aware of West Nile Virus symptoms.

	4d. Mountain lions	4d. Avoid mountain lions; if you encounter a lion that doesn't run from you- leave the area; if attacked- fight back!
	4e. Bears	4e. Stay at safe distance. Make noise to avoid surprising animal. If bluff-charged, look big, raise arms, stand your ground. If attacked, roll into ball with face toward ground and hands over neck. If attack continues, fight back.
	4f. Moose, deer	4f. Stay at safe distance. Make noise to avoid surprising animal. If charged, run to safe area or climb tree if available.
	4g. Disease (bubonic plague and Hanta Virus)	4g. Stay away from dead rodents and rodent feces, especially in closed buildings.
	4h. Encounters with strangers	4h. Report uncomfortable encounters with strangers in the park to a supervisor as soon as possible; report apparent illegal activity to a park ranger as soon as possible; do not get into a confrontation with visitors in the park.
5. Exposure to environmental variables	5a. Treatment of general injuries	5a. All NPS field staff and contractors should have current first aid and CPR certification; each field team should carry a first aid kit packed with applicable supplies; injuries should be reported to a supervisor.
	5b. Hypothermia	5b. Always anticipate bad weather and dress accordingly, or carry warm clothes with you; keep clothing as dry as possible; use synthetic fleece and non-cotton outdoor clothing in inclement weather; eat high energy nutritional supplements between meals; cover the head and neck to prevent heat loss; keep active to maintain the body's metabolism; drink plenty of liquids to prevent dehydration, although an individual does not "feel" thirsty; drink warm liquids not cold; understand the effects of cold and wind; most hypothermia cases develop between 30°F and 50°F.

	5c. Hyperthermia	5c. Hyperthermia may occur during high temperatures, monitor for dehydration, heat exhaustion, and heat stroke; symptoms include nausea, headache, and flushed, red skin; drink plenty of water; as heat increases, take frequent breaks in cool locations; wear lightweight breathable clothing.
	5d. Sunburn	5d. Field work takes place in full sunlight with little shade so wear a wide brimmed hat, sunglasses, and long sleeve shirt; use 30+ or greater SPF sunscreen and lip balm.
	5e. Whiteouts	5e. In the event of a snowstorm and white out conditions, immediately seek shelter & wait for conditions to improve.
	5f. Thunderstorms	5f. Avoid exposed ridge tops and being on or near lakes, meadows or other exposed areas if thunderstorms are approaching or developing nearby. Move to lower elevations away from tall trees as storms approach. If hair begins to stand up, immediately minimize exposure by moving to lower elevations away from isolated trees & crouch down on the balls of your feet to reduce ground contact. If possible, wait out storm inside of vehicle.
6. Specific to monitoring Lemhi penstemon	6a. Working on steep terrain.	6a. The hillslopes are steep in BIHO so proper supportive footwear is a must; hiking/trekking poles may provide additional support. Be mindful to avoid holes, rocks, exposed roots, etc. that may present a tripping hazard.
	6b. Chaining pins	6b. These are narrow metal rods with a loop on one end and a sharp point on the other end used for securing the reel tape during plot setup; make sure chaining pins are carefully stored when not in use; sheath pointed ends when carrying to avoid injury.
7. Volunteers/Citizen Scientists	7a. Unfamiliarity with communications, safety plans	7a. Make sure everyone involved with field work receives detailed instruction concerning communications between field crews and in emergency situations; give observers detailed instruction regarding safety plans.

	7b. Unfamiliarity with hazards	7b. Communicate all relevant hazards related to Lemhi penstemon field work; make copy of JHA available to all observers, including VIPs and Citizen Scientists; each field crew should have a crew leader who is knowledgeable with the protocol and park safety plans.
—	—	—

HA Instructions	Emergency Evacuation Instructions
The JHA shall identify the location of the work project or activity, the name of employee(s) involved in the process, the date(s) of acknowledgment, and the name of the appropriate supervisor approving the JHA. The supervisor acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity. Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP). Identify all known or suspect hazards associated with each respective task/procedure listed. For example: - Research past accidents/incidents. - Research the Health and Safety Code, or other appropriate literature. - Discuss the work project/activity with participants. - Observe the work project/activity. - A combination of the above.	Work supervisors and crewmembers are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite. Be prepared to provide the following information: - Nature of the accident or injury (avoid using victim's name). - Type of assistance needed, if any (ground, air, or water evacuation). - Location of accident or injury, best access route into the worksite (road name/number), identifiable ground/air landmarks. - Radio frequencies. - Contact person. - Local hazards to ground vehicles or aviation. - Weather conditions (wind speed & direction, visibility, temperature). - Topography. - Number of individuals to be transported. - Estimated weight of individuals for air/water evacuation. The items listed above serve only as guidelines for the development of emergency evacuation procedures.

Identify appropriate actions to reduce or eliminate the hazards identified. Abatement measures listed below are in the order of the preferred abatement method:

a. Engineering Controls (the most desirable method of abatement).
For example, ergonomically designed tools, equipment, and Furniture.

b. Substitution. For example, switching to high flash point, non-toxic solvents.

c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.

d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, and portable water pumps).

e. A combination of the above.
Copy of the JHA as justification for purchase orders when procuring PPE.

JHA and Emergency Evacuation Procedures Acknowledgment
We, the undersigned work leader and crewmembers, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents:

DATE	PRINT NAME	SIGNATURE
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Appendix D. Traveler's driving checklist

	CHECKLIST ITEM	YES	NO	N/A
1.	Has the traveler planned the trip to include rest stops and overnight stays?			
2.	Has the traveler checked the weather forecast for the intended route and planned accordingly?			
3.	Has the traveler been briefed not drive more than 10 hours in a 24-hour period? (note 1 & 2)			
4.	Have you briefed the traveler on the need to get at least 8 hours of rest prior to departure?			
5.	Have you discouraged the traveler from driving during late hours?			
6.	Have you stressed the importance of obeying speed limits and wearing seatbelts?			
7.	Have you briefed the traveler to inspect the vehicle prior to departure? (note 3)			
8.	Have you discussed the results of the risk assessment required prior to multi-day trips? (note 4)			
9.	Does the traveler have a cell phone, in-car charger and is he or she aware that texting is prohibited while driving while on official Government business? (note 5)			
10.	Does the traveler have the appropriate phone numbers in case of an emergency?			
11.	Does the traveler have maps that cover the planned route?			
12.	Is the vehicle equipped with an emergency kit? (note 6)			

Notes

1. If traveler has worked any portion of his or her shift prior to departure, time worked must be added to driving time to equal a maximum of 10 hours.
2. Traveler can exceed 10 hour driving time only if an emergency situation necessitates the need.
3. The following items shall be inspected (by the traveler or qualified person) prior to departure:

- a. *All fluids (fuel, coolant, windshield washer fluid, oil, brake fluid, power steering fluid and transmission fluid)*
 - b. *All lights*
 - c. *Tires to include spare (tread depth, air pressure and overall condition)*
 - d. *Jack and necessary equipment to change tire*
 - e. *Windshield wipers*
 - f. *Horn*
- 4. *Risk assessment (e.g., Operational Leadership Green/Amber/Red or Severity/Probability/Exposure analysis).*
- 5. *Texting is prohibited when driving by Presidential Proclamation 8610. It is recommended the traveler use a cell phone only when stopped; however, if this is not possible, a hands-free device will be used.*
- 6. *Emergency kit should contain:*
 - a. *Water*
 - b. *Food (energy bars, etc.)*
 - c. *Blanket(s)*
 - d. *Road flares*
 - e. *Flashlight*
 - f. *First aid kit*
 - g. *Candle*
 - h. *Lighter or matches*
 - i. *Jumper cables*
 - j. *Any other item the operator or supervisor deems necessary*

Supervisor's Signature

*Provisional Supervisor's Signature

Traveler's Signature

** Temporary supervisors during LE Training, FTET, details etc. In these cases, both supervisors are required to sign.*

Appendix E. Prescribed Fire Results for Burn Block 1 Conducted in September 2014

Prescribed Fire Experimental Design

A prescribed fire plan was developed for the Battlefield that is integrated into the long-term monitoring program (Harris 2013). The plan which was written by the Glacier National Park fire management team with substantial input from park and Network I&M staff outlines 4 consecutive fire treatments to be applied to each half of the two hillslopes during consecutive years (Figure E-1). The first treatment was applied to the southeast half of the Howitzer Hill (burn block 1) in September 2014 (Figure E-1). This was originally planned for 2012 but was delayed two years until it was evident that spotted knapweed infestations could be controlled (Harris 2013). The experimental design is a replicated asymmetrical before-after-control-impact (“beyond BACI” design; Green 1979, Overton 1994). This design supports strong causal inference to fire effects on Lemhi penstemon and spotted knapweed because of the highly-replicated structure in which each block is subjected to experimental treatment sequentially and treated and control plots are well replicated within each block. Importantly, the sequential asymmetry will enable climate and weather effects to be accounted for. Subsequent replicate burns in blocks 2-4 have not been conducted because of lack of financial and logistical resources available during fall wildfire fighting seasons, but over time it is anticipated that burn block 4 on the north end of the Horse Pasture will be completed first, and then blocks 2 and 3 will be completed subsequently.

Results of Rx Fire in Burn Block 1

Figure E-2 shows ignition activity and fire behavior. Figure E-3 shows results of fuel moisture measurements taken from vegetation clipped in the block during burn preparations. Figure E-4 shows the temperature at ~20 mm below ground as the fire raced through mid-slope block 1 over two temperature sensors. Figure E-5 shows the burn perimeter and the 9 intensive plots that were burned within that perimeter. Table E-1 shows the relative burn severity of those 9 plots, ranked by average changes in bare ground cover and qualitative inspection of pre- and post-burn conditions. Post-burn plot conditions were evaluated in October, 2014, one month after the burn. Figure E-3 shows burn severity of the entire block as measured coarsely using the normalized burn ratio (dNBR) from pre- and post-burn 30-m resolution Landsat imagery. Although coarse, this image generally aligns with the plot-level assessments made after the burn.

**BIHO Pasture Rx Plan
BURN BLOCK MAP**

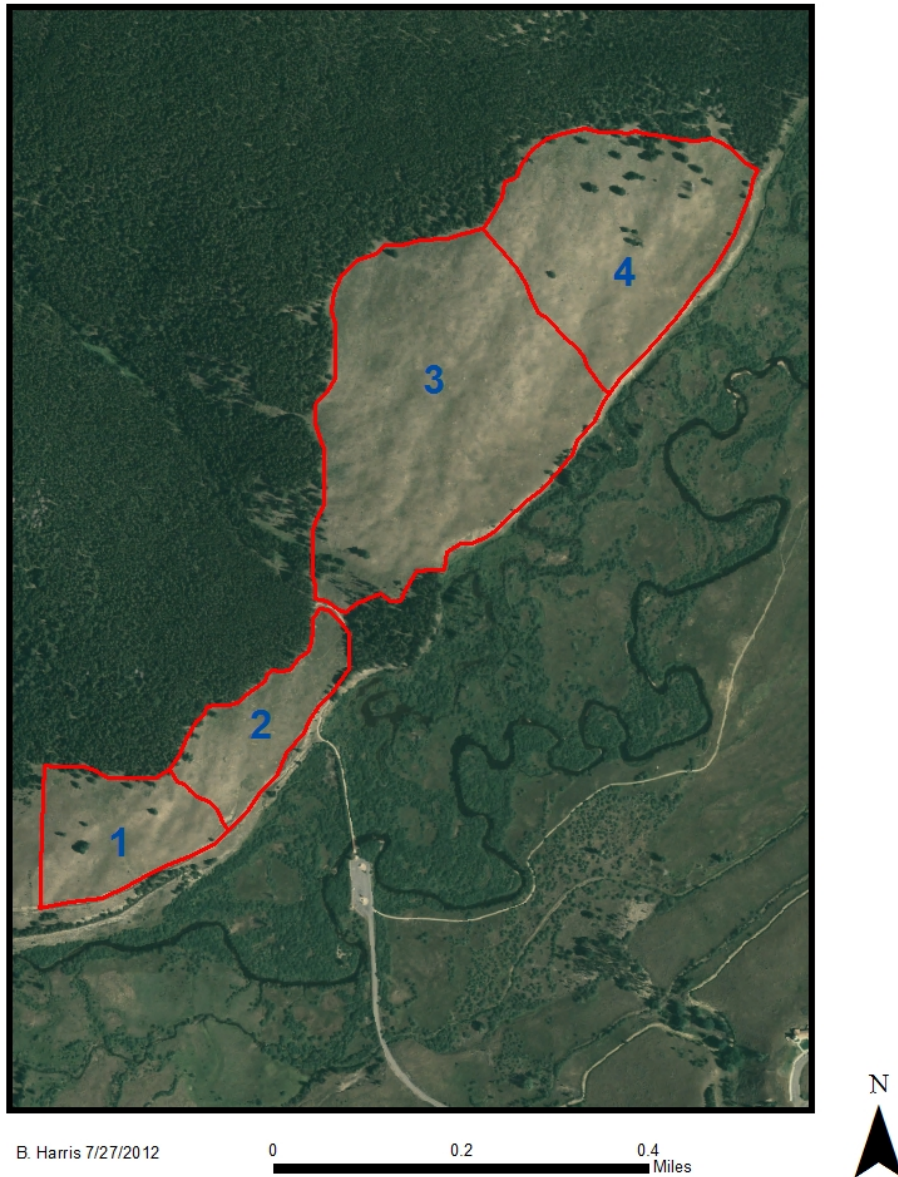


Figure E-1. The 4 proposed experimental burn blocks superimposed on to the Howitzer Hill and Horse Pasture long-term Lemhi penstemon and spotted knapweed monitoring study areas.



Figure E-2. Ignition of the prescribed burn in block 1, September 2014.

FUEL MOISTURE DATA SHEET

UNIT/LOCATION Pasture RX - BIHO North E Soil Sensor

COMMENTS Last Rain = 9-10-2014 0.01" Temp. = 46 RH = 48

DATE/TIME COLLECTED 09-13-2014 1000 hrs TIME IN /OUT OF OVEN 20 hrs

SAMPLERS Fire Effects Crew % FUEL MOISTURE = $\frac{\text{WET WT} - \text{DRY WT}}{\text{DRY WT} - \text{TARE WT}} \times 100$

SPECIES	CAN #	WET WT	DRY WT	TARE	W-D	D-T	%	COMMENTS
Soil Sample	40	242.0	236.0	108.0			4.7%	
Soil Sample	20	306.0	302.0	107.0			2.1%	
Soil Sample	4	251.0	249.0	108.0			1.4%	
Soil Sample	1	331.0	327.0	108.0			1.8%	
Soil Sample	15	341.0	338.0	105.0			1.3%	
							2.3%	

Figure E-3. Fuel moisture characteristics influencing the prescribed burn.

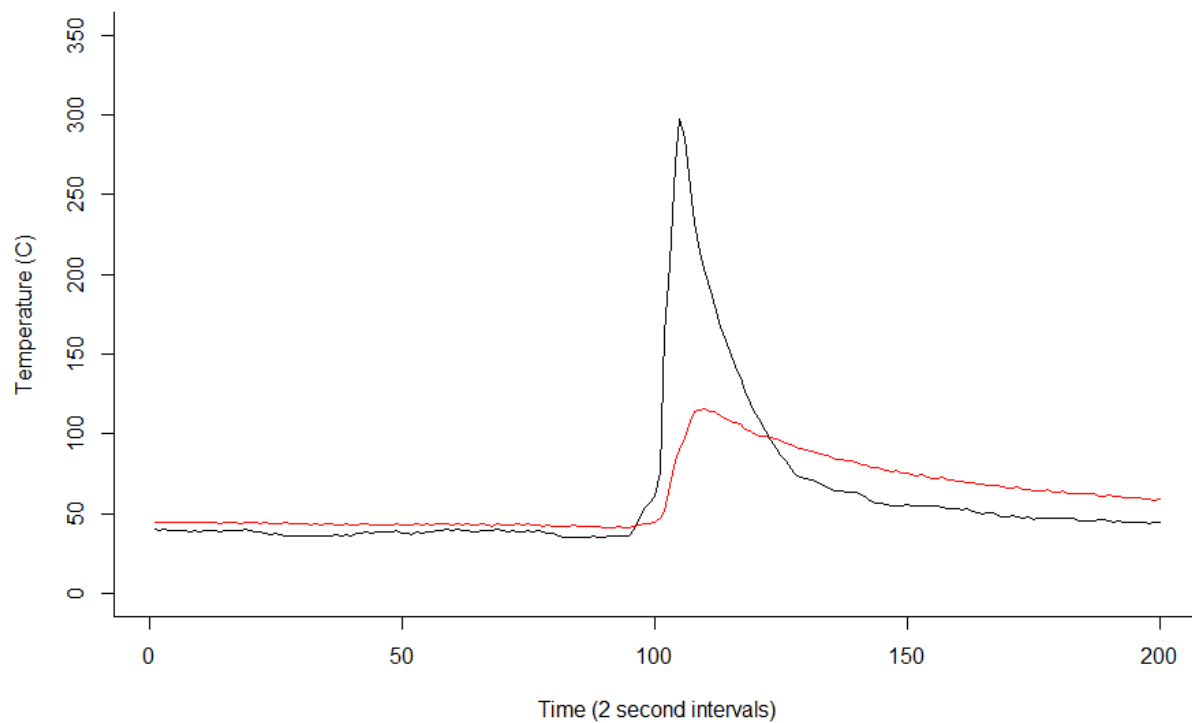


Figure E-4. Burn temperature profiles at two soil temperature data loggers, buried approximately 20 mm below surface. Note that the spike in temperature lasted approximately 1 minute as the fire raced uphill through dry fine fuels. Soil organic matter is low on the study area.



Figure E-5. The actual black-line perimeter of the first experimental burn in block 1, completed in September 2014. Nine intensive study plots were included in the perimeter. Plot 5 was excluded because firing technicians walked above the roadcut, unaware of the marked plot below them in the roadcut itself.

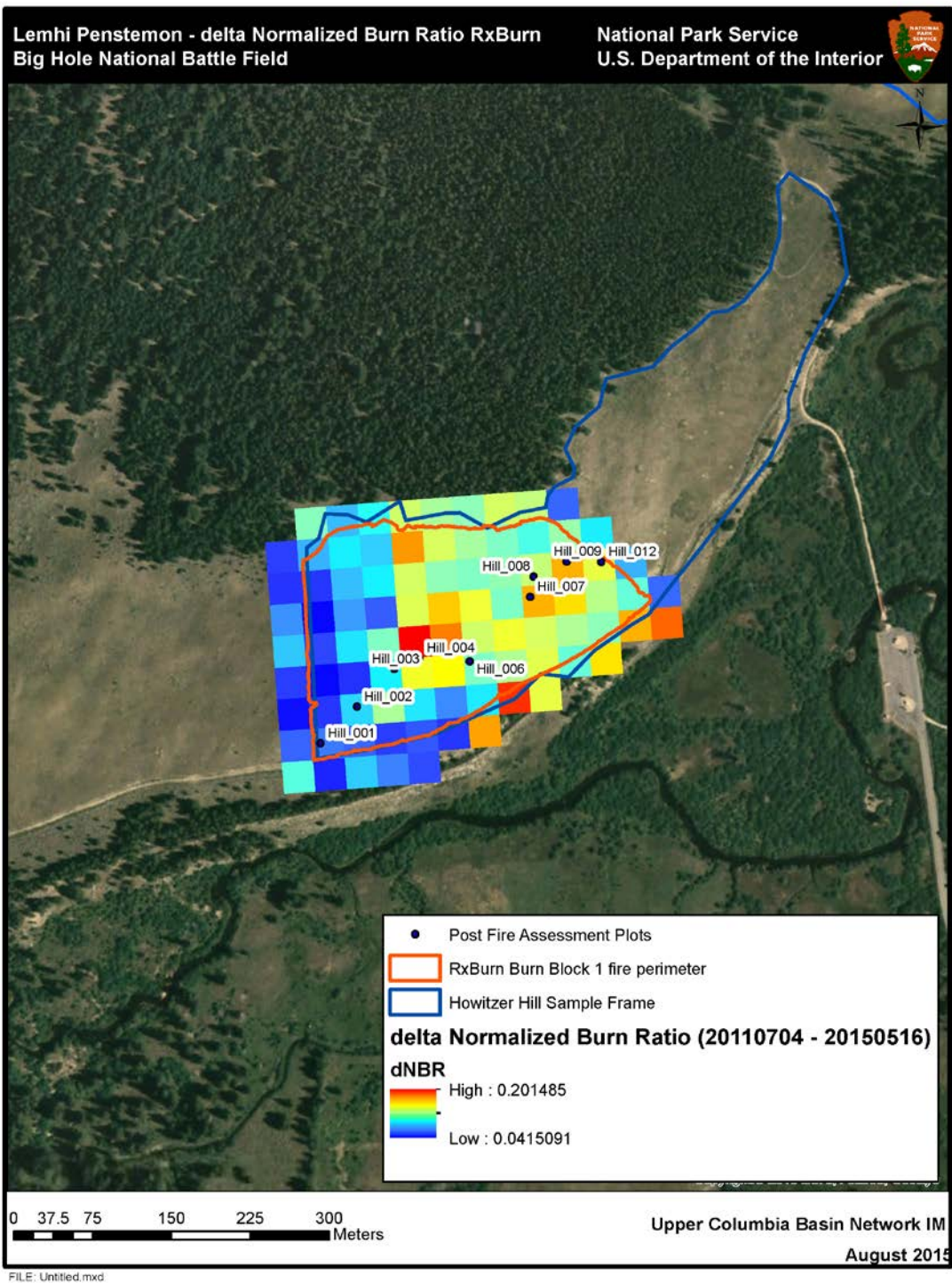
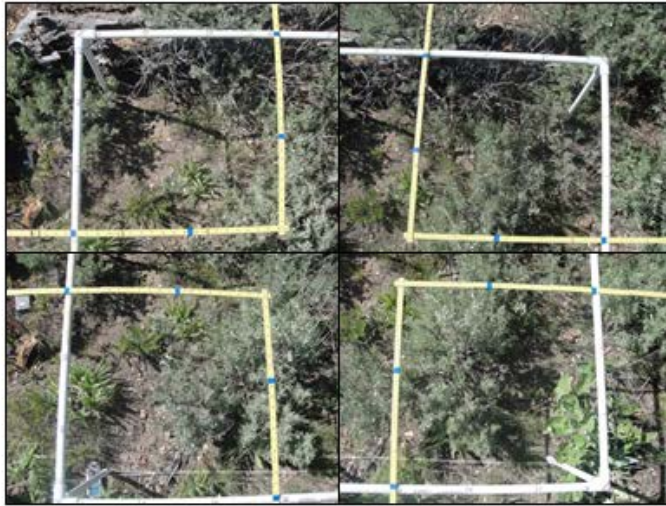


Figure E-6. Burn severity of burn block 1 following the September 2014 prescribed burn, measured using the normalized burn ratio computed from a pre-burn Landsat image dated July 4 2011 and a post-burn image dated May 16 2015. Although coarse, this severity map corresponds generally with plot-level assessments made by I&M staff in October 2014.

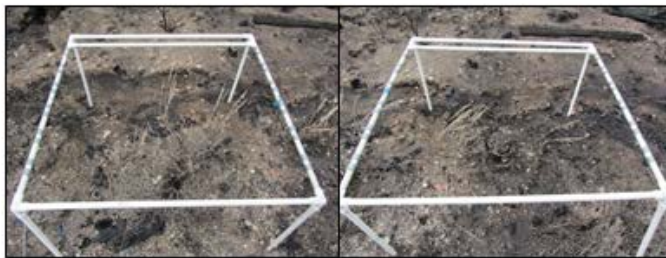
Table E-1. A ranking of burn severity of the 9 intensive plots within the burn block 1 perimeter. Rankings were based on change in bare ground and vegetation cover between June 2014 and October 2014, and with qualitative inspections of pre- and post-burn plot photographs (e.g., Figure E-7). Plots 6-8 increased in cover over the growing season, reflecting no loss of cover resulting from fire, although were still considered to have had some heat stress and, in general, non-zero fire impact.

Plot	Avg. Change Bare Ground	Rank
Hill_001	0.23	Low
Hill_002	0.16	Low
Hill_003	0.17	Low
Hill_004	0.42	High
Hill_006	-0.05	Very Low
Hill_007	-0.10	Very Low
Hill_008	-0.19	Very Low
Hill_009	0.24	Moderate
Hill_012	0.19	Moderate

Pre-burn June 2012



Post-burn October 2014



Post-burn June 2015



Figure E-7. Comparative photos of intensive plot 4, the most severely-burned plot among the 9 plots (see Table E-1). These and other photos taken before and after the Rx burn block 1 are stored at the UCBN offices.

Big Hole National Park Prescribed Fire Monitor Report from the Glacier National Park Fire Management Office

Pasture RX

9/13/2014

Burn Unit/Name: Pasture RX
Dates Burned: 9/13/ 2014

Acres Burned: 12.95 acres
Fuel Model(s): Mostly FM1 with some FM2

Personnel on Burn:

Burn Boss: Brad Harris (NPS)
Holding: Cody Montgomery (USFS)
Ignition: Dennis Divoky (NPS)
Monitors: Scott Lang/Katie Weidman (T) (NPS)

Holding Crew: 11 (Anaconda Job Corps)
6 Forest Service – 2 engines
Ignition Crew: 4 (NPS)

Background

The slopes of the NPS Big Hole Battlefield area were treated with fire in 1985?, 1988?, 1991 and 1997 by Forest Service Fire Management crews to assist the Park Service with tree encroachment and increasing sage on the steep slopes North of the visitor center. Lemhi penstemon is known to be growing on the disturbed slopes of the Battlefield and seems to be somewhat connected to disturbance including fire. The area that the Lemhi penstemon prefers is steep and southern facing consisting of mostly Idaho Fescue, Bluebunch Wheatgrass, Balsamroot, Rabbitbrush, Goldenrod, Sulphur Buckwheat, and Sagebrush. This earlier treatment was done in the spring and had good results. A fall burn period was picked for this treatment to try to match natural fire regimes in the area and the plant ecology of Lemhi penstemon.

Fire Behavior Observation

A test fire was conducted at 1103 hrs at the Northwest corner of the unit near the weather station. This test fire was favorable so black lining was started at 1130hrs on the upslope NW corner burning to the north and then to the East. Once black lining was completed strip firing was started at 1330hrs on the NW corner from the top of the Unit and continued toward the bottom of the Unit using a West to East and then East to West burn strip. Firing was completed at 1430hrs and the Unit smoldered and smoked in spots for a few hours into the evening. The Unit had a large patch on the West side of the Unit that did not burn that well due to low fuel in sparse vegetation, but the rest of the unit burned well due to good fuel loads, lowering humidity, and increasing winds. Sagebrush and rabbitbrush burned well but sagebrush could have been at a lower fuel moisture to create more mortality on the Unit. A cold front created a cloud mass that hung over part of the unit at about 1230 hrs which kept the RH up more than we would have liked but the Unit still burned well, mostly due to good winds. Average flame length was from 4"-5" during the test fire to averages of 1'- 2' with highs of 10' at times during the strip firing. The RH bottomed out at 19% at the end of firing at the bottom of the Unit. Winds averaged 4-5 mph with gusts as high as 12 mph during the burning period. Smoke monitoring observations showed good dispersal and light to moderate smoke volume for short

periods during active burning. Rate of spread was estimated at 40 +/- chains per hour on the steep slopes of the Unit.

*5% to 50% slope; 6500 ft elevation; S-SE aspect

PRAWS1 – Big Hole Battlefield MT (Pasture RX)

14 Sep 11:31 pm MDT	50 16 26	NNW	2G05	43	8	0	--	2.19	OK
14 Sep 10:31 pm MDT	54 17 23	NNW	2G05	47	8	0	--	2.19	OK
14 Sep 9:31 pm MDT	55 18 23	NW	3G05	49	8	0	--	2.19	OK
14 Sep 8:31 pm MDT	57 19 22	NW	3G05	51	8	4	--	2.19	OK
14 Sep 7:31 pm MDT	61 17 18	NNW	2G08	57	8	120	59%	2.19	OK
14 Sep 6:31 pm MDT	69 16 13	SSE	1G09	73	8	352	73%	2.19	OK
14 Sep 5:31 pm MDT	72 17 12	NNE	2G16	81	8	568	78%	2.19	OK
14 Sep 4:31 pm MDT	73 15 11	W	4G18	83	8	765	83%	2.19	OK
14 Sep 3:31 pm MDT	74 18 12	SSW	5G18	85	8	858	80%	2.19	OK
14 Sep 2:31 pm MDT	70 19 14	SW	10G20	82	9	954	84%	2.19	OK
14 Sep 1:31 pm MDT	70 19 14	WSW	11G21	81	9	860	76%	2.19	OK
14 Sep 12:31 pm MDT	69 21 16	WSW	8G21	80	9	835	79%	2.19	OK
14 Sep 11:31 am MDT	61 31 32	ESE	3G08	74	10	763	84%	2.19	OK
14 Sep 10:31 am MDT	51 28 41	E	4G08	65	10	552	79%	2.19	OK
14 Sep 9:31 am MDT	46 28 50	S	1G04	57	10	330	73%	2.19	OK
14 Sep 8:31 am MDT	38 28 66	WSW	1G03	42	11	103	60%	2.19	OK
14 Sep 7:31 am MDT	33 27 78	WNW	1G03	30	11	1	--	2.19	OK
14 Sep 6:31 am MDT	34 25 70	N	2G03	31	10	0	--	2.19	OK
14 Sep 5:31 am MDT	34 26 73	WNW	1G03	30	10	0	--	2.19	OK
14 Sep 4:31 am MDT	37 25 62	N	1G03	32	10	0	--	2.19	OK
14 Sep 3:31 am MDT	39 27 62	NW	1G03	34	9	0	--	2.19	OK
14 Sep 2:31 am MDT	41 27 56	NNW	2G04	35	9	0	--	2.19	OK
14 Sep 1:31 am MDT	42 26 53	SSW	1G04	37	9	0	--	2.19	OK
14 Sep 12:31 am MDT	45 26 47	NNW	2G04	37	9	0	--	2.19	OK
13 Sep 11:31 pm MDT	47 25 42	NE	1G05	41	9	0	--	2.19	OK
13 Sep 10:31 pm MDT	52 26 36	NW	4G06	46	9	0	--	2.19	OK
13 Sep 9:31 pm MDT	52 25 35	NW	3G05	45	8	0	--	2.19	OK
13 Sep 8:31 pm MDT	52 24 34	NNW	3G05	48	8	4	--	2.19	OK
13 Sep 7:31 pm MDT	59 24 26	NNW	2G07	57	8	134	64%	2.19	OK
13 Sep 6:31 pm MDT	66 25 21	NNW	3G11	72	8	357	73%	2.19	OK
13 Sep 5:31 pm MDT	69 22 17	WNW	4G11	77	9	544	74%	2.19	OK
13 Sep 4:31 pm MDT	68 22 17	N	3G16	77	9	601	64%	2.19	OK
13 Sep 3:31 pm MDT	67 23 19	SW	5G15	76	9	632	59%	2.19	OK
13 Sep 2:31 pm MDT	64 21 19	WSW	9G20	74	9	763	67%	2.19	OK
13 Sep 1:31 pm MDT	64 24 22	SE	5G12	77	9	1021	90%	2.19	OK
13 Sep 12:31 pm MDT	60 25 26	ESE	4G09	75	10	946	89%	2.19	OK
13 Sep 11:31 am MDT	55 26 32	E	4G09	68	10	783	86%	2.19	OK
13 Sep 10:31 am MDT	46 24 41	44 E	5G09	58	10	570	81%	2.19	OK
13 Sep 9:31 am MDT	43 25 48	ESE	3G06	54	10	336	73%	2.19	OK
13 Sep 8:31 am MDT	36 22 56	SW	1G03	43	10	117	65%	2.19	OK
13 Sep 7:31 am MDT	32 23 70	NNW	1G03	28	11	4	--	2.19	OK
13 Sep 6:31 am MDT	31 22 70	NNW	2G03	26	10	0	--	2.19	OK
13 Sep 5:31 am MDT	32 21 63	NNW	2G03	28	10	0	--	2.19	OK
13 Sep 4:31 am MDT	34 22 62	N	1G03	29	10	0	--	2.19	OK
13 Sep 3:31 am MDT	35 20 55	NW	1G05	31	9	0	--	2.19	OK
13 Sep 2:31 am MDT	42 20 41	NNW	2G06	37	9	0	--	2.19	OK
13 Sep 1:31 am MDT	46 21 37	44 WNW	4G09	41	9	0	--	2.19	OK

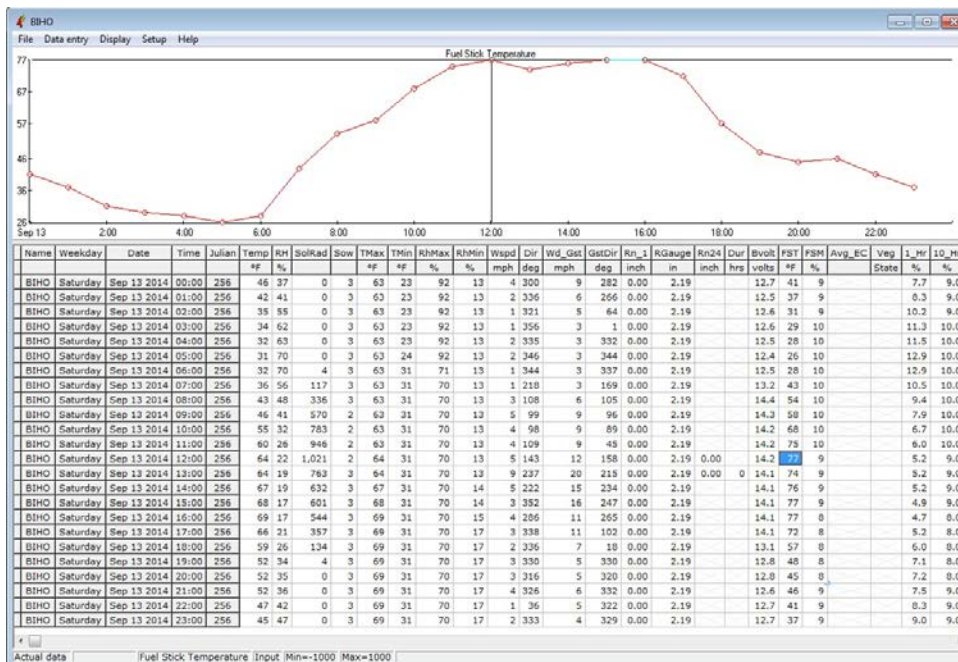
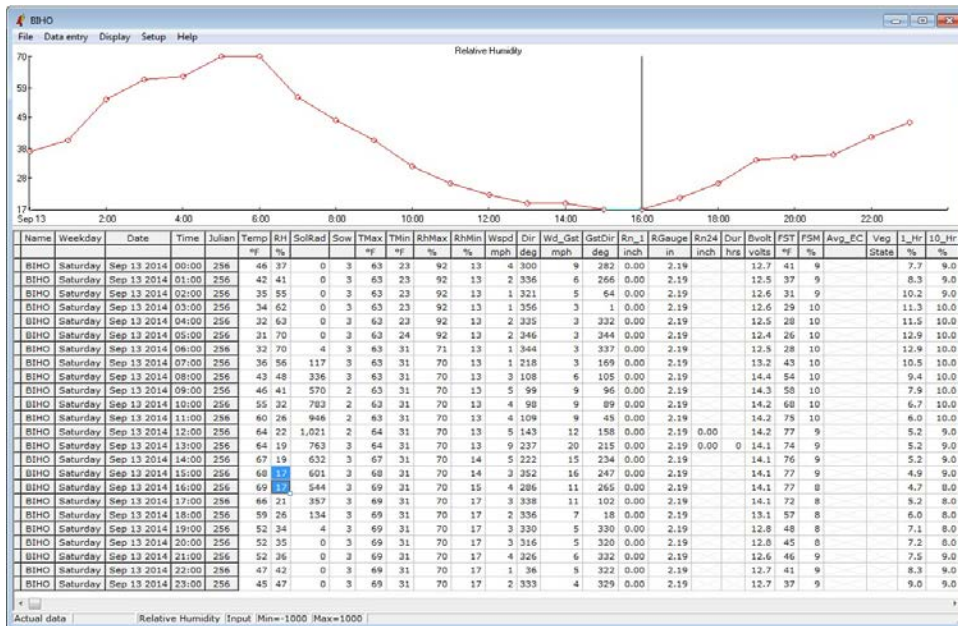
13 Sep 12:31 am MDT	47 21 36	45	WNW	4G07	42	9	0	--	2.19	OK
12 Sep 11:31 pm MDT	47 22 37		NW	3G07	42	9	0	--	2.19	OK
12 Sep 10:31 pm MDT	51 21 30		W	2G11	48	9	0	--	2.19	OK
12 Sep 9:31 pm MDT	50 19 29	49	W	4G10	49	9	0	--	2.19	OK
12 Sep 8:31 pm MDT	50 17 27		NW	3G05	46	9	5	--	2.19	OK
12 Sep 7:31 pm MDT	53 16 23		NNW	3G13	52	9	145	66%	2.19	OK
12 Sep 6:31 pm MDT	61 13 15		SW	7G18	66	9	389	79%	2.19	OK
12 Sep 5:31 pm MDT	63 13 14		SW	11G22	69	9	623	84%	2.19	OK
12 Sep 4:31 pm MDT	63 15 15		SW	8G22	72	10	818	87%	2.19	OK
12 Sep 3:31 pm MDT	63 11 13		WSW	10G18	74	10	952	88%	2.19	OK
12 Sep 2:31 pm MDT	63 20 19		N	3G10	77	10	1019	89%	2.19	OK
12 Sep 1:31 pm MDT	60 23 24		SSE	4G10	74	11	1016	89%	2.19	OK
12 Sep 12:31 pm MDT	53 22 30		S	3G09	69	11	938	88%	2.19	OK
12 Sep 11:31 am MDT	48 22 36		SE	3G08	62	12	789	86%	2.19	OK
12 Sep 10:31 am MDT	41 23 48		WSW	2G07	58	12	587	82%	2.19	OK
12 Sep 9:31 am MDT	35 24 63		E	2G05	46	13	352	76%	2.19	OK
12 Sep 8:31 am MDT	32 24 71			G03	37	14	128	68%	2.19	OK
12 Sep 7:31 am MDT	24 22 92			G03	22	14	5	--	2.19	OK
12 Sep 6:31 am MDT	23 21 91		NW	2G03	18	14	0	--	2.19	OK
12 Sep 5:31 am MDT	24 21 90		NW	1G02	20	14	0	--	2.19	OK
12 Sep 4:31 am MDT	25 22 89		NW	1G02	19	13	0	--	2.19	OK
12 Sep 3:31 am MDT	27 23 84		NNW	2G03	20	13	0	--	2.19	OK
12 Sep 2:31 am MDT	27 22 81		NW	1G03	21	12	0	--	2.19	OK
12 Sep 1:31 am MDT	27 22 80		SE	1G03	22	12	0	--	2.19	

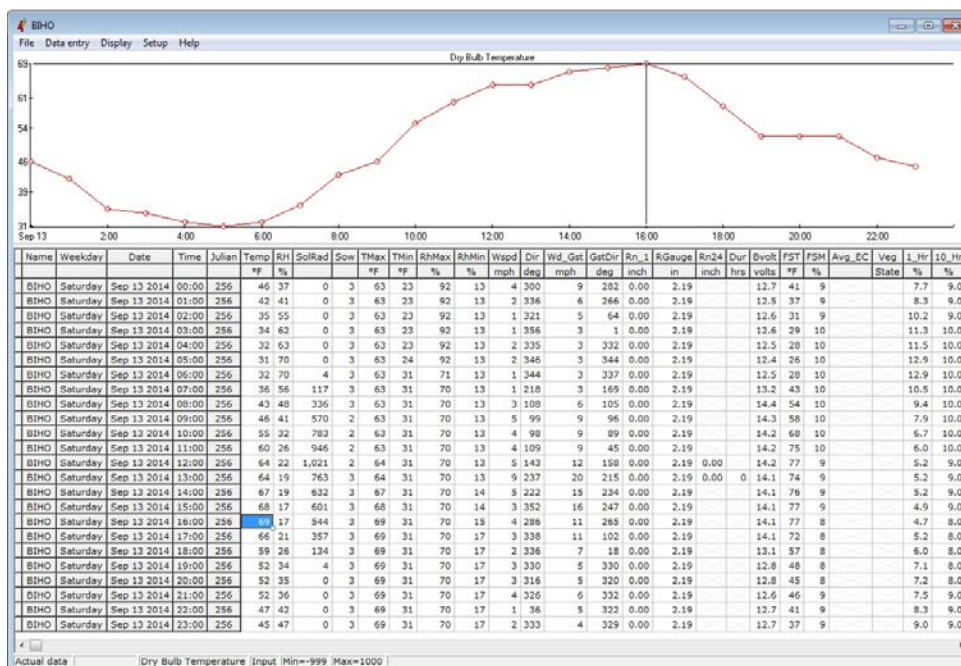
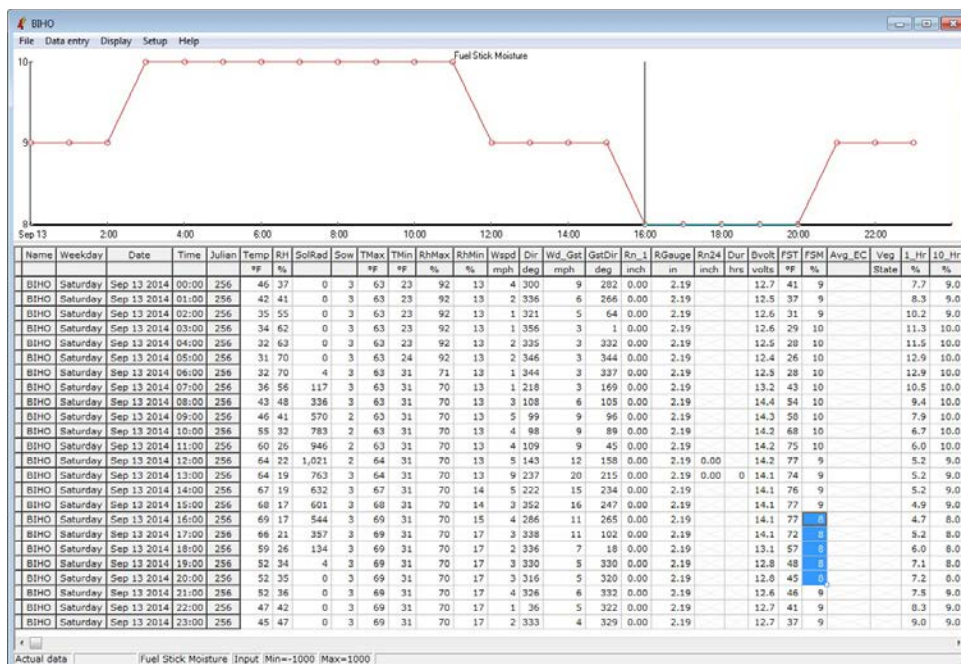
Pasture Rx Fire Weather (Sling)

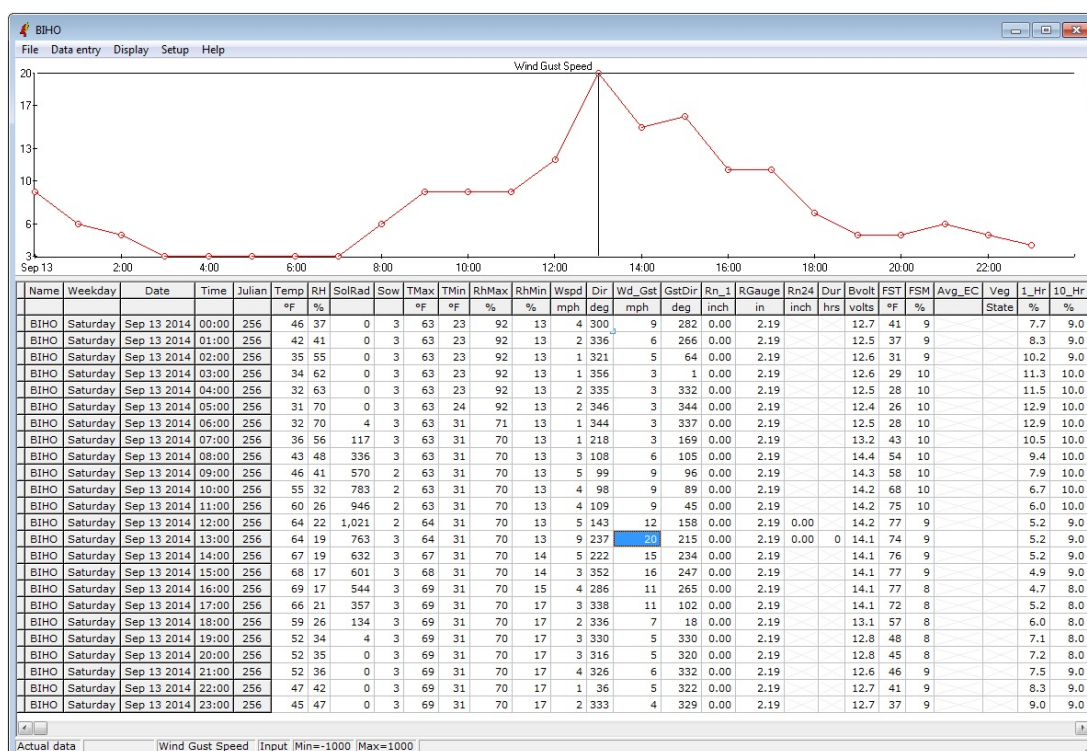
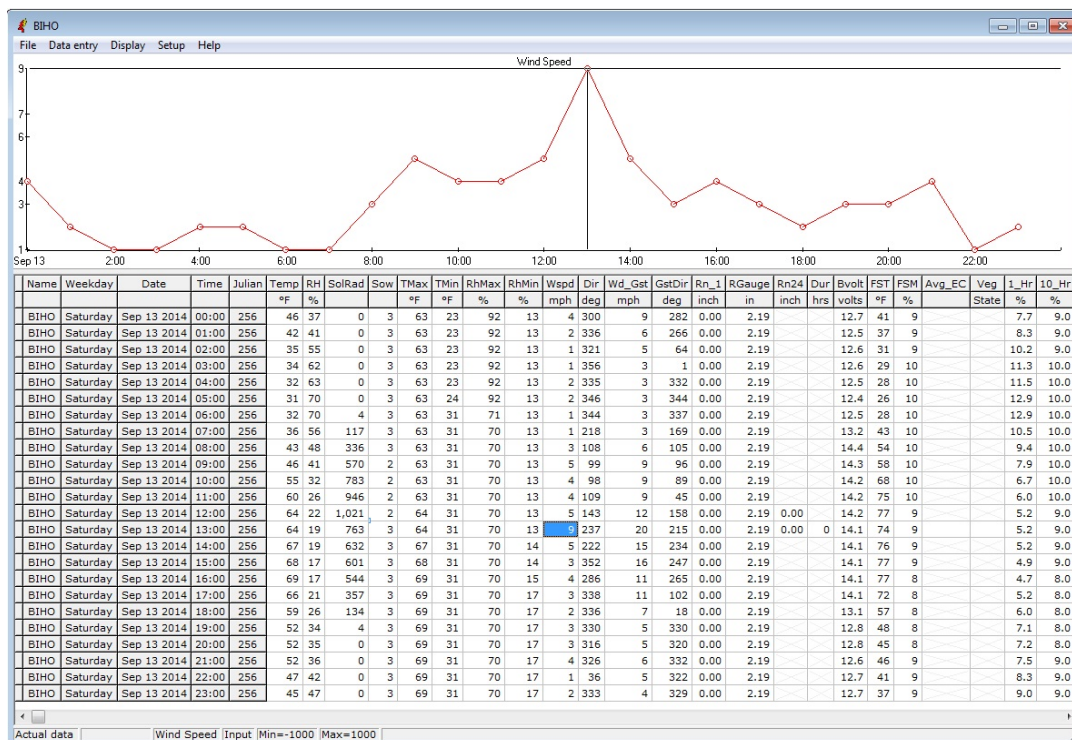
Date	Time	Dry	Wet	RH	Wind	Dir	FDFM	PIG	Comments
09-13-14	1100	46	36	41	2-6G7	E	8	40	
09-13-14	1200	54	41	35	5G7	NE	7	40	Clds from North
09-13-14	1300	60	44	29	3-4G9.5	ENE	7	50	Still Clds from N
09-13-14	1400	64	46	26	7G11	SW	7	50	Clearing of Clds
09-13-14	1500	68	48	24	2-4G7	W-N	7	50	H. Clds & Low Smoke

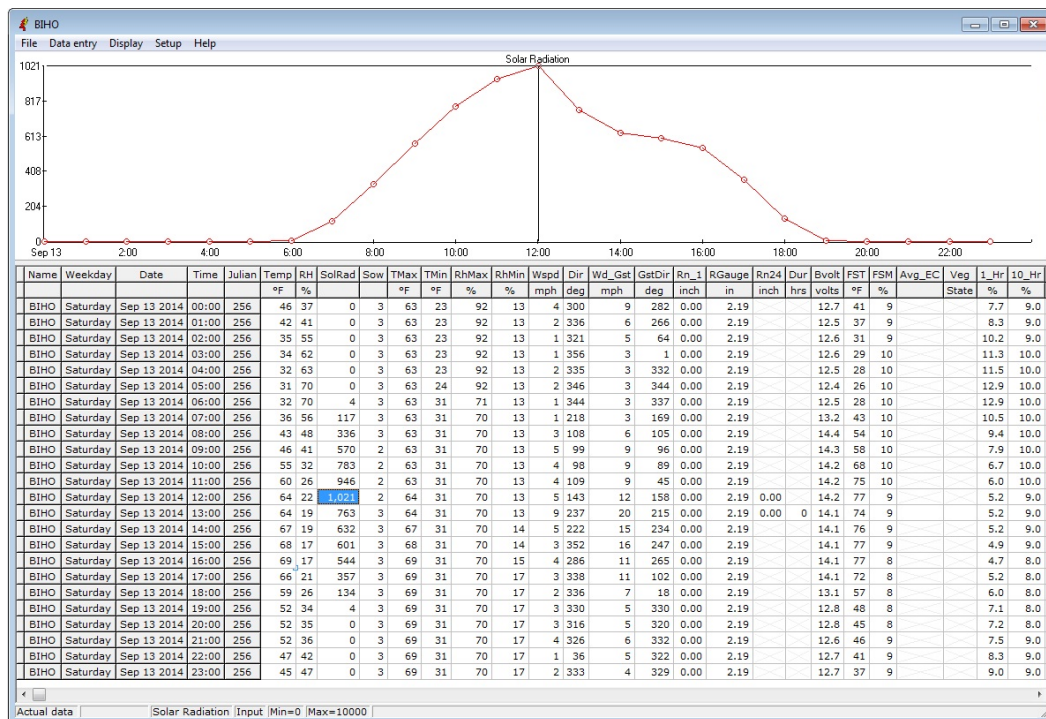
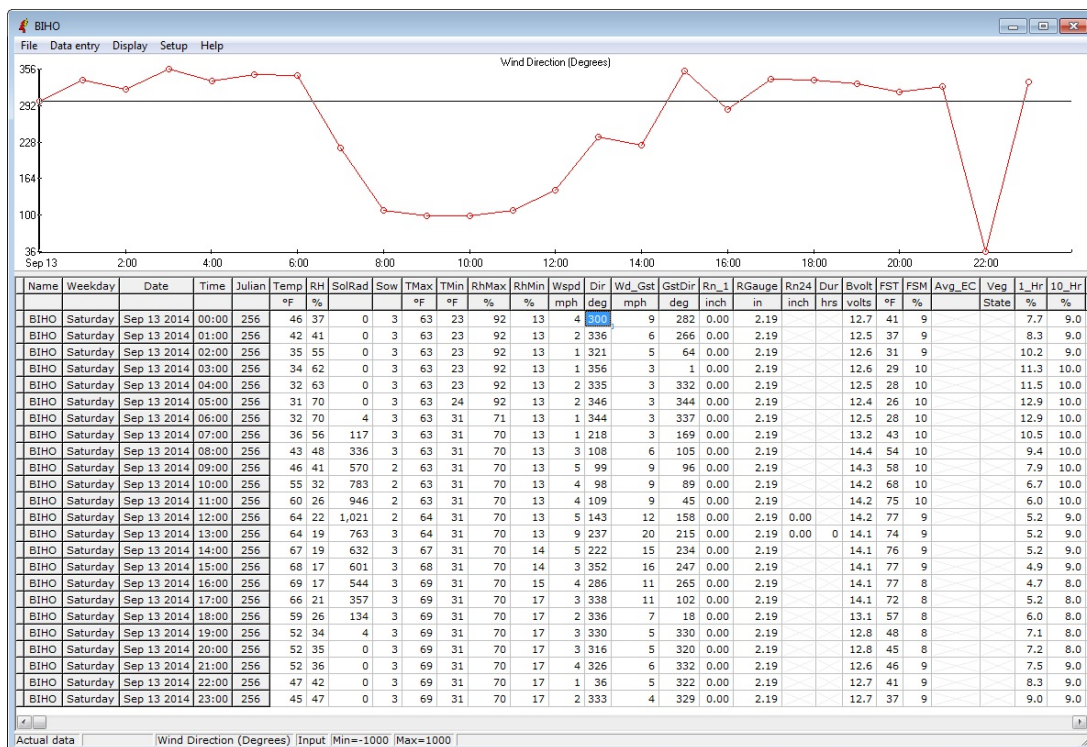
Pasture Rx Fire Weather (Kestrel)

Date	Time	Dry	RH	Wind	Dir	Cloud Cover
09-12-14	1730	64	12	10G15	W	0%
09-13-14	1130	55	31	1G7	E	0%
09-13-14	1230	60	29	3G8	E-NE	3%
09-13-14	1330	63	25	3-6	E	45%
09-13-14	1430	70	21	2-4	SW	5%









Burn Objectives:

Burn objectives were to restore fire as a natural fire regime disturbance on the open slopes of the Battlefield to increase Lemhi penstemon habitat while at the same time maintaining the historical landscape view of the Big Hole Battlefield. Removing conifer encroachment and setting back sagebrush was the main method to be used in restoring the historical landscape

view at the Battlefield. Another objective was to not increase the non-native populations, mostly Knapweed, in the prairie ecosystem at the Battlefield while treating the area with fire.

Recommendations:

The use of the portable remote weather station was very useful and should be used again in the future if possible. Slightly lower humidities, slightly higher winds, and lower needle and sage fuel moisture might make the burn have higher mortality rates. Taking some fuel moistures preburn might help dial this burn unit in better in the future. This year has been a wet year and fuels may have been higher than typically found at this site during this season. Weed monitoring and eradication before and after the burn would be a good idea considering some knapweed is in the area.

Positives

- RX plan and logistics was well prepared and implemented.
- Trainee assignments for various firefighters both USFS, Job Corps, and NPS.
- Fire allowed to continue its role in natural processes at the Big Hole Battlefield.
- Decreased sage and tree encroachment on area meadow ecosystems.
- Lemhi penstemon resource management/ monitoring project treatment completed. (NPS Upper Columbia Basin Network I&M Program)
- No injuries

National Park Service
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